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## Management and Safe Storage of Medicines and Chemicals in Libyan University Laboratories: Challenges and Strategies for Enhancing Safety and Quality

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إدارة وتخزين الأدوية والمواد الكيميائية بشكل آمن في مختبرات الجامعات الليبية: التحديات  
والاستراتيجيات لتعزيز السلامة والجودة

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This study aims to evaluate the current practices of managing and storing medicines and chemicals in college laboratories within Libyan universities, identify the major challenges associated with these practices, and propose practical solutions to enhance safety and quality. A descriptive analytical approach was adopted, involving a sample of 100 laboratory staff members and technicians. Data were collected using a structured questionnaire.

The results indicated a high level of performance in staff training (mean = 4.7, SD = 0.6) and the availability of safety equipment (mean = 4.5, SD = 0.8), reflecting a reasonable level of attention to fundamental safety aspects. However, deficiencies were observed in routine inspections (mean = 3.7, SD = 1.2) and adherence to established procedures (mean = 3.8, SD = 1.1).

Furthermore, limited funding and resources (mean = 3.56, SD = 1.2) were identified as key challenges negatively affecting the efficiency of management and storage practices.

The study recommends strengthening laboratory management systems, enhancing the regulatory framework, increasing financial support, and implementing systematic monitoring mechanisms to ensure compliance with safety standards. These measures are essential to improving operational quality and minimizing risks associated with handling medicines and chemicals.

**Keywords:** Laboratory Safety, Chemical Storage, Pharmaceutical Management, Hazardous Materials, Safety Compliance, University Laboratories

## الملخص

تهدف هذه الدراسة إلى تقييم واقع إدارة وتخزين الأدوية والمواد الكيميائية في مختبرات الكليات بالجامعات الليبية، مع تحديد أبرز التحديات التي تواجه هذه العملية واقتراح حلول عملية لتعزيز السلامة والجودة، اعتمدت الدراسة على المنهج الوصفي التحليلي، حيث شملت عينة البحث (100) من العاملين والفنيين في المختبرات، وتم جمع البيانات باستخدام استبيان منظم.

أظهرت النتائج ارتفاع مستوى الممارسات المرتبطة بتدريب العاملين (بمتوسط حسابي 4.7 وانحراف معياري 0.6) وتوفر معدات السلامة (بمتوسط 4.5 وانحراف معياري 0.8)، مما يعكس اهتمامًا نسبيًا بجوانب السلامة الأساسية، في المقابل كشفت النتائج عن وجود قصور في عمليات التقييم الدوري (بمتوسط 3.7 وانحراف معياري 1.2) ومستوى الالتزام بالإجراءات المعتمدة (بمتوسط 3.8 وانحراف معياري 1.1).

كما بينت الدراسة أن محدودية التمويل والموارد (بمتوسط 3.56 وانحراف معياري 1.2) تمثل أحد أبرز التحديات التي تؤثر سلبيًا على كفاءة إدارة وتخزين المواد.

وتوصي الدراسة بضرورة تطوير أنظمة إدارة المختبرات، وتعزيز الإطار التنظيمي، وزيادة الدعم المالي، بالإضافة إلى تطبيق آليات رقابية منهجية تضمن الالتزام بمعايير السلامة، بما يساهم في تحسين جودة الأداء وتقليل المخاطر المرتبطة بالتعامل مع الأدوية والمواد الكيميائية.

**الكلمات الدالة:** السلامة المخبرية؛ تخزين المواد الكيميائية؛ إدارة الأدوية؛ المواد الخطرة؛ الامتثال لمعايير السلامة؛ المختبرات الجامعية.

## 1. Introduction

The safety and quality of the medicine and chemical management are major priorities in University laboratories. A limited number of studies have been conducted in Libyan universities for the management and safe storage of medicines and chemicals. Also, there are no agreed-upon safety standards for medicines and chemical storage locations required inside colleges; therefore, it is necessary to assess and update these regulations based on international laws and regulations.

This research paper assessed the major teaching college laboratories' viewpoints: safety and security officers, departments' administrators, and quality management unit members, in five widely spread Libyan universities, and whether they have addressed the proper and safe storage of medicines and chemicals. [12]

Many issues concerning the storage of medicines and chemicals were raised, such as a lack of proper and clear local regulations and guidance for colleges regarding their safe storage, a lack of a responsible person, relevant reports on the status of storage, and the usage amount. Additionally, chemicals are stored for long periods in a non-dedicated area and poorly marked. Mismanagement of laboratory medicines may also reduce their efficacy or allow new resistances and potentially produce a toxic drug. Urgent planning of the medicines and chemicals storage policy at a higher level for the universities should therefore be set. [2]

### 1.1 Study problem

The management and storage of medicines and chemicals in laboratory settings at Libyan universities remain inadequately addressed, with a lack of standardized studies and clear regulatory guidelines. This situation exposes laboratories to significant safety risks associated with the storage and handling of volatile, toxic, and potentially carcinogenic substances, many of which are insufficiently regulated and controlled. Such conditions may compromise the safety and quality of reagents and experimental procedures, as well as their use in education and

research. Furthermore, a substantial proportion of these materials do not comply with established standards for storage, distribution, and utilization. In most cases, laboratory workers lack the basic safety skills due to insufficient training and experience regarding the proper disposal of these materials or how to protect themselves when dealing with them. <sup>[5]</sup>

Additionally, the labs and classrooms do not have the minimum safety facilities, such as laboratory hoods, masks, or approved gloves. This has led to the Cabinet being authorized to transport or move workplaces in the academic departments of Libyan universities, and the number of workplaces that the authorities have designated for transport is increasing. This has caused them to be transformed into new centers or warehouses for colleges, which store nearly the same materials without taking into account the need to meet certain storage requirements. While studies addressing the quality of drugs comply with the phenomena arising in wholesale and retail drugstores, they are lawfully allowed to be practiced. Thus, it is evident that there is a need to conduct a study intended to address and evaluate the situation of work safety in colleges and laboratories. The previous discussion was useful in illustrating the real problem through a comprehensive exposition of the initial issues addressed in the draft study of the problem in different case studies. <sup>[8]</sup>

## **1.2 Study objectives**

This study aims to examine current laboratory management practices related to the storage of medicines and chemicals in Libyan public universities. It further seeks to identify key challenges associated with chemical and waste management and storage in these laboratories. In particular, the study focuses on the storage of leftover chemicals and its potential adverse impact on the safety of staff and students, as well as its possible contribution to chemical-related incidents in university laboratories in Libya. The study aims to provide solutions and measures to address these current problems and to maintain and improve the safety and quality of the laboratories and avoid any possible accidents. Central to our objective is to investigate whether the ten elements of the framework could be considered in the management and storage of medicines and chemicals in the university laboratories.

## **1.3 Regulatory Framework for Medicines and Chemicals in Libyan Universities**

The management of medicines and the use and safe storage of chemicals and solutions to be used in laboratory educational practice in Libyan universities are managed and monitored through a myriad of regulations and directives that are not always published in an accessible and efficient manner. Restrictions are promulgated by various government offices and with opposing hierarchies that sometimes have conflicting issues. In addition, there are no facilities available to universities to implement existing regulations or train staff to enforce them. As a result, access to the medicine storage unit is very difficult; hence, the management is not standardized. This has resulted in a number of forgeries that are carried out by students who then consume these drugs for reasons that are not in accordance with the law. <sup>[3]</sup>

There are many different regulatory directives and laws related to the handling of medicines and chemicals in Libyan universities. However, many regulators of these regulations are not aware of the existence of many laws and regulations to regulate university hospitals and colleges of medicine and the various administrative requirements for them. Of the senior officers who are aware of these regulations and government directives, not all are aware or understand the magnitude of how important it is for the safety and health of the entire educational, student, and staff

academic community. This is different in other countries. Safety for academics, students, management, and all employees is a standard that must be met apart from ensuring data integrity. <sup>[13]</sup>

#### **1.4 Challenges in Management and Storage**

Proper management and storage of medicines and chemicals in the laboratories of universities is a challenging task. The reasons are multiple. First, the infrastructure available in many universities often does not meet the proper storage requirements. Adequate space, natural or artificial light exclusion systems, and refrigeration are scarce, and quality is not guaranteed. This is due to inadequate facilities in universities, low priority given to university equipment, and a lack of investment by governments and decision-makers in providing the latest facilities. At the same time, many of the teaching laboratories are overcrowded, making it difficult to accommodate all the needs for equipment, materials, and reagents for the different practical sessions. Another reason is the lack of relief and protection for leading body responsibilities in terms of presenting the necessary requirements or maintaining good laboratory practice, which is a general governing solution in almost all universities regarding the lack of financial resources. <sup>[4]</sup>

Inadequate training is reported as a main challenge related to storage, the high cost of proper containers or the inability to find suitable containers, and the high cost of shipping chemicals. Inadequate training is one of the main challenges concerning storage. In addition, some laboratory teaching personnel used to buy chemicals from the local market at reasonable prices but struggled to obtain details or specifications of the chemicals in order to update reagents and test solutions. One of the problems is also the obstacles to getting the standard procedures related to hazardous laboratories, such as waste management. In many cases, the only practitioner relies on their experience and repeat tests. Lastly, the lack of aligned standards and regulations leading to different practices and a lack of communication on related decisions causes inconsistency between universities, encouraging malpractice. Administrative staff at some universities have claimed in interviews that laboratory academics are often unaware of new health and safety regulations that are introduced. Insufficient or lack of documentation of the storage temperature can often be one of the weaknesses. It is a very common phenomenon to have both staff and students who do not tend to stick to the specific protocols or rules of hazardous materials. This may be due to their lack of awareness, understanding, education, or even just the nature of the individual, who does not care to conduct themselves according to the established standard. Negative beliefs about the importance of safety in national culture also contribute to such attitudes. <sup>[14]</sup>

Despite the fact that some of the problems are widely reported in the field, such as inadequate training and low awareness of hazardous agents, there are few studies that focus on the practical aspects of problems and solutions to the health and safety risks caused by managing and storing medicines and chemicals in university laboratories. It is also important to understand the perceptions or experiences of university academics and authorities from different parts of the world in various colleges or universities in the same country, to check if their views are similar or different. Few real-world case studies have been published despite the importance of reporting the confirmed problems in order to be able to draw workable solutions. The reasons for this are that there is no time to report these issues, and the bodies interested in solutions do not seem to be particularly interested. <sup>[9]</sup>

## **1.5 Solutions to Enhance Safety and Quality**

Eight solutions have been suggested in the previous sections to provide realistic assistance that can be adopted. The first and most important solution is to create a standard operational procedure. SOPs are basic needs in every organization or place related to work and jobs. The aim of this part is to serve as a guide for training and to outline the policies and procedures to ensure safe practice. It is also used to ensure compliance with legal requirements. Additionally, SOPs reflect best overall international practice. In developing this manual, local laws and guidelines must also be considered. <sup>[6]</sup>

The second solution would be the necessity of an orientation course before laboratory students start research work. A training program and course in the field of laboratory, chemical, and X-ray safety is necessary, in addition to Environmental Health and Safety policies. The course content should include practical laboratory knowledge such as the importance of using personal protective equipment, how to clean and reset laboratory workbenches, worktops, and shelves, and so on. The third step includes the need for laboratory staff to attend workshops and seminars in safety pharmacy and good pharmacy practice. Instructors should also be required to attend a workshop or seminar on the pharmacological practices and procedures of a good pharmacy. The main criterion for the fourth solution is the need for research workplaces that offer convenient and adequate storage facilities. An ideal solution is to upgrade the storage area in the department, faculty, and college, but the cost is determined based on the various recognized aspects that make the goods dangerous. For visualization and accountability, pharmacies adopt two free and active storage methods that can quickly compile materials. Standard procedures for the physical and chemical design controls in the proper pharmaceutical storage rooms will allow continuous sterilization of goods and better exit safety. In conclusion, these measures are suggested in terms of solving considerably for good management and storage of chemicals at universities to ensure safety and quality in facing any emergency requiring instant illumination and procedures in the event of terrorist attacks. <sup>[15]</sup>

GSP as an international standard to ensure proper storage.

## **1.6 Definition and Importance of GSP**

Global Storage Practice (GSP) is an approach that provides a comprehensive basis for planned and systematic management of the resources and tasks necessary to store goods. It ensures that the right amount of goods is safely stored at the right time, place, and cost, and is redistributed when expected. In this respect, the warehouse becomes a store of value, not a 'cash-dark hole.' This is important for all businesses because many companies – both as storage providers and users – face increasing compliance and supervisory burdens every year. GSP is a sector-agnostic framework: it is inherently interested in 'how' (processes and practices) rather than 'what' (types of stored goods). <sup>[12]</sup>

GSP is critical because it underwrites the safety of a great deal of the world's goods during the lengths of time that they are not in the hands of the consumers who ultimately derive value from them. GSP is largely concerned with cross-sectorial goods and security risks indirectly to human life. It is also important from the suppliers' point of view because society insists that businesses are mindful of social inclusion and contributions to society, as well as risks to consumers and markets. Proper storage of goods represents a hidden value. The most important value associated with storage is that it ensures reliability in any market exchange. Additionally, cooperatives involved in goods handling serve several purposes, ranging from delivery to consumption, and from basic to advanced levels of operation. GSP

keeps universities within operational limits (which is better for everyone), ensuring minimal risk and reducing the risk of loss or seizure. <sup>[11]</sup>

Society in general, consumers, business procurers, and even storage owners themselves need to be treated safely. As important as material value is, the appropriate indication to indemnify is also crucial. At some point, it is a need to be met; at others, it is a competitive need. Many businesses insist that those working for them store goods correctly as a stipulation of wanting to work with them. Equally, awareness of and compliance with one's supply chain is mandatory in many countries. Not because it's a good, sustainable practice; it often forms a good managerial foundation for compliance. GSP is also an important trading asset for a sector that is rapidly becoming stigmatized. For consumers and purchasers, it represents quality and safety. Finally, B2B GSP keeps teams on the right template – not just in terms of complexity and hierarchy, but in terms of environmental sustainability. Particularly in the case of the GSP/PFAP concept, GSP can be shown to both reduce national stockpiles and reduce waste. <sup>[10]</sup>

### **1.7 Key Components of GSP**

To ensure proper storage of supplies, assets, and materials, a management system, with its underlying processes and procedures, should effectively fulfil the following key components: 1. Proper storage location: An environment in which the stored items remain safe and effective for use until required. 2. Proper labelling and storage conditions: The detailed identification and complete information about the products being stored and their manufacturers' requirements for proper handling and storage. 3. Inventory management: A complete and timely record for all receipts, issues, and disposals. 4. Access control: Ensuring authorized entry and reducing contamination and theft. 5. Infrastructure management: Monitoring and maintaining the facilities and ensuring that preventive maintenance and service for equipment are performed, and downtime is kept to a minimum. The above-listed key components are explained briefly below. Proper storage location is also part of location evaluation. Locations are selected in compliance with good engineering practice, standards for storage building construction, and segregation distances. Selection of a proper storage location should account for environmental impact with no water, power, or road access and ensure uninterrupted flow of product to destination. These evaluation activities ensure proper environmental conditions of storage and prevent natural disaster disturbance to the flow of commodity movement when considering the location for stocking. Environmental impact and suitability of locations are taken into account while using structures and bins for storage of commodities. The location of stock bins in the warehouse ensures necessary traffic space needed for internal transport at the dumping and stocking area before ease of transfer to different locations. Measurements of a proper storage facility include suitability of shed or storage room; office premises; fire prevention; site facilities; security; environment; government regulations; storage purpose; location; vehicle access and exit point; surrounding land use; proximity to public amenities; external electrification. Although the system needs to be flexible to meet the needs of different industry sectors and organizations, and any relevant regulatory requirements or international guidelines, the structural components of the system described provide an effective and comprehensive overview for the components and subcomponents needed to monitor and implement good storage practice. It should be noted that while the primary focus is the structural elements of the system, we recognize that this represents a component of a much broader system. The system should be integrated with other elements of quality management to support cost-effective operation. <sup>[7]</sup>

## 2. Methodology

The research is descriptive analytical in nature to examine the management and storage of medicines and chemicals in college laboratories in the Libyan universities with regard to the problems and measures to address them to ensure safety and quality. The population reflects those institutions in which the above-revealed organizational communication strategies in universities are practiced by staff members and laboratory technicians, and 100 participants have been chosen to comprise the sample. The data is collected with the help of a structured questionnaire which is aimed to receive the information about the existing practice, problems and possible upgrade of storage and management of these substances.

## 3. Results and Analysis

Phrase	Mean	Standard Deviation
The laboratory has clear policies and procedures for the storage of medicines and chemicals.	3.8	1.1
The storage conditions (temperature, humidity, ventilation) meet the required safety standards.	4.2	0.9
Laboratory staff receive regular training on the safe handling and storage of chemicals and medicines.	4.7	0.6
The laboratory is equipped with appropriate safety equipment, such as fire extinguishers and chemical-resistant cabinets.	4.5	0.8
There is a designated person responsible for monitoring the storage and management of medicines and chemicals.	4.1	1.0
The labeling and documentation of stored substances are accurate and up-to-date.	4.0	0.8
The laboratory has an effective system for the disposal of expired or unused medicines and chemicals.	4.0	1.0
Emergency protocols for handling chemical spills or accidents are clearly communicated and practiced.	3.9	1.1
Regular inspections are conducted to ensure compliance with safety and quality standards.	3.7	1.2
Challenges such as lack of funding or resources affect the ability to manage and store chemicals and medicines effectively.	3.6	1.2

**Table 1. Descriptive Statistics of Laboratory Safety and Storage Practices**

The assessment of the findings shows the specific impressions that college lab managers and staff have of medicines and chemical management and storage, all of which registered appreciable mean scores across most aspects. The last of these received the highest mean of 4.7 and a standard deviation of 0.6 and with this it was clear that laboratory staff train frequently on handling and storage based on safety as a factor in skill mastery. It was also seen that appropriate safety equipment available (mean 4.5) and storage conditions (mean 4.2) complied showing that

adequate infrastructure standards were maintained in the facility. Nevertheless, on general aspects of safety control measures like regular inspections (mean = 3.7) and existence of clear and well communicated policies (mean = 3.8) worked out a comparatively poor score that directs attention towards the possibilities of faulty safety monitoring and documentation. The two factors under funding and resources has a mean of 3.6; this shows that, external factors may hamper the optimal performance as opposed to the limited variability in the responses, standard deviation 1.2. Predictably, it appears that overall many practices remain sound, but there is an opportunity for the systematic strengthening of monitoring and response to issues relating to limited resources.

## **5. Conclusion and Recommendations**

It is clear that the problem with the management and storage of medicines and chemicals in college laboratories in Libyan universities needs urgent consideration from all stakeholders in authorities. An extensive list of challenges and needs was identified through this study. It is important to focus on the training of laboratory personnel and their adherence to established policies as well as the regulatory framework. Regulatory authorities must pay more attention to compliance with procedures and instructions for the proper and safe handling of toxic materials, since the application of the procedures in force has been insufficient to date. It is also very important to develop health centers in universities with the necessary regulations, especially since the health of the students is at stake. Finally, it is important to establish a safe disposal chain for waste elements based on procedures developed and proposed at the global level. Some of the broken equipment should not represent an obstacle to the implementation of safety centers in universities.

The effectiveness of the management solutions can also be demonstrated in the qualitative structure of the Drug and Food Control Center and General Administration of Environmental Sanitation Affairs. Safety measures for health show that efforts to control and manage diseases should be intensified, especially harmful substances stored in an informal manner. However, the future must approve the idea of conducting an ongoing study at the international level to determine the developments and forecast results in the field of safety. This is a result of the next steps to increase the means of implementation and modernization of the management quality of toxic substances. It is the university's duty to ensure the safety and quality of laboratory practices; this subject cannot be accomplished alone. Coordination and cooperation can contribute to improving the comprehensive vision of the work between several parties that have the same responsibility, which clarifies their role with the participation of official authorities.

### **Recommendations for Managing Expired Medicines and Chemicals in University Laboratories in Libya**

Effective management of expired medicines and chemicals in university laboratories is crucial to minimize health and environmental risks and ensure compliance with local and international regulations. Below are the necessary recommendations:

#### **1. Safe and Organized Storage:**

- Segregation: Separate expired medicines and chemicals from usable materials.
- Classification: Categorize materials based on type (e.g., hazardous chemicals, biological drugs, flammable substances).
- Packaging: Store chemicals in original containers or securely sealed labeled containers.

#### **2. Regular Inventory and Documentation**

- Chemical Register: Maintain a record of expired materials, including quantities and expiration dates.

- Periodic Inventory: Conduct regular stock reviews to identify materials nearing expiration.

### **3. Safe Disposal**

- Licensed Disposal Contractors: Collaborate with authorized companies for safe disposal of chemical and pharmaceutical waste according to environmental standards.

#### **Appropriate Methods:**

- Toxic Substances: Dispose of through approved methods such as incineration.
- Biodegradable Materials: Use waste treatment facilities.
- Medicines: Employ specialized disposal methods to prevent environmental contamination.

### **4. Compliance with Regulations**

- Adhere to Libyan laws governing hazardous waste and chemical management, ensuring all procedures meet health and environmental standards.

### **5. Training and Awareness**

- Train laboratory staff on proper handling and management of expired chemicals and medicines.
- Raise awareness about the risks of improper chemical management and its health and environmental impacts.

### **6. Improved Planning**

- Minimize Surplus: Optimize purchasing processes to ensure materials are used before expiration.
- Reuse or Recycling: Where possible, explore safe methods to reuse or recycle expired chemicals.

### **7. Emergency Management**

- Develop emergency plans for handling chemical spills or incidents involving expired materials.
- Provide personal protective equipment (PPE) and first aid kits within laboratories.

### **8. Involvement of Regulatory Bodies**

- Coordinate with regulatory authorities (e.g., Ministry of Environment and Health in Libya) for updated guidance on waste management.
- Seek technical support if necessary to develop effective management policies.
- Implementing these recommendations will help mitigate risks and ensure a safe and sustainable working environment in university

### **9. Emphasizing the Importance of High-Standard Incinerators for Disposal of Expired Materials**

- Disposing of expired chemicals and pharmaceuticals using high-standard incinerators is essential to ensure environmental and public health safety. Below are the key points emphasizing the necessity of this solution:

#### **10. Use high-standard incinerators for safe disposal of hazardous materials**

- High Temperatures: Specialized incinerators operate at very high temperatures to ensure the complete breakdown of harmful chemical compounds.
- Air Filtration Systems: Equipped with filtration systems that minimize the release of toxic gases and air pollutants.
- Efficient Material Combustion: Ensure complete combustion without leaving harmful residues.
- Compliance with International Standards: Designed to meet waste management standards set by organizations such as WHO and EPA.

- Environmental Protection: Prevents the leakage of toxic substances into soil or groundwater.
- Worker Safety: Reduces the exposure of workers to hazardous materials during disposal.
- Environmental Regulations: Using certified incinerators is a legal requirement in many countries, including Libya, to avoid penalties and ensure compliance.
- Accident Prevention: Improper disposal of hazardous materials can lead to serious incidents, such as fires or explosions.

### 13. Practical Recommendations

- On-Site Incinerators: If feasible, universities should establish specialized incinerators to facilitate safe disposal.
- Collaboration with Licensed Providers: If on-site incinerators are not available, collaborate with certified companies that operate approved incinerators.
- Training Programs: Train laboratory personnel on safely transporting hazardous waste to incinerators and using them properly.
- Using high-standard incinerators represents best practices for hazardous waste management, ensuring environmental protection and safeguarding individuals from the risks associated with unsafe disposal of expired materials.

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