

Research on Safety Risk Assessment and Management System Construction of University Laboratory Based on Structural Equation Model

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Abstract

The laboratory is the ability to cultivate students' research and innovation, conduct quality education, and develop the cradle of high-quality talents. However, the laboratory has the characteristics of sudden and exploring, leading to frequent laboratory accidents, bringing huge losses and adverse effects to schools and society. The safety of university laboratories has become a topic that people have paid attention to in recent years, and the safety management of laboratory needs to be strengthened. In order to improve and improve the safety emergency management of laboratory, this article starts from the importance of laboratory management and construction, and is targeted at the four aspects that affect laboratory security: basic safety management, personnel safety management, operation safety management, chemical safety management, design survey Questionnaire and proposed assumptions, analyze the data of the obtained data with SPSS, use AMOS software to build a structural equation model, perform factors analysis and path analysis, and verify the assumptions proposed to better improve laboratory security provision Targeted and feasible suggestions. This article uses SPSS and AMOS software to analyze, verify the assumptions, and draw the following conclusions: Laboratory rules and regulations and laboratory management have positive impacts, and the effect is the most significant.

Keywords

University Laboratory; Laboratory Safety; Structural Equation Model; SPSS; AMOS.

1. Introduction

The laboratory provides a large number of scientific research talents for universities and society, but as the research projects become more frequent, various chemical consumption of chemicals with a certain risk will be exposed. It is the fundamental guarantee for colleges and universities. On April 20, 2022, a degeneration accident occurred in a laboratory in Central South University. The school had launched an accident investigation. Because some laboratories did not meet the safety regulations, the laboratory in the hospital has been shut down and rectified. In addition, in October 2021, the Nanjing University of Aeronautics and Aerospace University of Aeronautics and Astronautics had degenerate due to illegal storage of magnesium and aluminum powder, causing serious casualties. These painful lessons warn that we must continue to check the lack of missing, properly cope with the changing laboratory status quo, and further improve safety management [1].

In order to realize the comprehensive implementation of the safety responsibility system of college laboratories, form a situation of comprehensive management, improve the classification of danger sources of colleges and universities, and strengthen the management of the safety evaluation process of teaching and scientific research projects. Eliminate the occurrence of

major laboratory safety accidents, establish and improve the safety management system of the laboratory, strengthen the safety education and training of teachers and students, and actively cooperate with the special actions of laboratory safety. The occurrence of a safe and harmonious scientific research environment.

2. The Problem of Safety Management in the University Laboratory

2.1. Teaching and Scientific Research Shared, Hidden Safety Hazards Increased Significantly

Insufficient investment in security funds. In recent years, the construction funds of universities' laboratories usually focus on the investment of experimental instrument equipment procurement, thereby lighting up the construction of laboratory infrastructure. Due to the weak development foundation of some local universities, most universities have the current status of "the same laboratory, teaching and scientific research", and usually conflict with undergraduate teaching and scientific research experiments. These are not only important factor affecting the establishment of a good experimental teaching environment, but also an important part of the safety operation of the laboratory [2].

2.2. Laboratory Safety Management Mechanism Is Not Complete

The safety management of colleges and universities has problems such as overlapping work, unclear division of responsibilities, unknown division of labor, pushing each other, and repeated implementation. The main reason for this phenomenon is that colleges and universities do not pay enough attention to the basic safety management of the laboratory. Professional laboratory talent teams lack the work of laboratory safety management, and cannot implement laboratory safety management deployment efficiently and orderly. The laboratory management personnel shall require them in strict accordance with the relevant management system after the teachers and students enter the laboratory, and implement the rules and regulations of the laboratory to the end.

2.3. Safety Awareness Is Weak, And Education Does Not Pay Enough Attention

With the strengthening of the construction of university laboratories, the scale of the laboratory has gradually expanded, the openness has continued to increase, the number of experiments has continued to increase, which has brought difficulties to laboratory management, and the security issues that have occurred significantly. The main cause of laboratory safety accidents in recent years is caused by improper operation of laboratory personnel, followed by serious consequences caused by improper emergency disposal. Some teachers and students ignore the security rules and regulations of the laboratory, and they still do not use dangerous instruments as required. They also bring special personnel. They bring the prohibited items into the laboratory without permission. Huge hidden danger

3. University Laboratory Safety Assessment Index System

The safety management of the laboratory of colleges and universities involves many fields and majors, including laboratory basic construction, experimental equipment, experimental participants, etc. Therefore, the safety management of the laboratory must be done well. The accident must take safety management as a system engineering, and for this reason, the system construction of laboratory safety management should be carried out. According to the actual situation of a university laboratory, the structural model of the safety emergency management of college laboratories from basic safety management, personnel safety awareness, chemical safety management, and operation safety management.

The following table is the specific content in the safety emergency management evaluation index system and the instructions of various indicators:

Table 1. Universities Laboratory Safety Management Capability Rating Index System and Description

Potential variable	Observation variable number	Observation variable	Index description and judgment standard
Basic security management	5	Safety training assessment A1	Whether to assess
		Security rule A2	Whether there are security codes
		Security check A3	Whether to implement the inspection system
		Status A4	Is the safety status good
		Safety Facilities A5	Whether the safety facilities are complete
Personnel safety awareness	4	safety consciousness B1	Whether there is security awareness
		safety knowledge B2	Whether to learn security knowledge
		Emergency treatment measure B3	The degree of understanding of emergency treatment measures
		Safety operation regulations B4	Understand the degree of understanding of operating procedures
Chemical safety management	4	Critical chemical approved D1	Do you apply for approval
		Dangerous goods D2	Familiarity of hazardous chemical logo
		Pharmaceutical storage D3	Whether to categorize storage
		Take drug protection D4	Is there a protective device
Safety management	5	Pre -experiment operation C1	Understand the degree of understanding of operating procedures
		Operation in the experiment C2	Understand the degree of understanding of operating procedures
		Operation after experiment C3	Understand the degree of understanding of operating procedures
		Accident handling C4	Understanding of accident handling
		Waste C5	Whether to deal with waste correctly

4. Safety Evaluation Model of Universities Laboratory

4.1. Establishment of Structural Equation Model

The structural equation is used to describe the relationship between the potential variable and the potential variable. The form is as follows:

$$\eta = B\eta + \Gamma\xi + \zeta \quad (1)$$

The measuring equation represents the relationship between the indicator and the submarine variable, the form is as follows:

$$X = \Lambda\chi\xi + \delta \quad (2)$$

$$Y = \Lambda\gamma\eta + \varepsilon \quad (3)$$

According to the above analysis, combined with the four potential variables determined by the emergency management capacity evaluation index system of Table 1, this article will affect the safety awareness of the personnel of the emergency management capabilities of the university's laboratory. The two influencing factors of basic safety management are determined to be an exogenous submarine variable. The two indicators of chemical safety management and operation safety management are determined to be endogenous potential variables.

4.2. Main Theory Hypothesis and Model Construction

According to the above analysis, in order to verify the theoretical model constructed, the following assumptions:

H1: Personnel safety awareness of college laboratories has a positive effect on basic safety management

H2: The basic safety management of college laboratories has a positive effect on personnel safety awareness.

H3: Personnel safety awareness of college laboratories has a positive effect on chemical safety management

H4: Personnel safety awareness of college laboratories has a positive effect on operation safety management

H5: The basic safety management of college laboratories has a positive effect on chemical safety management

H6: The basic safety management of college laboratories has a positive effect on operating safety management

According to the above assumptions, the initial model diagram of the structural equation model of the safety emergency management capability evaluation of the university as shown in the figure is composed.

4.3. The Design of the Questionnaire

The quality of the questionnaire design directly affects the scientificity and reliability of the evaluation results. Design questionnaires with higher reliability and validity are the prerequisite for ensuring the quality of research. According to the purpose and actual needs of the evaluation, after referring to a large number of literature and information, after certification analysis, comparison, etc., 18 variables such as safety training assessment, safety facilities, emergency treatment measures, experimental operating procedures, chemical categories and storage, etc. Essence.

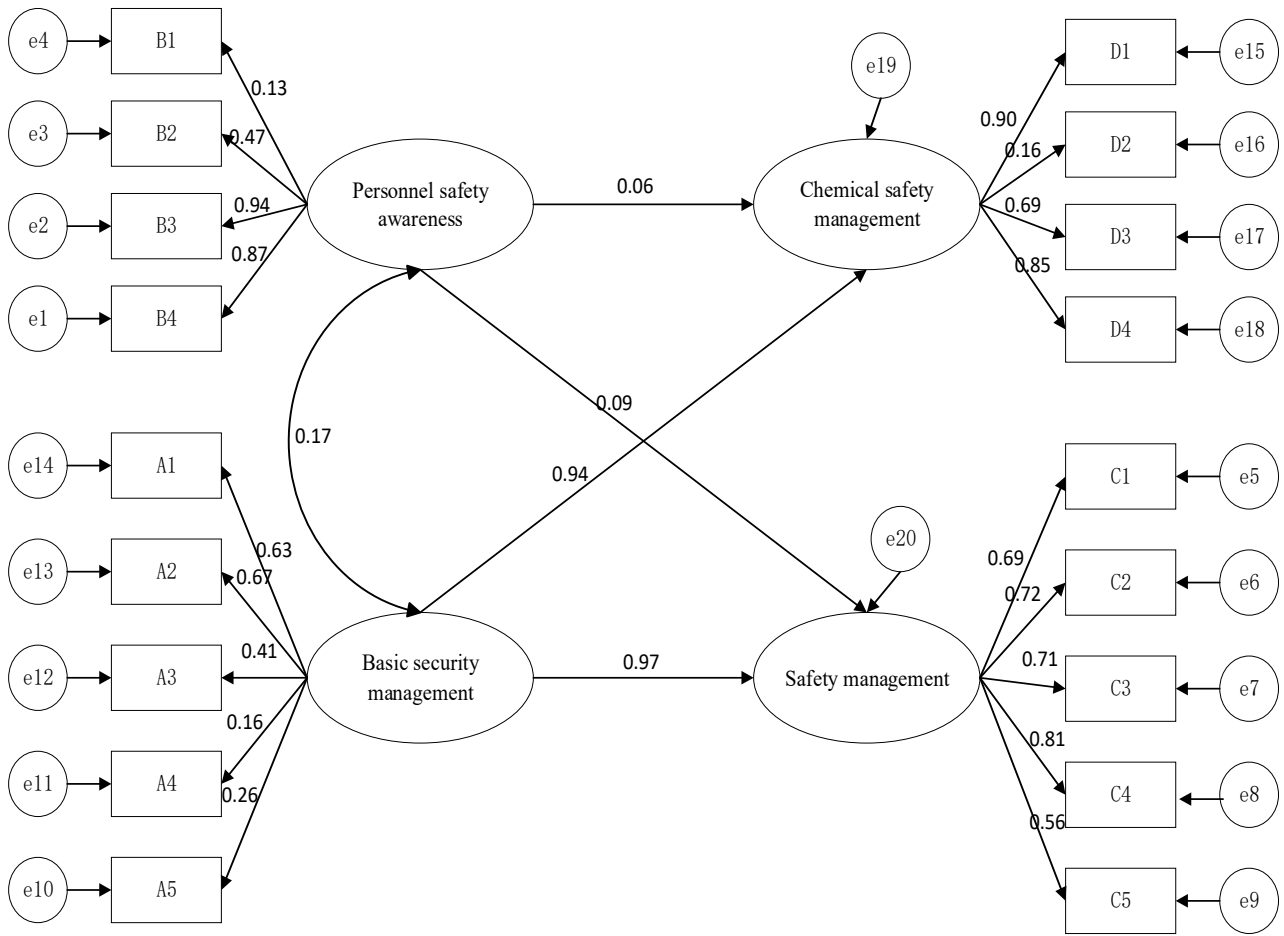


Figure 1. The Safety Emergency Management Capability Evaluation model of colleges and universities

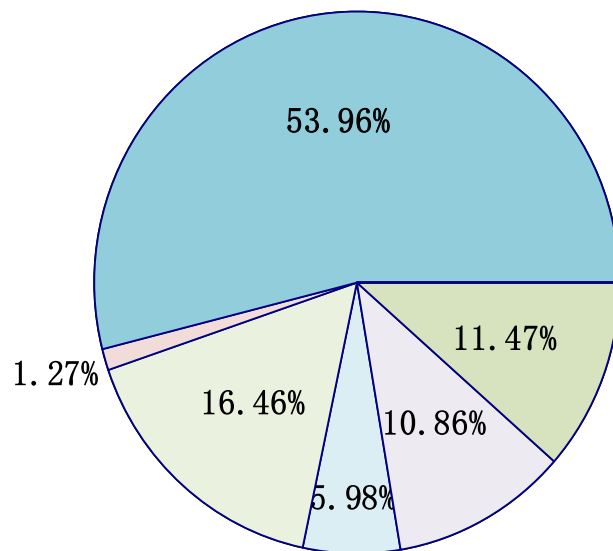


Figure 2. The distribution of survey objects in the region, 81.02% of the samples of northern colleges and universities, and 18.98% of the sample samples in southern universities.

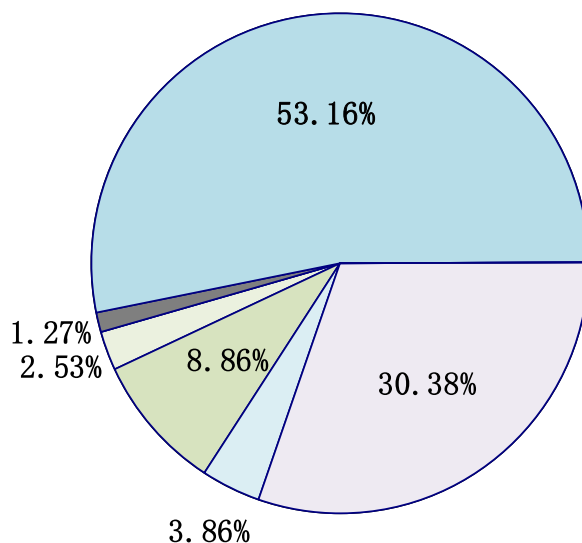


Figure 3. The distribution of subject majors in disciplines. From the survey of survey, it is biased towards security majors, accounting for 53.1%, chemical industry accounts for 8.86%, and other 38.04%.

4.4. Inspection and Analysis Based on Structural Equation Model

4.4.1. Letter Inspection

For the recycling questionnaire, the credibility of the questionnaire is measured by the size of the Cronbach (Cronbach) α coefficient. The test results are as follows:

Table 2. Reliability statistics

Klongbach Alpha	Klongbach Alpha, based on standardized items	Number
0.869	0.883	18

It can be seen from domestic and foreign studies that Cronbach (Klongbaha) α The criteria for judgment are: when the value is greater than 0.8, the credibility of this value is high; if the value is between 0.7 and 0.8, it shows good good ones. Reliability: If the value is 0.6 to 0.7, it means credible; if the value is lower than 0.6, it means unbelievable. It can be seen from the calculation results that the Cronbach'alpha (CA) of the observation variables is 0.869 between 0.7 and 0.8, indicating that the data is credible.

4.4.2. Validity Test

The validity inspection of the questionnaire refers to the analysis of the effectiveness of the questionnaire and the test results of the survey results of the survey questionnaire. 0.05, passed the Bartlett spherical test. The KMO value was 0.776, which was higher than 0.7. Therefore, the results of this questionnaire survey were suitable for factor analysis.

Table 3. KMO and Bartlite Inspection

KMO sampling appropriate amount number	0.776
Batli Special Ball Facility Inspection	Approximation
	Degree of freedom
	Significant
	3176.531
	153
	0

4.4.3. Assuming Verification Analysis

Table 4. Verification factor analysis data table

variable			Model parameter estimation value				Convergence
			Non - standardized factors load	S.E.	C.R.	P	Standardized factor load
Chemical safety management	<---	Basic security management	3.053	0.792	3.854	***	0.938
Chemical safety management	<---	Personnel safety awareness	0.059	0.062	0.958	***	0.057
Safety management	<---	Personnel safety awareness	0.087	0.060	1.461	***	0.088
Safety management	<---	Basic security management	3.017	0.803	3.756	***	0.971
B4	<---	Personnel safety awareness	1.000	---	---	---	0.875
B3	<---	Personnel safety awareness	1.060	0.088	11.987	***	0.938
B2	<---	Personnel safety awareness	0.543	0.073	7.437	***	0.472
B1	<---	Personnel safety awareness	0.153	0.078	1.974	***	0.134
C1	<---	Safety management	1.000	---	---	---	0.693
C2	<---	Safety management	1.237	0.121	10.248	***	0.720
C3	<---	Safety management	1.892	0.188	10.061	***	0.706
C4	<---	Safety management	1.603	0.141	11.396	***	0.809
C5	<---	Safety management	0.927	0.115	8.087	***	0.561
A5	<---	Basic security management	1.000	---	---	---	0.258
A4	<---	Basic security management	1.141	0.563	2.026	***	0.159
A3	<---	Basic security management	1.866	0.555	3.360	***	0.407
A2	<---	Basic security management	2.363	0.630	3.752	***	0.666
A1	<---	Basic security management	2.235	0.600	3.722	***	0.632
D1	<---	Chemical safety management	1.000	---	---	---	0.898
D2	<---	Chemical safety management	0.306	0.133	2.311	***	0.156
D3	<---	Chemical safety management	1.755	0.140	12.577	***	0.695
D4	<---	Chemical safety management	2.437	0.139	17.571	***	0.849

Table 5. Verifying factors Analysis of the fitting index

Adaptive indicator	suggested value	fitted value
CMIN/DF	<3.0	2.73
RMR	>0.05	0.035
RMSEA	<0.08	0.056
GFI	>0.9	0.932
NFI	>0.9	0.919
CFI	>0.9	0.946
IFI	>0.9	0.946

Based on the structural relationship between the submarine variables and the estimation value of the standardization path coefficient, the P value in the verification factor analyzes the level of confidence $\alpha = 0.001$ is significant. A verification and analysis of the structural equation model proposed before. H1: The standardized path coefficient of the safety management of basic safety management is 0.17, because the P value is greater than 0.001, indicating that the safety awareness and basic safety management have a certain two-way relationship, assuming the establishment. H3: The standardized path coefficients of the safety awareness of the university laboratory on chemical safety management are 0.6. Because the P value is greater than 0.001, it indicates that the safety awareness of personnel has a large positive impact on chemical safety management. It is assumed that it is established. H4: The standardized path coefficient of the personnel of the university laboratory is 0.17. Because the P value is greater than 0.001, it shows that the safety awareness of personnel has a significant positive relationship with operational safety management. H5: The standardized path coefficient of the basic safety management of the university laboratory for chemical safety management is 0.94, and the P value is greater than 0.001, indicating that basic safety management has a significant positive relationship with chemical safety management. H6: The basic safety management of colleges and universities laboratories on the standardized path analysis coefficient of operating safety management is 0.97, and the P value is greater than 0.001. It shows that the basic safety management is paired, and the operational safety management has a strong positive relationship.

4.4.4. Model Results Analysis

The direct effect of basic safety management through different influencing factors on personnel safety awareness is 0.17, which has different impacts on the safety management and operation safety management of hazardous chemicals. The direct effect is 0.94, 0.97. Basic safety management and hazardous chemical safety management and operation safety management have also had different impacts, and their direct effects were 0.17, 0.09, 0.06. The greater the path coefficient, the greater the impact of the ability of laboratory safety emergency management.

It can be seen from the figure that basic safety management has the greatest impact on laboratory safety emergency management, followed by personnel safety awareness, as well as chemical safety management and operation safety management. The results show that basic safety management has a positive positive impact on the emergency management capabilities of universities. The higher the laboratory coordination and linkage capacity, the more conducive to the laboratory to deal with emergencies.

In basic security management, the laboratory training and assessment, the security rules and inspection systems are large, and they have a positive effect on the safety management of university laboratories. They are: 0.63, 0.67, 0.41, 0.16, 0.26. Therefore, the laboratory administrator and the director of the teaching and research office will often conduct emergency publicity and education and training of students, so that students can understand and remember these emergency knowledge, so that the emergency knowledge is rooted in the students' hearts. At this time, we can directly associate emergency knowledge and quickly make judgments to stop the emergence of emergencies from the source. At the same time, the laboratory must have emergency facilities, fire hydrants, refuge, emergency corridor, etc. It is also necessary to have sufficient emergency supplies, such as fire extinguishers, medical packages, etc., to ensure that the timely crisis occurs, reduce the loss of personnel and property. At the same time, the laboratory must have its own safety culture, strengthen the students' awareness of safety, and make the first consider safety Not only are you responsible for yourself, but also responsible for other students and teachers of the laboratory.

In personnel safety awareness, the amount of emergency treatment measures and experimental operation regulations (B4) and the reagent (B2) have a large amount of load, which have a positive impact on the safety management of college laboratories. The effects are: 0.13, 0.47, 0.94, and 0.94. 0.87. This shows that the laboratory has complete operating procedures. Students should conduct experiments based on the correct operating procedures. When the crisis occurs, it should respond to reduce the loss of personnel and property. Correspondingly, the laboratory should conduct regular safety inspections and emergency drills to enable students to be in danger when they are in crisis and reduce danger. To understand the responsible persons responsible for the establishment, relevant personnel should fundamentally understand the importance of emergency management and improve the emergency quality of managers.

In the operational safety management, the experimental (C2) and the experiment (C3), and the load of the waste treatment (C5) factor were large, and the total effects were: 0.69, 0.72, 0.71, 0.81, 0.56. As a result, during the experiment, it should also be carried out strictly in accordance with the corresponding regulations of the corresponding experiments. Before the experiment is carried out, the experimental equipment should be installed, and it should be inspected whether it is correct and its firmness. During the experiment, it is strictly forbidden to go out. Leave the experimental desk to prevent the emergencies from being dealt with correctly in the first time. Put the used waste equipment in the corresponding position after experiments, and it is strictly forbidden to bring out the laboratory privately to ensure the safety of experiments.

In chemical safety management, chemicals apply for approval (D1), whether to protect (D4) when using chemicals, and do a good job of hazardous chemical safety management is the need for college experiments. The effects are: 0.90, 0.16, 0.69, 0.85. As a result, once the dangerous chemicals are not well managed in the production and use process, a major malignant accident may occur. The laboratory may have unimaginable consequences; dangerous chemicals have poor management during storage, transportation, and use in the process of storage, transportation, and use. There are many accidents caused by accidents. These accidents have caused serious social impacts, some bring serious losses to the people's lives and property, and some have serious impacts to the ecological environment

5. Staffing of the Safety Management of University Laboratory.

5.1. Establish and improve the Safety Management System of University Laboratories

Establish a hierarchical control system for college laboratories, and manage the safety responsibilities at all levels with three levels of safety management of schools, colleges, and laboratories. The person in charge of the school should be responsible for the safety of the laboratory. The first responsible person of the laboratory should support, supervise and guide the safety management of the laboratory. Each college must determine a major functional department in the laboratory safety work and coordinate with the relevant departments to coordinate with the relevant departments Essence To determine the division of responsibilities of laboratory safety management, in accordance with the principle of "who uses, who is responsible, who is in charge, and who is responsible", we must achieve the same responsibility of the party and the government, one post and two responsibilities, work together, losing responsibility, strict implementation of safety management Responsibility system, sound safety supervision system, and strengthen management according to law [1].

5.2. Strengthen Infrastructure Construction

Strengthen the safety infrastructure of the laboratory and ensure the safety management of the laboratory. The school should be equipped with a full -time security manager to increase the

investment in the construction of laboratory infrastructure construction. It should be rectified immediately for the weak links of laboratory safety and strengthen management. Strengthen the construction of school informatization, and conduct real-time supervision and management of major sources of laboratories. When constructing a laboratory, conflicts caused by the mixed use of undergraduate teaching and scientific research experiments should be overcome, and limited laboratory space should be rationally optimized to separate the teaching and scientific research laboratories. [2] In accordance with relevant laws and regulations, establish and improve the basic management system of laboratory, form a scientific and complete institutional system, and formulate relevant standards that meet the requirements of the school's own reality.

5.3. Strengthen the Sense of Self-Protection of Teachers and Students

Strengthen the safety awareness and sense of responsibility of teachers, students, and laboratory managers, ensure that they can give full play to their role, do a good job of daily safety management and inspection, eliminate hidden safety hazards, and achieve the actual needs of safety experiments. Perform regular safety management training, improve the safety management level of safety management personnel at all levels, understand the knowledge of the storage conditions, nature, logo, requirements, and waste disposal of dangerous goods, improve the safety level from the source, and meet the management needs of the laboratory. Universities should integrate laboratory safety education into students' training activities, and clarify the training goals of various types of majors at all levels.

5.4. Establish and Improve Project Risk Assessment and Control

Establishing and improving the risk evaluation of university laboratories must be evaluated and analyzed for experimental projects with operational risks. Each laboratory manager should identify and mark the danger of experimental equipment. When they are found to be dangerous, they should report immediately and formulate corresponding prevention and emergency plans. Before the school conducts scientific research experiments, the functional departments should evaluate the risk of the experiment, analyze the dangerous and harmful factors, classify the risk of the experiment, predict the possible accidents and the possibility of accidents, and control the accident and control the risk. With the strength of local governments and functional departments, strengthen the supervision of experimental projects. For experimental projects with major security risks, experiments are prohibited before carrying out security measures.

5.5. Safety First -Aid Facilities with Complete Supporting Facilities

Universities should strengthen the safety and emergency capabilities of the laboratory and establish a complete emergency system. The school-level, college-level, and laboratory three-level units formulate corresponding emergency plans and emergency measures, and conduct regular training and practical training for the person in charge of the laboratory and teachers and students. The person in charge of each link should be clarified for each link, and emergency personnel, supplies, equipment, funds, experimental protection equipment, and ensure the effectiveness of the use. When major accidents occur, you can respond immediately, start emergency equipment, and implement rescue to minimize the casualties and economic losses caused by the maximum likely, and it is not possible to report on the reporting and destroy relevant evidence.

6. Conclusion

This article uses a structural equation model to evaluate the safety emergency management capabilities of colleges and universities. Establish a model of safety emergency management capabilities for college laboratories from basic safety management, personnel safety awareness,

operation safety management, chemical safety management, etc., and evaluate the reliability and validity of this model. It can be seen from model studies that personnel security awareness has a positive impact on basic safety management; personnel security awareness, basic safety management have a positive impact on operation safety management and hazardous chemical safety management.

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