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A Study on Chemicals Used in Hospitals and their Effects

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Abstract

Hospitals are not only institutions where healthcare services are provided, but also professional working environments where numerous chemical substances are used intensively and systematically. These chemicals are indispensable elements for the effective and safe provision of essential healthcare services such as cleaning, disinfection, sterilisation, diagnosis and treatment. Various chemical compounds, such as antiseptics, disinfectants, sterilisation agents, laboratory reagents, medicines, and medical imaging agents, are used daily to ensure the continuity of hospital functions. However, failure to take the necessary precautions when using these chemicals, and lack of sufficient information and awareness, can lead to serious acute and chronic health problems for healthcare workers, patients and visitors. Effects that may develop due to chemicals include respiratory tract disorders, skin irritation, eye damage, allergic reactions and, in the long term, carcinogenic effects. Furthermore, failure to properly dispose of these substances in environmental waste management processes can cause water, soil and air pollution, leading to irreparable damage to the ecosystem. In this context, it is crucial to evaluate these chemicals not only in terms of their functional aspects but also in terms of their potential effects on human health and the environment. The primary objective of this study is to scientifically examine the chemical substances commonly used in hospital environments, their areas of application, their potential effects on human health, and their environmental dimensions. Furthermore, the objectives of the study include developing a chemical safety culture, reducing exposure risks for healthcare personnel, and contributing to the implementation of sustainable environmental policies.

INTRODUCTION

Ensuring hygiene standards, preventing infections, and guaranteeing patient safety in modern healthcare necessitates the regular, conscious, and controlled use of various chemical substances. In healthcare facilities in particular, a wide variety of chemical substances are routinely used, including surface disinfectants, antiseptics, sterilisation agents, laboratory reagents, pharmaceutical products, and radiopharmaceutical compounds^[1]. These substances play a critical role in controlling hospital infections, maintaining the sterility of surgical areas, and ensuring the reliable execution of diagnostic and treatment processes.

However, the improper use of these chemicals or inadequate personal protective measures can pose serious risks to healthcare workers, patients and visitors. These risks include short-term effects such as respiratory tract irritation, dermatological reactions, and eye damage due to acute toxicity, as well as neurotoxic, hepatotoxic, or carcinogenic effects that may develop as a result of long-term exposure. Furthermore, the disposal of these chemicals into the environment or their improper disposal can have irreversible effects on the ecosystem.

In this context, the main objective of the study is to identify the main chemicals commonly used in hospital environments, evaluate their potential effects on health and the environment in light of scientific data, and provide practical recommendations for their safe use. To this end, chemicals will be classified according to their areas of use, their toxicological profiles will be examined, and assessments will be made within the framework of national and international guidelines on safe working practices.

MATERIALS AND METHODS

Primary Chemical Substances Used in Hospitals

Cleaning and Disinfection Chemicals: Various cleaning and disinfection chemicals are used effectively in hospital environments to ensure infection control and prevent cross-contamination. Among these substances, sodium hypochlorite, glutaraldehyde, phenolic compounds, quaternary ammonium compounds, and alcohol-based disinfectants are widely preferred due to their strong antimicrobial properties^[2].

Sodium hypochlorite is particularly effective in surface disinfection and exhibits strong oxidising properties against a broad spectrum of microorganisms. However, when used at high concentrations, it can cause skin burns, respiratory tract irritation and mucosal irritation. Glutaraldehyde is used for high-level disinfection of semi-critical medical devices such as endoscopes; however,

exposure may cause effects such as headaches, bronchial irritation, and allergic dermatitis. Phenolic compounds are preferred for cleaning environmental surfaces due to their bactericidal and fungicidal effects; however, their use is not recommended, particularly in paediatric and neonatal wards, as their toxic effects may increase. Quaternary ammonium compounds exhibit both detergent and disinfectant properties, creating damaging effects on microorganism cell membranes; however, prolonged contact may cause skin dryness and allergic reactions. Alcohol-based disinfectants are widely used for hand antisepsis due to their rapid action and ease of use. With ingredients such as ethanol and isopropanol, they are effective against bacteria, viruses, and some fungi; however, frequent use can weaken the skin barrier, causing dryness and cracking.

All these chemicals are effective and safe when used at appropriate concentrations, in accordance with the manufacturer's instructions, and with adequate ventilation. However, if personal protective equipment (gloves, masks, goggles, etc.) is not used or is used inadequately, these substances pose serious occupational risks to healthcare workers. Therefore, in cleaning and disinfection practices, not only effectiveness but also the potential effects on human health and the environment must be considered; the safe use of these chemicals must be ensured through trained personnel and controlled use systems.

Sterilisation Agents: Sterilisation is a critical process in hospitals for preventing infections and ensuring patient safety. Chemical sterilisers are preferred for sterilising heat- and moisture-sensitive medical devices, particularly when physical methods (autoclave, dry heat steriliser, etc.) are not suitable. The most commonly used chemical agents for this purpose are ethylene oxide (EtO) and formaldehyde.

Ethylene oxide is frequently used in the sterilisation of medical equipment containing plastic, electronic or optical components due to its effectiveness at low temperatures. This gas, which has a broad antimicrobial spectrum, is extremely effective in eliminating bacteria, viruses, spores and fungi. However, from a toxicological perspective, ethylene oxide is a compound with carcinogenic, mutagenic, and reproductive toxic properties. Prolonged exposure may result in headaches, nausea, respiratory distress, and depressant effects on the nervous system. Furthermore, it has been classified as a Group 1 carcinogen by the International Agency for Research on Cancer (IARC)^[3].

Similarly, formaldehyde is a powerful disinfectant and fixative agent used in low-temperature sterilisation, and is particularly

preferred in laboratories and some non-autoclave sterilisation processes. However, formaldehyde is also an extremely hazardous chemical in terms of human health. Inhalation or skin contact can cause acute effects such as eye, nose and throat irritation, asthmatic symptoms and contact dermatitis, while long-term exposure increases the risk of nasopharyngeal cancer. For this reason, formaldehyde has been classified as a Group 1 carcinogen by the IARC^[3].

Laboratory Chemicals: Laboratory units in hospitals are important areas where diagnostic and research processes are carried out, and a wide variety of chemical substances are used intensively in these environments. Chemicals such as acids, bases, organic solvents (e.g. methanol, ethanol, acetone) and dyes (e.g. methylene blue, eosin) form the basic components of laboratory procedures. These substances are often toxic, corrosive, volatile, and in some cases, fire-hazardous compounds^[4].

Acids (e.g. sulphuric, nitric and hydrochloric acid) and bases (e.g. sodium hydroxide, potassium hydroxide) can cause serious chemical burns on contact with the skin and eyes, and mucosal irritation and lung damage if inhaled, due to their strong corrosive properties. Organic solvents, due to their lipophilic nature, are rapidly absorbed through the skin and can cause symptoms such as central nervous system depression, dizziness, nausea, and confusion. Certain solvents, such as methanol, are neurotoxic even at low doses and can cause optic nerve damage and blindness. Although ethanol has lower toxicity, prolonged and intense exposure can cause systemic effects such as liver damage.

Paints and painting agents used in laboratories may also be toxic and potentially carcinogenic. For example, fixatives containing formalin and certain aromatic amine derivatives are compounds classified as carcinogens.

Pharmaceutical and Radiopharmaceutical Substances: Pharmaceutical and radiopharmaceutical substances used in hospital settings play an indispensable role in the diagnosis and treatment processes of patients, particularly in oncology, haematology, and nuclear medicine units. In this context, cytotoxic drugs and radiopharmaceuticals, which are prominent in this field, carry potential risks that can harm not only target cells but also healthcare workers in the event of misuse or inadequate protection, due to their high biological activity (National Institute for Occupational Safety and Health^[5]).

Radiopharmaceuticals are compounds containing radioactive isotopes that are generally

used for diagnostic purposes (e.g. PET, SPECT imaging) or therapeutic purposes (e.g. radionuclide therapies). These substances affect target cells by emitting ionising radiation, and exposure can cause effects such as DNA damage, immunosuppression, and bone marrow suppression. Furthermore, due to the cumulative effect of radiation, increased exposure over time poses a serious occupational health risk for healthcare workers. Therefore, personnel working with radiopharmaceuticals must meticulously implement practices such as continuous dose monitoring with dosimeters, the use of lead-lined protective equipment, and the disposal of radioactive waste in accordance with specific protocols.

Waste Management and Emergency Preparedness: Waste generated in environments where cytotoxic and radiopharmaceutical agents are used requires special treatment, unlike ordinary medical waste. Such waste poses risks to the environment and public health. Therefore, very strict standards must be applied during waste classification, labelling, temporary storage, and disposal by authorised companies.

Steps to be taken:

- All waste must be collected in leak-proof containers marked with the UN symbol.
- Waste bags should be separated according to colour codes (e.g. purple bag-cytotoxic waste)
- Spill kits should be kept ready in case of spills
- Emergency protocols and eye wash/shower stations should be actively used
- Personnel should know what to do in case of spills or contamination

RESULTS AND DISCUSSIONS

Effects of Chemicals on Human Health: Chemicals used in hospitals are an integral part of healthcare services, but they also pose significant health risks to staff and patients. These risks vary depending on variables such as the type of chemical used, the concentration level of exposure, the duration of exposure, the route of exposure (inhalation, dermal, oral), and individual factors (age, underlying diseases, genetic predisposition)^[5,6].

Acute exposures usually occur through brief contact with high concentrations of chemicals and may present with the following symptoms:

- Skin irritation and dermatitis
- Mucosal burning sensation
- Watery eyes, redness, burning
- Headache, dizziness and nausea
- Respiratory tract irritation and bronchospasm

In particular, volatile and reactive substances such as disinfectants, solvents and sterilisation agents pose a high risk of acute effects. Although such symptoms are often mild and reversible, repeated exposure can lead to permanent damage.

Chronic exposures, on the other hand, arise from prolonged and continuous contact with lower concentrations. This situation poses serious health threats that hospital staff may encounter throughout their professional careers. In this context, the main effects reported are as follows:

- **Hepatotoxicity:** Organic solvents (e.g. chloroform, carbon tetrachloride) in particular can cause cellular damage by increasing liver enzyme levels.
- **Nephrotoxicity:** Ammonia, iodine compounds and certain antibacterial agents are known to impair kidney function.
- **Neurotoxicity:** Prolonged exposure to solvents can have adverse effects on the nervous system, causing conditions such as impaired concentration, memory problems and peripheral neuropathy.
- **Reproductive toxicity:** Exposure to cytotoxic drugs or chemicals with endocrine-disrupting properties has been linked to infertility, foetal development disorders, and miscarriage risk.
- **Carcinogenicity:** Formaldehyde, ethylene oxide, and certain paint and solvent components are classified as carcinogenic to humans (Group 1) by the IARC. Long-term exposure has been associated with haematological cancers and respiratory system neoplasms in particular.

Safe Use and Preventive Approaches: Ensuring chemical safety in hospital environments is of critical importance in terms of both protecting staff health and ensuring patient safety. Accordingly, multifaceted and systematic approaches should be adopted for effective and sustainable chemical risk management.

Firstly, comprehensive training programmes must be implemented on a regular basis. These training sessions should focus on the potential hazards of chemicals, safe usage procedures, emergency response techniques, and the correct selection and use of personal protective equipment (PPE). Periodically updating training in line with current legislation and best practices ensures that employees maintain a high level of knowledge and awareness.

The use of Personal Protective Equipment (PPE) is a fundamental measure in minimising exposure risks. The selection of equipment such as gloves, masks, goggles, aprons and respiratory devices should be based on the properties of the chemical

being used, and appropriate hygiene conditions should be maintained during use. Furthermore, it is important that PPE is comfortable and ergonomic for workers to ensure continuous use.

The proper labelling of chemicals and ensuring access to Safety Data Sheets (SDS) informs employees about the chemical's hazard potential and the measures to be taken in emergencies. The easy accessibility and comprehensibility of SDSs increases effectiveness in risk management.

Equipping hospital environments with effective ventilation systems also reduces respiratory exposure by preventing the accumulation of chemical vapours and particles. Technologies such as negative pressure systems, local exhausts and high-efficiency particulate air (HEPA) filters should be used, particularly in sterilisation and laboratory areas.

The disposal of chemical waste in accordance with relevant national and international environmental and health regulations is essential for preventing environmental pollution and, consequently, indirect risks to human health. Containers, labels and storage conditions used in waste management must comply with standards, and the collection and transport of waste must be carried out by authorised institutions.

Finally, risk assessment processes must be periodically updated. In these processes, exposure measurements, chemical stocks and usage intensity should be analysed to review the effectiveness of preventive measures. Risk assessments supported by workplace inspections and health monitoring programmes ensure the continuous improvement of chemical safety within hospitals^[7].

This holistic approach both prevents potential accidents in the workplace and contributes to minimising chemical-related health problems.

CONCLUSIONS

Recommendations and Future Strategies: Ensuring chemical safety and sustainability in hospital environments requires not only controlling existing risks but also adopting proactive and holistic approaches. In this context, the fundamental strategies that healthcare institutions can implement can be summarised as follows:

Establishment and Operation of Comprehensive Risk Management Systems: To prevent chemical exposure in hospitals, an integrated risk management system must first be established. This system should cover all processes, from the storage and use of chemicals to waste management and emergency response. Risk assessment procedures, exposure measurements, and

health monitoring programmes should be updated regularly based on the data obtained through their implementation. This enables the early detection of potential hazards and the implementation of effective measures.

Continuous and Up-to-Date Training Programmes: The establishment of a chemical safety culture depends on the continuity of training activities. All healthcare workers should be regularly trained on the hazards of chemicals, their safe use, the correct selection of personal protective equipment, and emergency procedures. Training content should be updated in line with national and international regulations and technological innovations, and supported by practical training.

Monitoring and Implementation of Technological Innovations: Technological developments play a critical role in reducing chemical exposure. The widespread use of modern equipment such as closed-system drug transfer devices, automated dosing systems, local exhaust ventilation and biological safety cabinets significantly reduces workers' exposure to chemicals. Furthermore, the preference for innovative and environmentally friendly chemicals should be adopted as a long-term strategy for reducing toxic risks.

Effective Waste Management and Environmental Sustainability: The proper collection, transport and disposal of waste from chemicals used in hospitals is of vital importance for both worker health and environmental protection. In this context, waste management plans that comply with national and international environmental regulations should be prepared and implemented. Furthermore, waste reduction and recycling methods should be explored, and negative impacts on the environment should be minimised in line with sustainability principles.

Multidisciplinary Collaboration and Management

Support: Success in chemical safety is only possible with internal collaboration and strong management support, not just technical measures. Coordination must be ensured between relevant departments (e.g., occupational health and safety, environmental management, clinical departments); management must support the necessary resources and policies. Furthermore, employees should be encouraged to actively participate in suggestion and feedback mechanisms.

Performance Monitoring and Continuous Improvement

Support: Performance indicators should be established and regular audits conducted to measure the effectiveness of the systems put in place. Risk reduction strategies should be revised by analysing data such as exposure limits, accident reports, and training participation rates. Embracing a culture of continuous improvement ensures the advancement of hospital chemical safety and compliance.

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