ISSN 2786-6661
eISSN 2786-667X

UDC: 613.955-047.44:[373.5.091.6:623.12
https://doi.org/10.32345/USMYJ.1(152).2025.47-54

Received: October 02, 2024
Accepted: January 15, 2025

Comprehensive hygienic assessment of the conditions of pupils stay in the shelters of a general secondary education institution

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Abstract: *in connection with the beginning of a full-scale war of the aggressor country against Ukraine, staying in shelters and bomb shelters has, unfortunately, become an integral part of our lives. That is why it is very important that the premises allocated for these needs meet the minimum hygienic requirements, especially regarding educational institutions and pupils' health. The physical and chemical parameters of the environment of a typical shelter of a general secondary education institution (lighting, noise, vibration, air quality) were measured and assessed. The research methods used in our work are descriptive, content analysis, instrumental, full-scale hygienic experiment, sanitary examination, lighting, chemical, and statistical. The studied physical and chemical factors of the educational environment are important components for ensuring a healthy educational environment and an effective educational process. Appropriate assessment and management of the levels of physical and chemical parameters in school shelters are key to ensuring the quality of education and children's health in the educational process. Legislative aspects requiring intervention and correction measures were identified. Gaps in the legislative field were identified regarding the standardization of local vibration parameters for children in educational institutions both in peacetime in general and wartime in particular. During measurements using modern mobile equipment, it was possible to establish unsatisfactory parameters of local vibration that occurred at pupils' workplaces while performing written tasks. If implemented, such a convenient mechanism for monitoring local vibration levels at their workplaces will allow timely interventional preventive measures to improve the condition of educational furniture in shelter rooms and common classrooms. Factors that deviated from the recommended values and may negatively affect the health of children and staff of secondary education institutions were identified. The noise level exceeded medical and sanitary standards, especially during the operation of power-generating equipment, which may negatively affect the health and concentration of students. The obtained noise indicators did not comply with the hygienic standards of State Sanitary Norms and Rules under the condition of operation of power generating equipment (the normative value should not exceed 40 dB). The maximum allowable concentration (MAC) of CO_2 did not comply with the recommended values for general-purpose premises (within 0.07-0.1%), as it increased after classes, exceeding the recommended values for general-purpose premises. This may affect the health of schoolchildren and impair their attention during studies.*

Keywords: Workplace; Child; Vibration; Carbon Dioxide; Disinfectants; Public Health; medical and sanitary standards.

ISSN 2786-6661
eISSN 2786-667X

Introduction

In connection with the beginning of a full-scale war of the aggressor country against Ukraine, staying in shelters and bomb shelters has, unfortunately, become an integral part of our lives. That is why it is very important that the premises allocated for these needs meet minimum hygienic requirements, especially regarding educational institutions and children's health. The need to ensure minimum hygienic parameters in such conditions is currently critical.

Psycho-emotional overload caused by a long stay in shelters and constant threats can have serious consequences for the mental state of children and adults. In addition to the significant psycho-emotional stress during the announcement of air alarm signals, physical and chemical factors of the environment can also be unfavourable. In the case of being in shelters, their initial assessment for compliance is most often not carried out considering medical and sanitary standards (since the assessment of compliance with safety factors is of primary importance).

Another unfavourable factor is the destruction of our country's energy infrastructure, which creates additional pressure on maintaining hygienic conditions for children in shelter facilities, as electricity generation equipment is being operated near schools.

The main physical factors of the educational environment that can affect children are such as lighting, noise, vibration, and microclimate (air temperature, air velocity, relative humidity, radiation temperature). The main chemical factors of the educational environment are air quality in general and the concentration of carbon dioxide (CO_2), which is the main anthropotoxin in particular [1, 2, 3,4].

In the case of poor-quality, insufficient, or excessive lighting, schoolchildren's mental and physical performance decreases, eye fatigue develops quickly, and vision deteriorates, which can subsequently lead to reduced visual acuity and the occurrence of ophthalmological diseases [5].

Prolonged noise exposure harms the functioning of many important organs, such as the heart, liver, and digestive organs, but first of all, of course, hearing suffers. Even when the noise is insignificant but prolonged, it creates a corresponding load on the nervous system and has a psychological impact [6,7].

Increased carbon dioxide concentrations in classroom air are also an adverse risk factor for the nervous system of schoolchildren [8, 9]. Depending on the exposure concentration, CO_2 can cause various health effects. These can include headaches, dizziness, anxiety, tingling or prickling sensations, difficulty breathing, sweating, fatigue, rapid heartbeat, increased blood pressure, coma, asphyxiation, and convulsions.

Also, one of the important aspects of hygienic monitoring of staying conditions is the recent possibility of using sensors of mobile devices (smartphones, tablets) to measure some physical factors (lighting, noise, vibration, etc.). Such accessibility creates the prerequisites for children to control their environment and increases interest in preserving their own health.

This opportunity for self-monitoring can inspire children to become more proactive about the conditions in their environment and create a database for reasoned conclusions about the need to improve shelter conditions. This can open a dialogue between children, teachers, and school administration to ensure safe and healthy environments.

Moreover, this approach can contribute to education about the importance of hygiene standards and a healthy environment, developing in children a sense of responsibility for their own health and the environment. A sense of control over the situation can positively impact the psychological state of individuals, especially in stressful situations during war.

Aim

Hygienic assessment of the conditions of children staying in shelters during air raids. The assessment included an analysis of physical parameters, such as lighting, noise level, and vibration, as well as determining the concentration of carbon dioxide and assessing the state of the air environment in the shelter from the standpoint of hygiene and epidemiology through indirect analysis of the quality of cleaning with the use of disinfectant solutions to ensure the highest standards of safety and comfort for children in wartime.

ISSN 2786-6661
eISSN 2786-667X

Materials and methods

Assessing natural lighting was impossible due to the lack of window openings. Under these conditions, it is possible to assess the parameters of artificial illumination, noise, vibration, ventilation efficiency, and active chlorine content in disinfectant solutions.

Research methods – descriptive, content analysis, instrumental, field hygienic experiment, sanitary and hygienic expertise, light-engineering, chemical, statistical.

This shelter is located in the basement of the main school building and consists of two rooms measuring 20x9 m and 10x6 m.

When assessing the level of artificial lighting, it was taken into account that in the larger room, there are 8, and in the smaller one - 6 fluorescent lamps, the power capacity of each lamp is 21 W, and there are two illuminators in the lamp. Measurements were carried out at 7 control points in accordance with the methodological recommendations specified in DBN V.2.5-28:2018 [10] for measuring the level of artificial illumination at a distance of 0.8 m from the floor and 1 m from the walls using sensors of mobile devices tmd2725 Ambient Light Sensor Non-wakeup (ams AG); range : 0...1; resolution: 0.01 (1%); power: 0.08mA. Product Parameters – Supply Voltage [V] -1.7 - 2.0, IIC Bus -1.8, Programmable – Gain, integration time, interrupt Integrated Capabilities – ALS, Prox, IR LED, Recommended Operating Distances [cm] <15, Temperature Range [°C] - 30 to 85, Packages – Surface mount module, pin count 8, software – Lux -O- Meter lichtmesser 1.01.10; the measurement error, compared to the standard luxmeter Yu-116, was no more than (1-4 lux).

When measuring noise level, the children's workplace, where the sound level meter was located, was taken as the control point. The measurement was carried out for several seconds, after which the device processed the recorded values and recorded the strongest one. Measurements were carried out with a noise detector m&sen mi 9 mi9 m9 using the Sound software application Meter (Smart Tools. Ver. 1.7.14). Compared to the standard SHUM-1-M sound level meter, the measurement error was no more than (1-3 dB). The measurements were carried out in the absence of schoolchildren to assess the background noise levels with the electric generator located outside turned on and off.

To assess ventilation efficiency, the level of carbon dioxide in the air was determined using the Lunge-Zeckendorf express method. The principle of this method is to pass the tested air through a titrated solution of carbon dioxide using phenolphthalein. Phenolphthalein is pink in an alkaline medium and becomes transparent after reacting with CO_2. The result is estimated using the ratio of the number of spent syringe volumes and the CO_2 concentration in atmospheric air (0.04%) and in the tested room, where the CO_2 concentration is unknown [11].

The assessment of the regulatory framework for vibration regulation and cleaning regimes was carried out, taking into account information from the official websites of the Verkhovna Rada of Ukraine, the Cabinet of Ministers of Ukraine, and the Ministry of Health of Ukraine.

The children's workplace was taken as the reference point when measuring the vibration level. Vibration measurements were carried out on the working surface of the study tables for 1 min while writing work tasks using a sensor (accelerometer (Iis2hh12, V.1, Type 1, power 0.001 mA, resolution 0.0012 m/s^2, maximum range ±78.4532 m/s^2, maximum delay 20000 ps) and a mobile application (iDynamics RPTU Kaiserslautern-Landau).

To determine the level of active chlorine in the working solution of the disinfectant, 10 samples were taken. According to the determination conditions, 100 ml. of distilled water was poured into a conical flask, then 1 ml. of chlorine water, 5 ml. of potassium iodide, 2 ml. of sulfuric acid /1:3/ were poured, and then titrated with 0.05 sodium thiosulfate solution to a straw-yellow colour. Then, 2 ml of starch was added, and the titration was continued until the blue colour of the liquid, which appeared after adding starch, completely disappeared. The concentration of active chlorine was calculated from the amount of sodium thiosulfate used for titration.

Results and discussion

The legislation of Ukraine regulates standards for vibration levels in school premises; namely, they must comply with the requirements of the

ISSN 2786-6661
eISSN 2786-667X

Sanitary Regulations for general secondary education institutions, which, in turn, states that vibration levels in production premises of educational institutions must comply with the requirements of the State Sanitary Standards for General and Local Industrial Vibration (SSN 3.3.6.039).

However, the legislative framework contains indications on the level of vibration in educational institution buildings, while there are no clear instructions on the standardization of local vibration, which can be created at the children's workplace and transmitted to the joints of the upper limb during writing [12].

This issue arose during the hygienic assessment of children's workplaces in shelter rooms, where a flat floor surface is not always provided, and the educational furniture installation plane unevenness creates additional vibration when children perform written and graphic tasks on the surface of educational tables. Therefore, checking local vibration levels is important as one of the components of ensuring a healthy educational environment.

Increased levels of local vibration may also increase the risk of inflammation (tendinitis, tendovaginitis, bursitis, synovitis) of the articular apparatus parts of the working upper extremities in children and staff, which requires systematic analysis and management of these risks [13, 14].

Measurements were made of vibration levels of the work surfaces of 30 tables in the shelter rooms.

After conducting measurements, we obtained the following data:

– minimum vibration acceleration 0.17078 m/s^2,
– maximum vibration acceleration 1.69927 m/s^2,
– median 0.35254 m/s^2,
– maximum displacement 0.04399 m,
– minimum displacement 0.00237 m,
– median 0.02014 m.

When comparing the average values, it was found that the value of the Student t-test is greater than tcr (at f – 2, tcr – 2.228, significance level $p \leq 0.05$), therefore, these differences are statistically significant. At the same time, deviations from the recommended values along the horizontal axis were established: displacement – 0.01257 m.

Another risk factor during a shelter stay is the decrease in air quality. The CO_2 content in the shelters was measured. The maximum concentration of CO_2 in these rooms was 0.5±0.01% (after the lesson sessions), and it was found to be doubled after the lessons.

It should be noted that in addition to the full-scale war on the territory of our country, in accordance with the Resolution of the Cabinet of Ministers of Ukraine No. 928 dated August 19, 2022, quarantine restrictions were in effect due to COVID-19 until June 30, 2023 [15], which required certain approaches to ensuring an anti-epidemic regime and an appropriate level of air quality in educational institutions. However, the aforementioned and related documents also do not clearly indicate the mechanisms for controlling air quality in shelters in general and shelters of educational institutions in particular.

According to the Sanitary Regulations, all premises and equipment of an educational institution are subject to daily wet cleaning, including window sills, floors, heating devices (or protective grilles), furniture, and blackboards. Wet cleaning of educational and educational-production premises is carried out after the end of the last lesson, or after each training shift (in the case of organizing shift training in an educational institution), sports halls – after each training session and after the end of training sessions and section sessions [16].

The regulations, in turn, do not specify requirements for cleaning in shelter rooms/shelters of these educational institutions.

It should be noted that the quality of cleaning in shelters is extremely important because the number of people per unit area of the room has increased, and the volume of air per person, on the contrary, has decreased. Poor ventilation and poor-quality cleaning can lead to an increase in the concentration of pathogenic microorganisms in the air of these rooms in the event of an insufficient concentration of active chlorine in the disinfectant, and as a result, cause an increase in the risk of infection of children and adolescents during their stay in the shelter of an educational institution, or cause irritation of the respiratory

ISSN 2786-6661
eISSN 2786-667X

tract, the occurrence of allergic reactions and exacerbation of existing chronic diseases due to an increase in its concentration above the recommended levels of use.

An analysis of the market of disinfectants permitted for use in educational institutions was conducted. Disinfectants that have passed state registration in accordance with the requirements of the Resolution of the Cabinet of Ministers of Ukraine dated August 15, 2023, No. 863 «On Approval of the Regulations on State Registration of Disinfectants» are used for disinfection [17]. The register of these disinfectants and antiseptics is posted on the official website of the Ministry of Health for free access, including 2,122 disinfectants. However, in accordance with the column «object of application», 96 such products are allowed to be used in educational institutions [18].

The frequency of disinfectant use is carried out per the instructions for using these products. The effectiveness of use is assessed by the concentration of active chlorine in the working solution with which surfaces are treated. The active chlorine concentration in the solution during cleaning during the quarantine period should be within 0.015/0.06%, considering the aetiology of infectious diseases (intestinal and droplet infections/tuberculosis). The personnel involved in preparing working solutions strictly followed the instructions for preparing these solutions. Working solutions of the product were prepared in enameled (without damaging the enamel), glass or plastic containers by dissolving the appropriate amount of the product in drinking water at room temperature.

The content of active chlorine in the selected 10 samples of working solutions was: No. 1 – 0.01 mg/l; No. 2 – 0.011 mg/l; No. 3 – 0.01 mg/l; No. 4 – 0.01 mg/l; No. 5 – 0.01 mg/l; No. 6 – 0.013 mg/l; No. 7 – 0.01 mg/l; No. 8 – 0.01 mg/l; No. 9 – 0.014 mg/l; No. 10 – 0.01 mg/l.

X – 0.0108 mg/l, $\tilde{X}$ – 0.01 mg/l, minimum – 0.01 mg/l, maximum – 0.014 mg/l.

The detected indicators established reduced concentrations of active chlorine in working solutions of disinfectants, which indicated a discrepancy in the concentration of active chlorine in the original product.

This situation is a risk factor for worsening epidemic indicators among children of educational institutions since there is no clearly prescribed mechanism for controlling cleaning in shelter facilities. For example, the Sanitary Regulations state that premises are cleaned with open transoms (windows), which is technically impossible in a shelter facility.

The measurements of illumination levels revealed that the average illumination level in room #1 was 328.57±1.99 lux, and in room #2 it was 327.14±1.68 lux.

The noise level in the absence of children was, on average, in room #1 – 21.29±1.11 dB, in room #2 – 21.14±1.07 dB. With the generator running outside in room #1 – 42.26±1.01 dB, in room #2 – 43.13±1.26 dB.

Conclusions

The studied physical and chemical factors of the educational environment are important components for ensuring a healthy educational environment and an effective educational process. Appropriate assessment and management of the levels of physical and chemical factors in school shelter facilities are key to ensuring the quality of education and children's health in the educational process.

The results of the hygienic assessment of children's stay conditions in shelters indicate several important aspects. The standard illumination level met the requirements and even exceeded them, which is a positive factor for children's learning. After all, in turn, under normal lighting conditions, according to the requirements of the State Sanitary and Epidemiological Service, the illumination level should be at least 300 lux, while in the rooms, this indicator was higher.

However, the noise level exceeded hygienic standards, especially during the operation of the power-generating equipment, which can negatively affect the health and concentration of children. The obtained noise levels did not comply with the hygienic standards of the State Sanitary and Epidemiological Service when the power-generating equipment is operating (the normative value should not exceed 40 dB).

Gaps in the legislative field were identified regarding the standardization of local vibration

ISSN 2786-6661
eISSN 2786-667X

parameters for children in educational institutions in peacetime and wartime in particular. During measurements using modern mobile equipment, it was possible to establish unsatisfactory parameters of local vibration that occurred at children's workplaces while performing written tasks. If implemented, such a convenient mechanism for monitoring local vibration levels at their workplaces will allow timely interventional preventive measures to improve the condition of educational furniture in shelter rooms and common classrooms.

The maximum allowable concentration (MAC) of CO_2 did not meet the recommended values for general-purpose premises (within 0.07-0.1%), as it increased after classes, exceeding the recommended values for general-purpose premises. This may affect the health of schoolchildren and impair their attention during study.

After statistical processing of the data, it was found that the values of the Student t-test were greater than tkr (at f – 2, tkr – 4.303), due to which it can be concluded that the obtained data are statistically significant (significance level $p \leq 0.05$).

The study confirms that a properly designed and rationally used shelter only positively affects schoolchildren, increasing their productivity and safety during classes and reducing fatigue and injuries.

However, in our case, an increase in noise levels was detected (by its characteristics, it was constant – noise, the sound level of which changes in time by no more than five dBA when measured with a sound level meter on the «slow» time characteristic and the «A» frequency characteristic); and a fivefold increase in CO_2 content after the classes.

Appropriate measurements of noise and CO_2 levels showed only partial suitability of the sheltered areas for the long-term stay of children. Given the availability of opportunities to improve hygienic conditions for children, attention should be paid to installing exhaust equipment and noise insulation measures.

Therefore, compliance with all norms and requirements for shelters in educational institutions will protect and preserve the lives of children in war conditions and positively impact their health during the educational process.

Financing

The current study was performed without financing.

Conflict of interests

The authors have no conflict of interest to declare.

Consent to publication

The authors have read and approved the final version of the manuscript. The authors agreed to publish this manuscript.

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A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of the article

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Комплексна гігієнічна оцінка умов перебування учнів у приміщеннях-укриттях закладу загальної середньої освіти

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Анотація: *у зв'язку із початком повномасштабної війни країни-агресора проти України, перебування в укриттях та бомбосховищах стало, на жаль, невід'ємною складовою нашого життя. Саме тому дуже важливо, щоб відведені для цих потреб приміщення відповідали*

ISSN 2786-6661
eISSN 2786-667X

мінімальним гігієнічним вимогам, особливо, коли мова йде про навчальні заклади і стан здоров'я учнів. Було проведено вимірювання та оцінено фізичні і хімічні параметри середовища типового укриття закладу загальної середньої освіти (освітлення, шум, вібрація, якість повітря). Методи дослідження, використані в нашій роботі, – описовий, контент-аналізу, інструментальний, натурного гігієнічного експерименту, санітарної експертизи, світлотехнічний, хімічний, статистичний. Досліджені фізичні і хімічні фактори освітнього середовища є важливими компонентами для забезпечення здорового навчального середовища та ефективного освітнього процесу. Відповідна оцінка та управління рівнями фізичних і хімічних показників у приміщеннях сховищ шкіл є ключовими аспектами забезпечення якості освіти та здоров'я учасників навчального процесу. Виявлені законодавчі аспекти, які потребують заходів поліпшення та корегування (intervention and correction). Було встановлено прогалини в законодавчому полі щодо нормування параметрів локальної вібрації для учнів в освітніх закладах як в умовах мирного часу загалом, так і воєнного часу зокрема. Під час вимірювань із застосуванням сучасних мобільних засобів вдалось встановити незадовільні параметри локальної вібрації, що виникала на робочих місцях учнів під час виконання письмових завдань. Такий зручний механізм контролю рівнів локальної вібрації на своїх робочих місцях за його впровадження дозволить вчасно проводити інтервенційні профілактичні заходи поліпшення стану улаштування навчальних меблів не тільки у сховищах, а і у загальних приміщеннях навчальних класів. Встановлені показники, які мали відхилення від рекомендованих значень, що може негативно позначитись на стані здоров'я учнів і персоналу закладів загальної середньої освіти. Рівень шуму перевищував гігієнічні норми, особливо під час роботи електрогенеруючого обладнання, що може негативно впливати на здоров'я та концентрацію учнів. Отримані показники шуму не відповідали гігієнічним нормативам ДСанПіну за умови роботи електрогенеруючого обладнання (нормативне значення не повинно перевищувати 40 дБ). Гранично допустима концентрація (ГДК) CO2 не відповідала рекомендованим значенням для приміщень загального призначення (в межах до 0,07-0,1%), так як підвищувалась після проведення занять, перевищуючи рекомендовані значення для приміщень загального призначення. Це може вплинути на стан здоров'я школярів та погіршити їх увагу під час навчання.

Ключові слова: робочі місця, діти, вібрація, діоксид карбону, дезінфектанти, медико-санітарні нормативи, громадське здоров'я.