

Biosecurity in Biological and Biomedical Institutions in Misurata City: Education and Situation.

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Abstract

Biological materials could cause threats when used intentionally on living beings especially mankind. The issue of biosecurity is rising nowadays to protect people over the world from being hurt by biological materials. Education plays an essential role to improve biosecurity. This project was designed to estimate the level of understanding of BRM in specific biosecurity in biological and biomedical laboratories in Misurata city, also the study supports the including of BRM in the curriculum at biological and biomedical departments at Misurata University.

A questionnaire was designed to understand whether BRM is included in the curriculum at Universities and the level of biosecurity at organizations that participants working for. One hundred and eight graduated lab technicians from different universities and working for food and medical laboratories in the addition to research laboratories participated in this project. The questionnaire was designed to understand the level of information participants have as well as the level of security in laboratories they are working for. In addition, their advice was collected.

On the base of participants' answers, only about 12% studied BRM, and it was indicated into modules for 25%. During their studies, 45.5% informed about the risk of biological materials, 26.6% believe the information about biological security they gained was not enough. Only 7.9% informed about the security of sample storage. 58% working with samples can cause diseases, only about 10% believe that samples are securely stored. In percent, participants answered that access is limited 13.9%, inventory 15.8%, guards 42.6% and cameras 40.6%. Proper transportation inside the organization and outside it was 28.7% and 19.8% respectively. Proper waste management is managed by 10.9%.

This study shows the weakness of biosecurity in biological organizations in Misurata and recommends expanding the subject of BRM in the education system in Libya. In addition, improve biosecurity issues in medical and food laboratories. More research should be undertaken to develop BRM at biological and biomedical laboratories.

Keywords: Biorisk management. Biosecurity. Education. Misurata.

Introduction

Biosecurity covers a broad spectrum of potential risks and threats ranging from criminal activities, such as sabotage and isolated acts of violence, to bioterrorism and espionage. The term is also used to describe environmental risks in the areas of agriculture and food safety.

Education is the main process to develop human life and provide different paths for human prosperity. The need for biological and biomedical experiments has increased over all the world. In the 21st Century, Biotechnology has expanded life science and has become the most rapidly growing area of cutting-edge science worldwide. Great social benefits were provided such as public health, agriculture, and energy because of the development of biotechnology [1]. This technology is peaceful and improving human life, however, it generates risks.

Careful attention has been paid to the potential adverse effect of biotechnology research on the conservation of biological diversity and the environment under the concept of biosafety [2]. However, it can also rise the concept of dual-use; whereby the development of peacefully adopted scientific research can be used for destructive purposes, such as bioterrorism and bio-war [3]. As a consequence of the possibility of the dual-use for biological research, the international society has one significant enterprise in which, life science research has to be exclusively for peaceful purposes. A wide range of international communities in science emphasized the increasing need to develop a responsible culture in life science research concerning dual-use issues [4]. It is increasingly recognized that education is the prerequisite for coordinate policy decisions in preventing and

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responding to intentionally and unintentionally misuse of life science against humans and the environment [5].

The national research council reported that North America leading the Market share of biotechnology followed by Europe, Japan, and South America, all together holding 100% of the market [6]. This leads that, biotechnology has been dominated by these countries. The size of the industry reflects on the population that dealing with innovative biotechnology research. In these regions, the rise of awareness about dual use is a salient matter [7]. Three different surveys were implemented [7: 8: 9] in North America, Europe, and Japan, respectively, a similar outcome was realized. These surveys concluded that biosecurity educational provision is very little for life scientists. In addition, surveys in Europe and Japan concluded that the lack of education provisions is a major contributory factor leading to a lack of awareness of biosecurity aspects among life scientists

If the country intends to operate laboratories that provide a combination of diagnostic, clinical, and/or research activities involving human and/or animal pathogens have to be equipped with biosafety and biosecurity capabilities. As operating such laboratories is important for all countries, not all countries have enough resources to implement appropriate BRM principles and practices. [9]. Libya is a North African country facing a situation that had been marked by political and military instability since 2011, a different groups fighting to seize the power in the country, along with the increase in the number of immigrants from the south Sahara countries crossing the insecure long borders of Libya to reach the south coast of Europe. Consequently, the destruction of the infrastructure of national security and health institutions certainly will increase the transfer of the pathogen throughout the country, affect human life in Libya and neighboring countries in both Africa and Europe. In addition, the insecure situation of the country increases the chance of terrorist groups penetrating biological and biomedical institutions for their illegal purposes. Biosafety and biosecurity are challenging issues in countries that their resources are low, as being restricted due to many challenges [9]. Laboratory BRM was evaluated as inadequate and poorly maintained in many low-resource countries [11,; 12; 13].

The WHO has developed a system to facilitate the Bio Risk Level (BSL) according to the risk of the biological organism and divided it into four groups [14]. However, other BSL classification by country according to national policies. Kimman suggested that the classification of pathogens and their control measures should be undertaken with the goal, which to reduce all potential risk. To reach this in low

resources countries, money and time should be spent on such projects to guarantee biosafety and biosecurity at laboratories and institutions. Laboratory building should be designed through national regulatory agencies or described in specific international guidelines, and engineers should take in mind the requirements of biosafety and biosecurity physical security aspects (Pastoreino *et al.*, 2017). Devices to protect laboratory workers should be provided according to the BSL of the lab. Regulations should be undertaken, all laboratory experiments should be implemented following the guiding protocols, and biosafety and biosecurity rules should be undertaken and should meet the WHO regulations [13].

Education is essential for laboratory staff. It will offer a good understanding of the handling of hazardous biological materials, moreover, it provides knowledge about their epidemiology and the pathogenicity to humans and the environment of these agents used in research. Training and education about the use of PPEs as well as physical containment measures will reduce the spread of pathogens. Laboratory staff should be educated and trained about backing, shipment of hazardous laboratory materials Laboratory staff is in the front line to fight diseases and control outbreaks, so, they properly acquire infection due to the exposure to pathogens. Therefore, it is necessary to be trained and educated to avoid acquiring laboratory infections. Training and education also reduce the potential risk of viral outbreaks as well as laboratory accidents.

Laboratory that established to involve hazardous biological materials must be carried out with preventive measures and proper training of laboratory staff to avoid laboratory-acquired infections. Specific training must be carried out for manipulated pathogens. Thus, the certification program of BRM associations should be the initiating step for training and education of staff standardization. The area of this research requires the establishment of a good BRM system. Libya located in the north of Africa, in the middle between the North and the south of the world. The illegal migration, in the addition to unstable insecurity. This study ‘of my knowledge’ is the first in Libya. It was established as the first step to build up a good BRM system. It will push forward to include BRM in the curriculum at Libyan Universities as well as encourage institutions working in the region to implement training workshops to raise awareness about Biosafety and biosecurity, which ultimately develop working with biological materials.

This study assesses the level of information that working technicians are informed of either at the university or during their careers. As well as, assessing the situation in institutions they are

working in, to build up biosafety and biosecurity curriculum at the university and implement workshops to elevate their knowledge to raise the awareness of biotechnology dual-use.

Materials and methods

Study area

The study was conducted in Misurata city, Libya during a period of time from beginning of August to the end of September of 2019. The city is located in the central region of Libya. The city population is about 600.000 and contains Misurata university and many other biological institutes and laboratories.

Included population

One hundred and eight questionnaires were collected from eight laboratories working in the field of biological and biomedical areas at the city of Misurata- Libya.

Questionnaire design

Participants were asked about personal information: their age, the organization they were graduated from, and working experiences. The next group of questions' answer used to evaluate the information provided about BRM during the study period. The third group of questions was designed to assess the biosafety and/or biosecurity levels at participant institutions. The fourth group was about the information they gained during their study at faculties.

Ethics consideration

Personal information was treated as confidential information, and participants were promised that cannot be shared unless having the participant permission.

Results

This study was implemented to understand the background of graduated technicians who are working for the medical and biological institutions in the city of Misurata-Libya. One hundred and eight participated in this study. The majority of them graduated from the faculty of science (61.1%), (24.1%) graduated from the faculty of medical and 14.8% did not answer the question (table 1).

Table 1: participants' education and graduation

The age average was 34 years, about 28% were young technicians, 3% were more than fifty years of age, and 50% did not give their age information (figure 1).

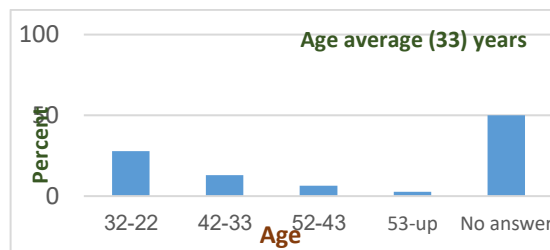


Figure 1. The location of participants' graduation.

Participants were holding different qualification levels 56.5% were at BSc level while about 9% were graduated and 16.7% were MSc and other participants did not answer the question (figure 2).

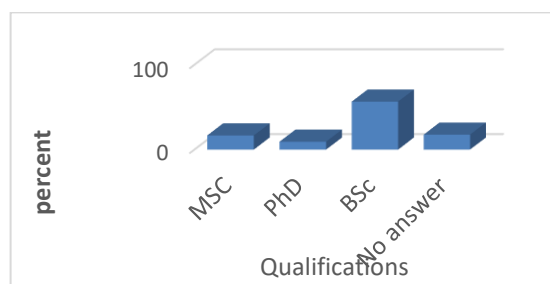


Figure 2: participants' qualifications

Information during study at faculties is essential for students to be qualified and provided with sufficient BRM information to protect themselves and their community. In this study, participants were asked questions about information during their graduation (Table 2). BRM was not included in the curriculum during their studies for 74% of participants and 13.9% did not answer the question, only 11.9% think it was included during their studies. While 24.8% of participants believe BRM was included in other modules and 64.3% decided it is not included in any module during their studies. Students are supposed to follow biosafety instructions during laboratory sections, 64.3% believed that laboratory sections were not implemented under enough biosafety conditions, however 19.8% answered yes they were. 41.6% of participants think that good safety practices increase the interest in education attainment. The seriousness of used biological materials in the

Faculty	Number of participants (%)
Medical	26(24.1)
Science	66(61.1)
No answer	16(14.8)
Total	108(100)

laboratory section was apprehensive for 45.5%.

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Moreover, only 26.7% think that information provided during graduation is enough to avoid risk. 61.4 % demand to be taught enough about the seriousness of biological materials. Only 25.7% were informed about BRM when attending workshops. Teaching students about proper sample

storage, only 7.9% of participants were taught how to properly store samples and 32.7% were informed that sample transportation should be implemented under certain conditions.

Table 2: information during study period.

No	Question	Yes (%)	No (%)	N/A (%)
1	Was BRM included in the curriculum?	11.9	74.3	13.9
2	Was any of modules included or indicated to enough information about how BRM Working?	24.8	64.4	10.9
3	Was laboratory training done under enough biosafety conditions?	19.8	64.3	10.9
4	Is the interest of the educational institution in your safety during the study period an incentive to increase interest in educational attainment?	41.6	36.6	21.8
5	Were you aware of the seriousness of the biological materials used in the labs?	45.5	33.7	20.8
6	Do you think that information you have had sufficient to avoid the risks?	26.7	53.5	19.8
7	If you study in the field of biological or medical sciences, do you demand that you be taught more about the seriousness of biological materials?	61.4	20.8	17.8
8	Have biosecurity been mentioned in any of the courses or workshops?	25.7	53.5	20.8
9	During your study or job, have you been taught to store samples secretly?	7.9	81.2	10.9
10	While studying. Has it been indicated that the transfer of biological samples should take place under certain conditions?	32.7	48.5	18.8

Understanding the goals of biological laboratory personnel in the development of biosecurity and biosafety contributes to the establishment of a solid plan to develop BRM in the future. In this study, participants' personnel at laboratories were asked to share their aspirations and advice with us to assess whether they accept and participate in the improvement of BRM at laboratories. The teaching of BRM at the undergraduate level was advised by 83.2% and 82.2 recommended implementing workshops to raise the efficiency of workers in biological and biomedical laboratories. 70.3% of

participants believe that the attention to biosafety and biosecurity is an incentive to work and increase the affiliation. 61.4% of participants pointed out that laboratories they work for, need more security guards. The security of information was recommended by 75.2% of participants and about half of the recommended access limit for biological materials. Participants were asked whether transporting biological materials under a certain procedure is a barrier that can be neglected, only 31.7% agreed. When the participants were asked if they believe that the implementation of BRM will increase the confidence of the institutions of civil society, 64.4% answered yes. Terrorist groups are a very important issue for biosecurity, 41.6% of all

respondents are concerned that biological material they are dealing with may reach terrorist groups. participants were asked questions about information during their graduation (figure 3).including BRM in the Libyan education system. This is either in the form of separate materials or among other materials

or through workshops. About 68.3% of participants advised teaching BRM within their disciplines in the future. This can be in the form of separate modules or included in other modules or by running workshops (table 4).

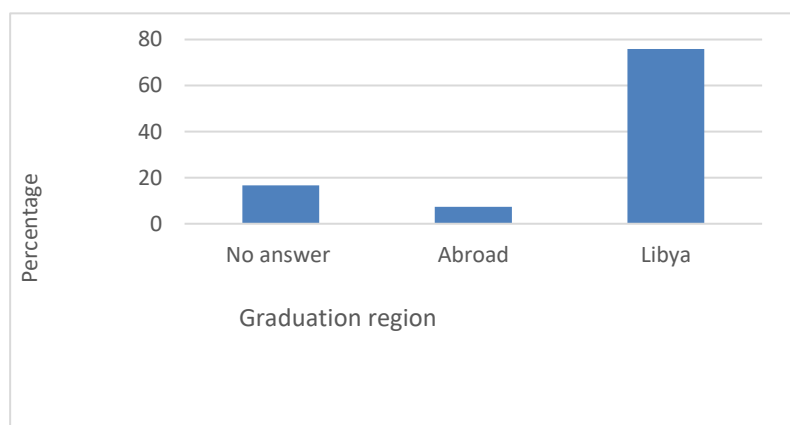


Table 4: Participants evaluation of BRM at institution they working for and their recommendations.

No	Question	Yes (%)	No (%)	N/A (%)	
1	Do you recommend teaching biological risk management at the undergraduate level?	83.2	0	16.8	
2	Do you recommend holding workshops to raise the efficiency of workers in biological and medical laboratories?	82.2	1.0	16.8	
3	Do you think that attention to security and biosafety is an incentive to work and increases affiliation?	70.3	5.9	23.8	
4	Do you think that the institution needs more guard than is available?	61.4	11.9	26.7	
5	Would you recommend confidential information so that it is securely available?	75.2	5.9	18.8	
6	Do you think that access to laboratories is a right for all employees of the institution equally?	40.6	49.5	9.9	
No	Question	Yes(%)	No (%)	N/A (%)	
7	Do you think that the transport of biological materials under certain conditions is a barrier that can be neglected?	31.7	46.5	21.8	
8	Do you expect that improved biosecurity performance contribute to increased confidence in the institution by civil society organizations?	64.4	2.0	33.7	
9	Do you have fears of any fanatical or terrorist groups that may exploit any security breaches to exploit biological materials for illegal acts?	41.6	25.7	32.7	
10	Do you recommend teaching biorisk management within your specialty?	68.3	5.0	26.7	
11	In case recommended, would you commend?	Numbers	separate	included	workshop
12		5	5	4	

Information during study at faculties is essential for students to be qualified and provided with sufficient

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BRM information to protect themselves and their community. In this study, participants were asked questions about information during their graduation (Table 2). BRM was not included in the curriculum during their studies for 74% of participants and 13.9% did not answer the question, only 11.9% think it was included during their studies. While 24.8% of participants believe BRM was included in other modules and 64.3% decided it is not included in any module during their studies. Students are supposed to follow biosafety instructions during laboratory sections, 64.3% believed that laboratory sections were not implemented under enough biosafety conditions, however 19.8% answered yes they were. 41.6% of participants think that good safety practices increase the interest in education attainment. The seriousness of used biological materials in the laboratory section was apprehensive for 45.5%. Moreover, only 26.7% think that information provided during graduation is enough to avoid risk.

61.4 % demand to be taught enough about te seriousness of biological materials. Only 25.7% were informed about BRM when attending workshops. Teaching students about proper sample storage, only 7.9% of participants were taught how to properly store samples and 32.7% were informed that sample transportation should be implemented under certain conditions.

Biosecurity and biosafety are implemented in the institution participants' work for was shown in table 3. Participants were asked whether they work with biological materials every day, 44.6% answered yes they are. But 58.4% were working with pathogens. Unfortunately, only 8.9% were trained by employers to protect themselves and protect others from being infected by pathogens. The vast majority of participants think that. Only 14.9% of cleaners determine the risk of biological materials. Moreover, waste disposal applied properly was the answer of 10.9% of participants. The transportation and storing of biological samples are very essential for biological materials security. Participants were asked whether pathogens are stored in a locked place, only 9.9% believed they are in a locked place, only 5% answered that the lockers were controlled with a PIN. And 7.9% responded yes when being asked whether the laboratory door is equipped with an IT system. Specific procedures sample transportation between sections at the same institution is required, this was the answer for 28.7%. Whereas it was 19.8% when samples are transported between the laboratory and other institutions. Moreover, 15.8% told that inventory was applied routinely. Less than half ensured that the laboratories they are working for are monitored

by security guards. While 40.6% insisted that cameras be installed in and outside of their working laboratories. The restricted access to laboratories was the answer for 13.9% of laboratory staff that participated in this study. Yet, criminal records are reviewed by the employer was the answer for 25.7% of them. Only 18.8% were asked by their managers for their ideas to participating in the improvement of biosafety and/or biosecurity levels at their institutions (table 3).

Table 3: Participants' work institution.

No	Question	Yes (%)	No (%)	NA (%)
1	Do you work with biological materials every day?	44.6	47.5	7.9
2	Do you work with agents that could cause disease?	58.4	31.7	9.9
3	Have you been trained by your employer to protect yourself and others from infection from any of the organisms or their toxins?	8.9	80.2	10.9
4	Are these objects kept in locked places?	9.9	54.5	35.6
5	Are these items saved with restricted PIN numbers?	5	60.4	34.7
6	Does everyone working with you know the content of all the biological materials stored in your organization?	9.9	41.6	48.5
7	Is access to the laboratory allowed for specific people?	13.9	49.5	36.6
8	Is the inventory applied routinely?	15.8	45.5	38.6
9	Are there control cameras inside and outside the organization?	40.6	37.6	21.8
10	Are the criminal records of the employees followed up before they enter the work?	25.7	36.6	37.6
11	Are there any security guards who can protect it well?	42.6	31.7	25.7
12	Is the transfer of samples between the sections according to specific procedures?	28.7	35.6	35.6
13	Are samples transferred to and from the institution according to specific procedures?	19.8	34.7	45.5
14	Are cleaners aware of the danger of biological materials?	14.9	44.6	40.6
15	Is the waste disposed according to the required procedures?	10.9	45.5	43.6
16	Does your manager ask you to provide any feedback or ideas on biosecurity and biosafety within the organization?	18.8	64.4	16.8
17	Do the door locks of the places where the samples are stored are equipped with IT systems?	7.9	64.4	27.7

Participants were asked to share their ideas about including BRM in the Libyan education system. This is either in the form of separate materials or among other materials or through workshops. About 68.3% of participants advised teaching BRM within their disciplines in the future. This can be in the form of separate modules or included in other modules or by running workshops (table 4).

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Discussion

This study was designed and performed to understand the level of biosafety and biosecurity in biological research, medical analysis laboratories, and Food and Drug Control Center in Misurata city. Participants were working as technicians at laboratories that commonly work with biological materials. The vast majority of participants have never attended any modules in BRM, neither as a separate course nor included in other courses. However, some did not decide whether they have attended it or not. Data in figure 2 shows that every two out of three participants were graduated in Libya. This information indicates that BRM is not included in the curriculum at Libyan national Universities. Heckert [10] argued that laboratory managers in the addition to scientists are in charge of raising the issue of BRM in low resources countries [9]. Connell and McCluskey proposed opening a biodefense 'certificate' academic curriculum for students at the university, as a part of improving biosecurity in the US. This brings us to the importance of teaching biosecurity and biosafety to the working staff who work with biological materials to prevent biological disasters. More than 58% working with pathogens, and less than 10% were trained by their employers. Staff working with pathogens might be at risk unless they are properly trained on how they are protected. Working with microorganisms classified BSL2 and BSL3, which cause morbidity and mortality, justifies the need for capacity building of laboratory staff. Human errors are important in

laboratory accidents, in addition, laboratory-acquired infections are still reported. Training the staff who are working with biological materials is a challenge for low resources countries, which should be funded by international funders to overcome this challenge [9].

At graduation, students are supposed to have enough knowledge to be protected from exposure to biological materials. Our data shows that the majority of participants neither feel they were not enough protected during their university studies, nor the information they gained at the university is enough to know clearly the risk of biological materials. Qasmi and colugos concluded that a difference was observed in the post-assessment compared to pre-assessment after postgraduate students have attended the BRM course. Participants were more aware regarding biorisk materials. In The United States in conjunction with other countries, it was planned to develop a new module at the Universities and related institutions to be delivered for life science and related subjects students and researchers. Good safety practices not only protect students from exposure to biological materials but also increase the interest in education attainment. This was indicated by more than 40% of participants. Consequently, running a module or training courses to educate students at the university will have more than one benefit. They will be safe, ready for their job, and motivated at laboratory sections.

Biorisk management was not implemented properly in the laboratories. Cameras and security guards are applied; this was the answer for more than 40% of participants. Yet. Less than ten

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percent believe that other included security issues are implemented. This is an alarming point; Biosecurity should be implemented regarding the BSL that the lab has permitted. Even though the presence of Cameras and guards are presented at some -but not enough- laboratories, other biosecurity sides such as information security, inventory, and transportation of samples are available for a low number of participants.

The questionnaire was designed as multi-choice, however, some participants selected the 'I do not know answer. This answer was in all questions even at a high percentage at some points. The lack of vocabulary used to describe BRM subjects could lead them to select this choice. For instance, they could not differentiate between the principles of laboratory safety instructions and RBM. This can be judged by applying another survey after educating them by applying for a training course.

Conclusion

This study was conducted at Misurata- Libya in 2019 to investigate the impact of including BRM in the curriculum of students of biology and biomedical science. The vast majority of technicians working at biological and medical laboratories were graduated from Libyan Universities and had never been educated about BRM, yet working with pathogenic agents. Biosecurity mitigating aspects are not enough to allow these laboratories to work with high-risk pathogens. BRM should be included in the curriculum at universities in the departments the graduate students to work for biomedical and biological laboratories. Moreover, biosecurity aspects should be taken place in laboratories that work with high-risk biological materials in the addition to pathogenic organisms.

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الامن الحيوي بالمؤسسات الحيوية والطبية بمصراتة – ليبيا: التعليم و الوضع الراهن.

نصر الدين رجب ارحومة ، كريم جبريل كريم، عبدالغنى امشحييت، الدوكالى الكسكاس

الملخص:

يتسبب الاستخدام السيئ للمواد البيولوجية بقصد في التسبب في الضرر على الكائنات الحية وخاصة للانسان، في الفترة الاخيرة بدأ الاهتمام بالامن الحيوي لاجل حماية الجنس البشري من التعرض للخطر كنتيجة للتعرض للمواد الحيوية الضارة، يلعب التعليم دورا أساسيا في عملية تطوير الامن الحيوي، تمت اقامة هذه الدراسة لاجل تقييم مستوى فهم ادارة المخاطر الحيوية وخاصة الأمن الحيوي لدى خريجي كل من العلوم الحيوية والعلوم الطبية والعاملين بالمنشآت العاملة بالمجالين بمدينة مصراتة بليبيا، كذلك لدعم تضمين ادارة المخاطر الحيوية بالمناهج المقررة بالجامعات على طلبة العلوم الحيوية والطبية بجامعة مصراتة.

تم اعداد استبيان لاجل فهم ما اذا درس المشاركون في الدراسة منهج مخصص لادارة المخاطر الحيوية او كانت جزء من منهج مادة اخرى، كذلك فهم مستوى الامن الحيوي بالمؤسسات التي يعملون بها، تم جمع مادة وتماثيه استبانات شارك بها فنيوا معاميل يعملون في كل من مركز الرقابة على الاغذية والعاملون في المختبرات الطبية بالاضافة الى العاملين في معاميل البحوث البيولوجية والطبية، صمم الاستبيان لمعرفة مستوى فهم المشاركين لادارة المخاطر الحيوية كذلك مستوى الامن الحيوي بالمعامل التي يعملون بها بالاضافة الى الادلاء بتوصياتهم حول اهمية تدريس المخاطر الحيوية و تطوير الامن الحيوي بالمؤسسات التي يعملون بها.

بناء على اجابات المشاركين بالدراسة، حوالي 12% فقط من المشاركين يعتقدون أنهم درسوا ادارة المخاطر الحيوية كمنهج مستقل، في حين يعتقد 25% منهم انهم درسوها كجزء من منهج مادة اخرى. خلال دراساتهم الجامعية، 45% اجابوا انه قد تم اعلامهم بخطورة المواد البيولوجية، يعتقد 26.6% منهم يعتقد ان المعلومات التي تحصلوا عليها اثناء الدراسة غير كافية. كانت نسبة الذين تم تعليمهم امن حفظ العينات 7.9%، من بين المشاركين كانت نسبة من يتعاملون مع عينات ممرضة 58% منهم 10% فقط يعتقدون أن العينات يتم حفظها بشكل انت، من بين المشاركين يعتقد 13.9% بان الدخول الى المعمل محدد على افراد مخصصين بينما اجاب 15.8% منهم بأن الجرد السنوي يتم اقامته في حين اجاب 42.6% بوجود كمرات مراقبة بالمعامل و 40.6% اجابوا بوجود افراد حراسة للمبنى، يعتقد 28.7% بان تنقل العينات يتم بشكل صحيح داخل المؤسسة بينما يعتقد 19.8% بأن نقل العينات خارج المؤسسة يتم بشكل صحيح، في حين يعتقد 10.9% منهم بأن التخلص من النفايات يتم بشكل صحيح.

تبين هذه الدراسة عدم كفاية الاجراءات التي تضمن توفير الامن الحيوي بشكل كافي داخل معاميل المؤسسات الطبية والحيوية بمدينة مصراتة الليبية، وتوصي بتعليم الامن البيولوجي داخل المؤسسات التعليمية بالمرحلة الجامعية والخاصة بتدريس العلوم الطبية والحيوية بليبيا، بالاضافة الى الرفع من مستوى الاجراءات المتعلقة بتطبيق الامن الحيوي بالمعامل العاملة بالمجالات الطبية والحيوية والغذية، كذلك توصي الدراسة باقامة بحوث اشمل و اوسع لاجل تقييم الوضع الراهن و توضيح مستوى الخطر الذي قد يتسبب عنه عدم الاهتمام بالامن الحيوي.

الكلمات المفتاحية: الامن الحيوي، الامن البيولوجي، الرقابة على الأغذية، ادارة المخاطر الحيوية