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Risks and Precautions of Asset Management in Chemical Laboratories

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Abstract: Chemical laboratory assets are an indispensable material basis for various scientific research, teaching, and industrial production, and play an important role in the entire process of scientific exploration. With the advancement of the new curriculum reform, the chemistry experiment course puts forward higher requirements for students' experimental ability and comprehensive quality. This article will start with the status quo of fixed asset management in analytical chemistry laboratories, discuss its risks and take corresponding measures to prevent them in order to reduce unnecessary losses. This article established a chemical laboratory asset management risk model and tested the performance of the model. The test results show that the accuracy of the risk identification is higher than 0.89 and can reach a maximum of 0.99, and the time required to identify risks does not exceed 5 seconds. It is hoped that this article will provide reference value and practical significance for relevant workers, and provide constructive suggestions, so that students, teachers and schools can be standardized and reasonable when using chemical instruments.

1. Introduction

The chemical laboratory is an indispensable and important place for scientific research and teaching, and plays an irreplaceable role in daily teaching research, experimental equipment management, and instrumentation. However, in recent years, with the country's increasing investment in education funds and the continuous emergence of various scientific research projects, the problem of school asset shortage has become increasingly serious, restricting the development of colleges and universities. Therefore, strengthening the construction and management of chemical laboratories has become an imperative task [1].

There are currently some problems in the management of chemical instruments and equipment in China: first, there is a lack of unified standards; second, there is a lack of an effective and unified accounting system; and, non-profit assets are not included in the budget, etc. These problems have brought obstacles to the development of experimental research. Although some achievements have been made in the research of chemical experimental assets in China, many scholars start from the current situation of university laboratories and believe that strengthening the construction of biological disciplines is the key to doing a good job in basic biological education and improving the comprehensive strength of schools [2-3]. Some scholars also believe that the use of experimental instruments and reagents in colleges and universities is an important issue, which is directly related to the amount of materials consumed by students in the learning process. Therefore, it is necessary to strengthen the school's supervision and management of the use of experimental equipment, medicines and other related resources, as well as the recycling of waste after use; at the same time, it is also necessary to increase teachers' awareness of investment in chemical instruments and equipment [4-5]. Therefore, this article will evaluate and study the risks of chemical laboratory asset management in order to improve the current problems.

The assets of the chemical laboratory are indispensable and important resources in scientific research, teaching and production practice, and play a key role in improving the scientific research ability of the school and cultivating the spirit of innovation. In recent years, as the reform of the education system continues to intensify and experimental funds increase year by year, the prices of chemical instruments and equipment continue to decline. From the perspective of the chemical engineering discipline, this article discusses how to strengthen the construction of university laboratory management mechanisms, take effective measures to reduce the probability of risk occurrence, establish a scientific, reasonable, safe and reliable reagent measurement system, and improve related facilities and instrument functions. Through these efforts, the efficiency and safety of chemical laboratories can be improved, and the development of experimental research in schools can be promoted.

2. Discussion on Asset Management of Chemical Laboratories

2.1. Failure Risk Algorithm

Fault tree analysis is a method that abstracts a logic gate to analyze a large number of systems or phenomena with typical rules. By simplifying the system or phenomenon into a process that is easy to observe and identify, the fault tree analysis method can intuitively display the intrinsic structure, characteristics, status and development trends of things in a smaller number. The characteristic of this method is that it can reveal the correlation between the occurrence of the event and the consequences of the event and the hazards, and establish a mathematical model [6-7]. When using this method, it is first necessary to conduct in-depth investigation and analysis on the research object, logically deduce all its events, and divide them into limited and orderly parts, and each event can be subdivided into several sub-problems. Each branch is composed of top risks - accidents. If a failure occurs in an event, it is necessary to analyze the event or factors as a whole, and gradually investigate the causes and effects of the failure until the link where the failure occurs is found. The probability of failure in each link in the entire link should be minimized as much as possible, or controlled within the lowest range, to ensure that the degree of harm to controllability is minimized [8-9]. Then, based on basic theoretical knowledge, determining the probability distribution of the system or phenomenon in various fields and the severity of the accident that may result.

On the premise that every pair of basic events is independent, letting the probability of occurrence of basic event $X_1, X_2, ..., X_n$ be denoted by $a_1, a_2, ..., a_n$ respectively. In the actual research and application of many scholars, the method of approximate calculation is more common, and each event S is:

$$S = \{A_1, A_2, \ldots, A_n\} \quad (1)$$

For any event B in S, it can be described as consisting of n disjoint events BA, BA2, B.... BA, that is:

$$B = BA_1 + BA_2 + \ldots + BA_n \quad (2)$$

According to the first term approximation method, it is deduced that the probability of occurrence of the top event is approximately equal to the algebraic sum of the probabilities of all basic events in each minimal cut set, that is:

$$q \approx \sum_{r=1}^{N} \prod_{x_i \in K_r} a_i \quad (3)$$

Among them: r represents the minimum cut set number; i represents the basic event number; Nk represents the minimum cut set number in the system. Fault tree analysis is a method that uses quantitative calculation models to predict and analyze objective probability results under specific conditions. It uses technical means such as logical reasoning and mathematical operations to reveal the potential connections between things, and forms a relatively independent but strictly conservative whole through the mutual transformation of qualitative and semi-experience. Based on the known or potential system operating conditions, it can be determined whether there is a fault and the cause of the occurrence and development of the phenomenon can be found [10-11]. When abnormal conditions are discovered, corresponding measures should be taken immediately to eliminate risks. Before repairing chemical instrument equipment, a comprehensive and complete inspection of its performance, principles, methods, etc. must be carried out. If the root cause of the problem cannot be found and solved in a timely manner after the problem is discovered, it may cause system failure in the subsequent process, affect the operating efficiency of the entire process, and even cause economic losses or endanger life safety. Therefore, it is necessary to attach great importance to fault tree analysis and take timely measures to prevent and solve problems.

2.2. Risk Classification of Chemical Laboratories

Since the chemistry laboratory is a unique work environment, it requires the use of a variety of equipment and chemicals. In order to ensure the safety and reliability of use, strict requirements must be imposed on these items. In addition, great care must be taken when handling flammable and explosive substances, and they cannot be randomly placed in dangerous places or mixed with other irrelevant factors. Some reagents may pose safety concerns and other risks. The assets of chemical laboratories are different from general equipment, which are highly experimental and dangerous. In order to avoid damage or loss of equipment due to irregular use, these assets must be kept and maintained regularly, and a specialized agency should be established to be responsible for supervision and inspection. For flammable and explosive items, they must be stored regularly in accordance with national regulations, and moisture-proof measures must be taken to prevent fires and unnecessary losses [12-13]. For large instruments and equipment, dedicated personnel are required to manage and perform regular maintenance and repairs to ensure their normal operation and perfect functionality. The following are the classifications of risks: (1) reagents, fuels and other substances are flammable and corrosive; (2) poisonous gases or radioactive pollution are easily produced; (3) there are non-toxic or non-hazardous elements and other harmful substances. However, due to the characteristics of these items, it is difficult to completely avoid mixing with other chemicals. The risks in chemical laboratories mainly consist of three factors: first, the quality of experimental instruments and equipment; second, the wide variety of experimental drugs, including reagents, intermediates, and chemical raw materials, if the quality of experimental instruments and equipment is not up to standard, for students, whether the operating environment and teaching conditions are good will directly affect their learning results and ability improvement, for teachers, it is crucial whether the teaching aids meet the requirements and purpose of use; third, there are many types of chemicals and they are complex [14-15]. Figure 1 shows the proportion of chemical laboratory risk categories.

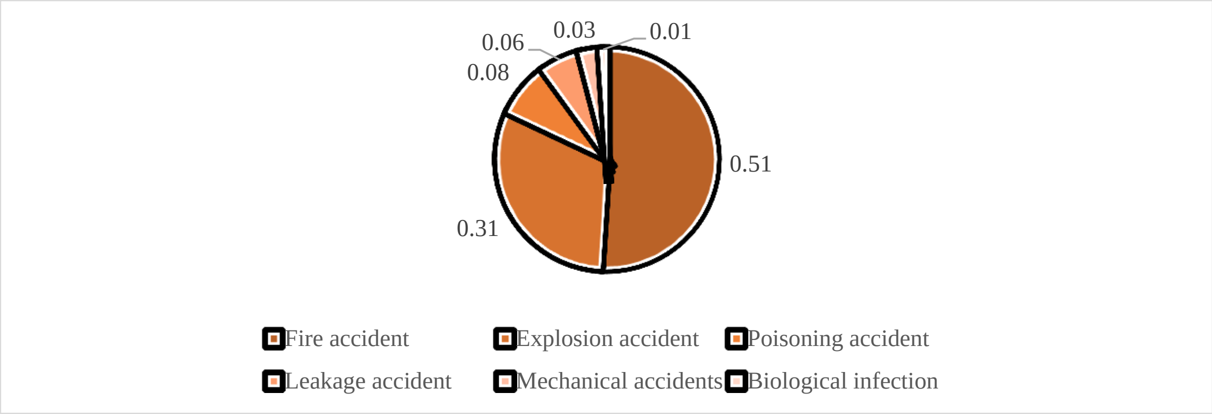

Figure 1. The proportion of laboratory accidents in universities

Because students need to use a lot of reagents and various auxiliary tools in the teaching process, the school has the risk of equipment failure that may lead to dangerous accidents. At the same time, some reagents may be lost or failed due to human factors, causing unnecessary losses or safety hazards. In addition, materials such as flammable materials, oxidants, and corrosive gases are easily oxidized and deteriorated, which may cause fires and other risks.

2.3. Chemical Laboratory Asset Management

Chemical experimental assets are the material basis for laboratory teaching and research work and an indispensable part of school education. When purchasing chemical experimental instruments, a comprehensive quality review is required [16-17]. First, choosing equipment produced by regular manufacturers that meets standard requirements and can be used stably for a long time. Secondly, according to the drug catalog stipulated by the country and the school, listing the models and specifications of the corresponding reagents, and keep records. In addition, it is also necessary to establish a laboratory asset management system, operating procedures, and related document and file storage systems. Finally, when purchasing experimental instruments, it is necessary to strictly follow legal, compliant, and reasonable purchase procedures, and report incomplete procedures or missing items in a timely manner. For the management of instruments, equipment and reagents, the following points should be paid attention to:

(1) Instruments and equipment: Instruments, medicines, etc. must be strictly calibrated; before use, it needs to understand the instructions for the items required by relevant personnel and obtain the corresponding certification materials before using or purchasing equipment and utensils for scientific research and daily production activities.

(2) Reagent management: Chemical laboratories need to maintain and repair reagent facilities on a regular basis, including the purchase and scrapping of fixed assets, instruments and equipment.

(3) Purchase of new equipment: Reagents are non-flowing products, which need to be stored properly during the experiment to prevent deterioration or damage. For reagents that are prone to corrosion, it is also necessary to take good care of them to prevent accidental damage. Equipment that has aged, is seriously damaged, or is not suitable for use, such as air conditioners, glass and other materials, should be replaced in time.

(4) When purchasing, it is necessary to measure in strict accordance with relevant requirements and national standards. After purchase, it is necessary to take stock regularly to verify whether the actual inventory is consistent with the book balance. For reagents that have not been put into storage but have been used and have been scrapped or damaged, they should be reported to the laboratory management staff in a timely manner for approval of the replacement treatment method, and issue a list of assets, which can be disposed of only after approval from the financial department. This can effectively control the risk of asset management [18-19].

For schools, the laboratory is a place for students to carry out material basic knowledge and skills required for learning and research, and it is also an important and indispensable resource. With the rapid development of science and technology, the requirements for laboratories and even chemical experiment equipment are also increasing. Therefore, more attention needs to be paid to the rational use and protection of chemical experimental assets to meet the needs of teaching and scientific research.

3. Experimental Process of Chemical Laboratory Asset Management and Prevention

3.1. Risk Identification Modeling for Laboratory Asset Management

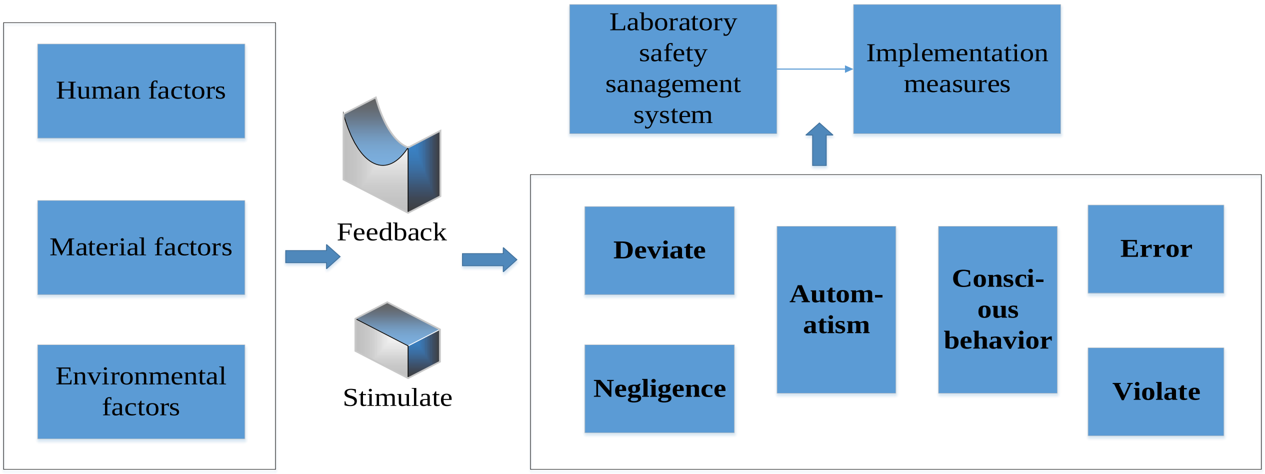

Figure 2. Error model of chemical laboratory risk management system

In When assessing the risk of chemical laboratory assets, a risk identification model should be used for analysis. This model (as shown in Figure 2) can understand existing problems from different perspectives, such as technical and economic aspects. Technically, it is necessary to consider whether the equipment and instruments can work normally, and the impact of their safety and reliability on the quality of materials and raw materials required in the chemical production process, experimental conditions and environmental requirements. When evaluating various raw materials and products in a laboratory, there are several methods that can be used to determine how the sample was prepared, such as qualitative or quantitative. By analyzing and evaluating potential hazards or hazards that may exist in the inventory and the extent of the consequences that may occur, it can be determined whether the required instruments and equipment meet the requirements of the standard. At the same time, it is also necessary to clarify the causes of different types of accidents and the degree of harm caused, as well as what countermeasures should be taken to reduce losses and reduce risk levels, so as to optimize the laboratory asset management system. Here are the basic steps for building a model [20]:

(1) Identifying key indicators used to assess risk, such as asset value, asset vulnerability, and asset substitutability. These metrics should match the goals and requirements of laboratory asset management.

(2) Collecting data related to laboratory assets, including information such as asset type, quantity, value, and storage conditions. Data related to specific operations can also be collected, such as chemical usage records, safety incident and accident records, etc.

(3) Preprocessing the collected data, including data cleaning, data conversion, and processing of missing values, to ensure the accuracy and completeness of the data.

(4) Based on the determined evaluation indicators, calculating the value of each indicator on each asset. For example, an asset's value and vulnerability indicators can be calculated.

(5) Determining a corresponding weight for each indicator to reflect its contribution to the overall risk, which can be determined through methods such as expert opinion surveys or the analytic hierarchy process.

(6) Multiplying the value of the risk indicator by the weight and perform a weighted sum to calculate the comprehensive risk score of each asset.

(7) According to the comprehensive risk score, assets are divided into different risk levels, such as low risk, medium risk and high risk.

(8) According to the risk level, formulating corresponding risk control measures, including improving storage conditions, regular inspection and maintenance of assets, strengthening safety training and emergency response plans, etc.

(9) Monitoring and evaluating the effectiveness and practicality of the laboratory asset management risk assessment model, and continuously improve and optimize it based on the needs and feedback of the laboratory.

3.2. Risk Assessment Model Performance Test

The performance test of the risk assessment model mainly covers all aspects of system analysis, including software quality, hardware, and environment. In the laboratory, there are various and complex instruments and equipment, so establishing a sound and reasonable chemical experiment asset management system needs to fully refer to a large amount of actual data as a basis. During the laboratory construction process, the diversity of drugs and reagent types and the potential impact of various factors must be fully considered, and evaluation and control measures must be prepared to reduce risk levels and save costs. System analysis is mainly based on past experience, with the help of specialized software tools to evaluate the risk quantitative model. In order to correctly assess the degree of danger that may exist in experimental equipment and its physical environment, as well as the potential consequences of accidents, it is necessary to consider whether it can truly reflect the actual situation and historical experience and is representative when selecting appropriate evaluation criteria. These evaluation criteria will be used to measure the strength of the relationship between various risk factors and impact factors, as well as the level of severity, and finally determine a reasonable risk identification threshold.

4. Experimental Analysis of Chemical Laboratory Asset Management Risk Assessment

According to the current status analysis of chemical laboratory asset management, risk assessment is based on the analysis of existing asset conditions and makes reasonable suggestions based on the actual situation. However, due to the high price of experimental instruments and reagents, the wide range of sources of medicines, and the fact that students are easily affected by external factors during use, it is necessary to establish a new effective, safe and reliable evaluation system to ensure the safe and efficient operation of the laboratory. Table 1 shows the likelihood of chemical laboratory risks occurring. Next, this article tests the performance of the risk assessment model in the face of these risk events.

Table 1. Risk assessment testing

Basic event	Probability
Weak safety awareness	0.058
Violate operating regulation	0.2473
Improper use	0.2472
Inqualified safety management	0.0857
Equipment trouble	0.057

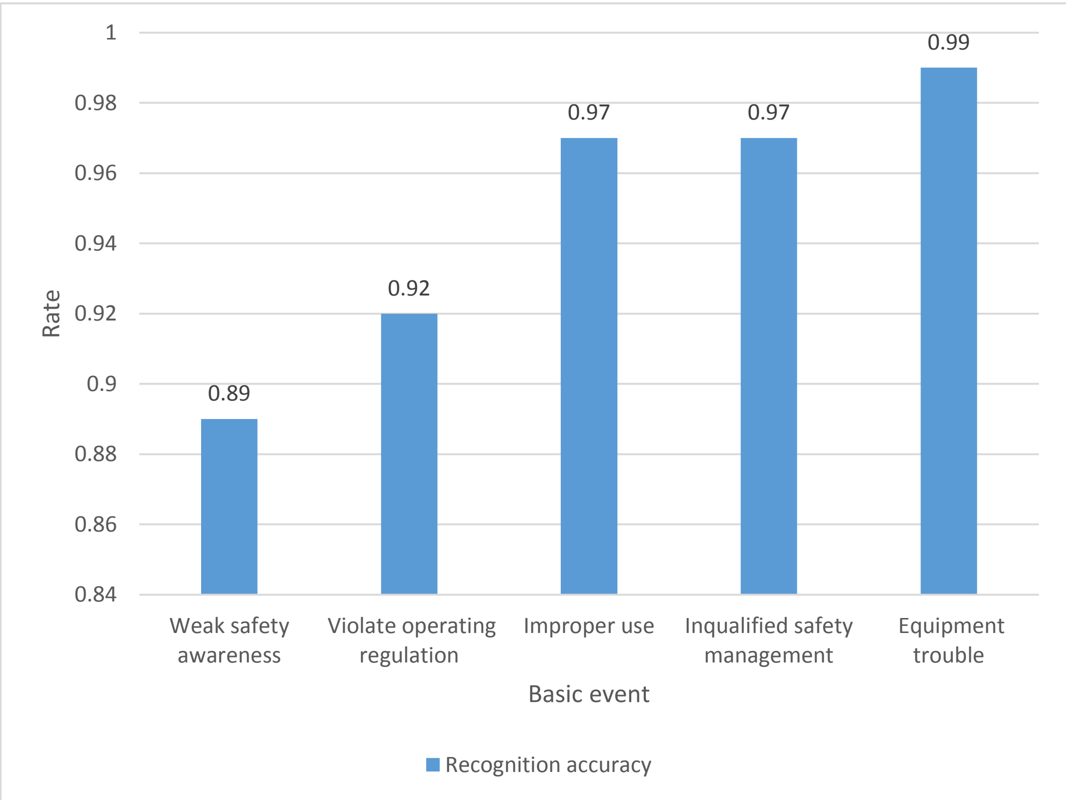

Figure 3. Risk identification accuracy

Chemical instruments and equipment may malfunction, be lost or damaged during use. These problems are often caused by defects in the experimental equipment itself, and these problems may lead to accidents in laboratory materials. Risk identification accuracy is an indicator that measures the conclusions and evaluation results drawn after analyzing and studying various potential factors.

To determine whether discussions and countermeasures are needed, a combination of risk management techniques (such as mathematical modeling) and decision support systems are used. According to the data in Figure 3, the accuracy of this risk identification is higher than 0.89, and can reach a maximum of 0.99.

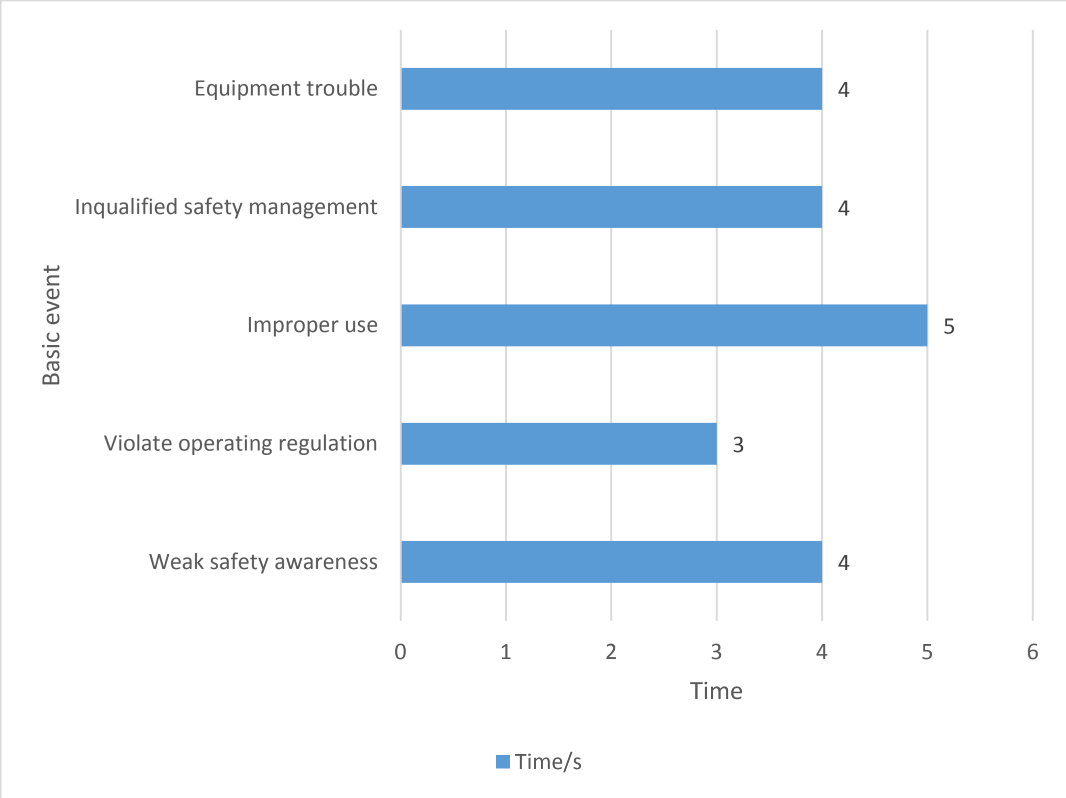

Figure 4. Risk identification time

Before using the experimental equipment, engineering technicians or management personnel with rich experience in chemical equipment and equipment will determine whether the equipment needs to be replaced based on the accurately recorded test data and operating specifications in the past. By analyzing the data in Figure 4, it can be concluded that this model requires no more than 5 seconds in identifying risks.

5. Conclusion

Chemical laboratory assets play an important role in the process of scientific research and teaching, and play a decisive role in their role in the field of scientific inquiry activities. This article will analyze the purchase and use of chemical experimental instruments and equipment from the perspectives of national policies, school management and scientific research, and provide relevant suggestions for current problems in experimental instrument assets, such as the lack of unified standards and imperfect evaluation systems. Finally, this article also proposes measures to strengthen laboratory fixed asset management awareness, improve relevant system construction, and establish a rational evaluation mechanism.

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If any, should be placed before the references section without numbering.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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