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Summary

Exposure to biohazards in health care settings is very common, but their handling increases in the clinical laboratory environment, and maintaining organised control of biosafety standards will provide protection for health care workers. (2)

We will conduct the following study focused on occupational risk factors caused by biological agents to which professionals working in the clinical laboratory of the Hospital Básico del Ángel are exposed. This study will be carried out using the Biogaval - Neo 2018 method. Data will be collected from June to December 2022, through field observation using a mixed qualitative-quantitative-quantitative descriptive methodology to identify the work areas with the highest occupational risk.

The Biogaval method aims to provide a guide for technical personnel in occupational health and safety to analyse the different areas where there is a probability of biological risk, as well as to guide the implementation and execution of preventive and control measures.

In the different areas of the laboratory, workers had accidents with biological agents with possible contagion with microorganisms through punctures, lacerations, or cuts, including inhalation of aerosols and contact with contaminated material. In view of these risk factors, it is necessary to evaluate the conditions in which they work, since this will be the beginning of a series of decisions that will improve the performance of the institutions that work under these risks.

Keywords: Biosafety; clinical laboratory; biological risks; health risks; personnel protection.

Introduction

The clinical laboratory participates in the diagnostic support in hospitals, in which the manipulation of human biological samples for analysis is carried out, so there is direct contact with pathogenic microorganisms that can cause diseases that affect the health of the staff working, these conditions could be mild, moderate, severe and/or cause death (1).

In the laboratory we find the following work areas: sample taking, haematology, biochemistry, uroanalysis, coproanalysis, coagulation, diagnostic support for tuberculosis, transfusion medicine, in which, depending on their complexity in the handling of biological samples, the occupational risks due to illness can increase (3).

Another cause that increases the likelihood of accidents and illnesses in the health sector is the lack of information or monitoring of the biosafety standards used during the working day in hospital facilities (2).

Biosafety is defined according to the World Health Organisation as those principles, techniques and practices applied in order to avoid unintended exposure to pathogens and toxins, or their accidental release. The correct use of protective equipment, proper design of facilities and continuous training of personnel are important aspects for the successful reduction of occupational risk factors in areas where biological samples and their respective waste are handled.

In the work environment of the clinical laboratory, health personnel participate in the handling of sharps, and in the same way the handling of body fluids represents a potential health risk causing infectious diseases of great importance, which can enter the organism by the following routes of infection: Respiratory route: Commonly by the aspiration of aerosols resulting from processes within the working day. Blood route: Through accidents with sharp objects. Digestive route: Through bad habits or substandard actions (3).

The above-mentioned information justifies the need to apply a risk analysis method to assess the biological risk in order to meet the following objectives:

- Determine occupational risk factors due to exposure to biological agents.
- Diagnose the current exposure conditions of workers at the source of the biohazard.
- Identify risk factors by means of tools and methods applicable to occupational health conditions.
- Propose an epidemiological surveillance plan aimed at the prevention of biological factors for the improvement of the working environment in the short and medium term.

Methodology.

The data obtained will be specific to the research site, the clinical laboratory of the basic hospital in the city of El Ángel, which is why it will be a field study with a cross-sectional quantitative approach from June to December 2022, in which the Biogaval method will be used as a research instrument, in addition, the official information obtained from the existing documents in the Clinical Laboratory will be used. (6)

The Biogaval method aims to provide a guide for technical personnel in occupational health and safety to analyse the different areas where there is a probability of biological risk, as well as to guide the implementation and execution of preventive and control measures.

In the research method used for this study, the following steps can be distinguished:

Determination of positions to be evaluated: the universe of the study was made up of 20 workers from the clinical laboratory of the basic hospital in the city of El Ángel, who are exposed to biological risk and who made up the sample selected by convenience and who gave their consent to participate, each one constituting the object of the study and observation.

It should be considered that the establishment selected for the research study is a high-demand functional centre, with a large influx of patients and years of operation in the city. It should be noted that the laboratory has advanced technology in process equipment and the latest innovations in sampling, a very good physical, organisational and administrative structure.

Identification of the biological agent: We will study the work procedures, work equipment, health status of the workers, age, sex, duration of the working day, and the most common microorganisms when handling biological samples (4,7,8).

Quantification of the variants determining the risk: We will take into account the route of transmission, which can be indirect, direct, and aerosols. This will make it possible to establish the number of days of absence due to the disease, and also to consider the possible sequelae or death of the worker (8).

Vaccination, we will take into account the exposed workers who are vaccinated, as long as there is a vaccine for the biological agent and the frequency of carrying out risk tasks, as well as the time that workers are exposed to the biological agent in the different areas or sections of work with the following scale:

- (Rarely: < 20 % of the time).
- (Occasionally: 20 % - 40 % of the time).
- (Frequent: 41 % - 60 % of the time).
- (Very often: 61 % - 80 % of the time).

Hygiene measures adopted: 41 aspects provided by the BIOGAVAL method were applied to perform the percentage calculation between the resulting score of affirmative answers and the maximum number of possible answers. To the affirmative answers, risk reduction coefficients were applied on a scale of:

- (0 less than 50%)
- (-1 from 50 to 79%)
- (-2 from 80 to 95 %)
- (-3 over 95 %)

Calculation of the level of risk: by applying the formula:

$$R = G + T + P + P + F - V - \square H$$

Where: R = Risk level. G = Group to which the biological agent belongs. V = Vaccination. T = Route of transmission P = Probability of contact.

Interpretation of the biological risk levels: taking into account the calculation of the risk level (R), the interpretation takes into account two levels: Biological action level (BAT=12. Higher values require the adoption of preventive measures to reduce exposure). Biological exposure limit (BEL=17. Higher values represent intolerable risk situations that require immediate corrective action). The information obtained was entered into a database and processed in Microsoft Office Excel 2013. The results were analysed using descriptive statistics, using number and percentage as summary measures. The results were presented in tables and graphs for better understanding.

Population and sample.

For the present study, the sample corresponds to the 20 workers of the basic hospital of El Ángel, who are divided into the following work areas.

Table 1: Number of persons per workstation

WORKPLACE	NO. OF WORKERS	MEN	WOMEN
Sample collection	3	1	2
Haematology	2	1	1
Biochemistry	2	1	1
Uroanalysis and coproanalysis	1	0	1
Transfusion medicine	2	0	2
Diagnosis of Tuberculosis	2	1	1
Administrative	8	3	5

Source: Elaborated by Johanna Mayanquer.

Results

Description of areas of work with increased susceptibility

In the clinical laboratory of the basic hospital in the city of El Angel, blood, urine and faeces samples are processed, which are used to help diagnose diseases caused by fungi, parasites and also other microbiological organisms, such as viruses and bacteria.

The following work areas can be identified in the laboratory:

Table 2: Description of the working area

Job vacancies	Activities
Reception and sampling	Patient care - Collection of blood, tissues and other body fluids
Haematology and blood chemistry	Haematological tests - Blood chemistry - Coagulation time - Electrolyte studies
Uroanalysis and co-analysis	Physical, chemical and microscopic examination of urine - Physical and microscopic examination of faeces - Nuclear polymorph and rotavirus investigation of faeces
Tuberculosis diagnostic support	Bacillus identification by Ziehl Neelsen stain
Transfusion medicine	Crossmatching - blood group identification - dispensing of blood components
Administrative	Receipt of samples - filing of results for HIV, tuberculosis.

Source: Elaborated by Johanna Mayanquer.

Biological hazards in the workplace

In the area of reception and sample taking, a "Very frequent" risk was obtained for viruses and bacteria, while for parasites and fungi, a "Frequent" risk was obtained. The haematology and blood chemistry area presented an "Occasional" risk for viruses, bacteria, and for parasites and fungi, a "Rarely" risk was obtained. (10) Within the tuberculosis diagnostic support area, a "Very frequent" risk was obtained for bacteria, and a "Frequent" risk for viruses, parasites and fungi. The Uroanalysis and coproanalysis area had a "very frequent" risk for parasites and a "frequent" risk for bacteria, while the risk for viruses and fungi was "occasional". Finally, the epidemiological surveillance area did not register relevant risks, obtaining a "Trivial" risk in all the identified hazards (5,11).

Table 3: Biological agents by workstation

Biological agent	Possible disease	Work area
Escherichia coli	Haemorrhagic diarrhoea, urinary tract infections	Uroanalysis and coproanalysis
Staphylococcus auereus	Skin and mucosal infections	Sampling, Uroanalysis and coproanalysis
Psedomonas aeroginosa	Funiculitis, otitis, pneumonia	Uroanalysis and coproanalysis
Streptococcus ssp	Streptococcal infections	Sampling, Uroanalysis and coproanalysis
Mycobacterium tuberculosis	Tuberculosis	Tuberculosis diagnostic support
Human immunodeficiency virus	AIDS	Haematology and blood chemistry, sampling
Hepatitis A virus	Hepatitis	Haematology and blood chemistry
Hepatitis B virus	Hepatitis	Haematology and blood chemistry
Hepatitis C virus	Hepatitis	Haematology and blood chemistry
Coronavirus SARS- CoV-2	Covid-19	Reception and sampling
Influenza virus	Influenza	Reception and sampling

Source: Elaborated by Johanna Mayanquer.

Table 4: Scoring of biological agents according to the group they belong to (G)

Biological agent	Group/Score
Escherichia coli	2
Staphylococcus auereus	2
Psedomonas aeroginosa	2
Streptococcus ssp	2
Mycobacterium tuberculosis	3
Human immunodeficiency virus	3
Hepatitis A virus	2
Hepatitis B virus	3

Hepatitis C virus	3
Coronavirus SARS- CoV-2	3
Influenza virus	2

Source: Elaborated by Johanna Mayanquer.

Table 5: Score according to transmission pathways (T)

Biological agent	Group/Score	Transmission route
Escherichia coli	2	Direct/Indirect
Staphylococcus auereus	2	Direct/Indirect
Psedomonas aeroginosa	2	Direct/Indirect
Streptococcus ssp	2	Direct/Indirect
Mycobacterium tuberculosis	3	Air/direct
Human immunodeficiency virus	3	Direct/Indirect
Hepatitis A virus	2	Direct/Indirect
Hepatitis B virus	3	Direct/Indirect
Hepatitis C virus	3	Direct/Indirect/Air
Coronavirus SARS- CoV-2	3	Direct/Indirect/Air
Influenza virus	2	Direct/Indirect/Air

Source: Elaborated by Johanna Mayanquer.

Table 6: Vaccination score by biological agents.

Biological agent	Vaccine	Score
Escherichia coli	Vaccinated less than 50% vaccinated	1
Staphylococcus auereus	Vaccinated less than 50% vaccinated	1
Psedomonas aeroginosa	No vaccine or low efficacy	1
Streptococcus ssp	No vaccine or low efficacy	1
Mycobacterium tuberculosis	No vaccine or low efficacy	1
Human immunodeficiency virus	No vaccine or low efficacy	1
Hepatitis A virus	Vaccinated less than 50% vaccinated	1
Hepatitis B virus	Vaccinated less than 90%	4
Hepatitis C virus	No vaccine or low efficacy	1
Coronavirus SARS- CoV-2	More than 90% vaccinated	4
Influenza virus	More than 90% vaccinated	4

Source: Elaborated by Johanna Mayanquer.

Frequency of performing risky tasks (F)

Mycobacterium tuberculosis Typically = > 80%, risk score 4

According to the tabulation of hygiene measures we have:

$$Porcentaje = 28/\ 28 + 11 * 100 = 71.79\%.$$

This gives a final score for each of the biological agents of 1.

Table 7: Calculation of risk level by biological agent.

After analysing all the variables applied in the Biogaval method and calculating each of them, the formula: $R = G + T + P + F - V - MH$ was applied.

Biological agent	*Risk level (R)*
Escherichia coli	7
Staphylococcus auereus	7
Psedomonas aeroginosa	7
Streptococcus ssp	7
Mycobacterium tuberculosis	9
Human immunodeficiency virus	8
Hepatitis A virus	7

Hepatitis B virus	5
Hepatitis C virus	8
Coronavirus SARS- CoV-2	10
Influenza virus	9

Source: Elaborated by Johanna Mayanquer.

Table 8 Biological Action Level (BAT) and Biological Exposure Limit (BEL).

Biological Action Level (BAT) = 8. Higher values require preventive measures to reduce exposure.

Biological Exposure Limit (BEL) = 12. Higher values represent intolerable risk situations requiring immediate corrective action.

Biological agent	***Risk level (R)***	**NAB**	**LEB**
Escherichia coli	7	No shares	No shares
Staphylococcus auereus	7	No shares	No shares
Psedomonas aeroginosa	7	No shares	No shares
Streptococcus ssp	7	No shares	No shares
Mycobacterium tuberculosis	9	Requires preventive measures	No shares
Human immunodeficiency virus	8	No shares	No shares
Hepatitis A virus	7	No shares	No shares
Hepatitis B virus	5	No shares	No shares
Hepatitis C virus	8	No shares	No shares
Coronavirus SARS- CoV-2	10	Requires preventive measures	No shares
Influenza virus	9	Requires preventive measures	No shares

Source: Elaborated by Johanna Mayanquer.

With the present tabulated results we can observe that the lowest biological risk belongs to the hepatitis B virus, given that its vaccination has been applied to all workers and does not present a relevant degree of incidence. But if we analyse the results, what happens with the Mycobacterium tuberculosis, SARS-coV2, and Influenza bacteria that have a high risk of presentation or contamination to the staff of the clinical laboratory of the Hospital del Angel, which if no emergency measures are taken can cause occupational disease.

The risk estimation analysed showed that no biological agent exceeded the biological exposure limits (BEL), however 4 of them exceeded the biological action level (BAC), which were; influenza virus, SARS-CoV-2 coronavirus and Mycobacterium tuberculosis.

In addition, it was possible to classify the work areas with the highest biological risk, these being the support areas of tuberculosis diagnosis, haematology, blood chemistry and reception with sample taking.

Discussion

In the research carried out in the clinical laboratory of the Hospital del Angel, microorganisms with biological action below the risk limit were identified, and those that exceed this limit are viruses that tend to be in group 3 or 4, which have a higher score when calculating the risk, added to the fact that their routes of contagion tend to be direct, indirect and areas, and also due to the fact that the hygienic measures adopted in the work area tend not to be fully complied with, which does not contribute much to reducing the risk.

It is also important to mention one of the biological agents that currently has proliferated greatly in society, a variant of SARS-CoV-2 known as covid-19, given that in the estimation of this study it presented a risk that must be controlled, being one of those that exceeded the NAB. This is because most laboratories or health institutions operated with limited guidance and uncertainty, as the new SARS-CoV-2 represents a major challenge for several health institutions, as they did not have sufficient protective equipment, which makes their infection cycle much more difficult.

Taking into account studies carried out in the provincial hospital of Ambato - Ecuador, Sailema (2014) carried out a study on the incidence of biological risks in laboratory workers, the results obtained from this research correspond to an ABN exceeded by the biological agents Mycobacterium tuberculosis, HIV, hepatitis B, hepatitis C, and the influenza virus. This is in agreement with what was obtained from the present investigation, however only in relation to influenza virus and Mycobacterium tuberculosis. Since the other biological agents did not exceed the ABN, it should be noted that the results obtained for the hepatitis b virus represented the lowest degree of risk, because 100% of the staff were vaccinated against this disease, which considerably reduced the risk calculation.

The final interpretation is that the handling of biological samples with possible contamination of microbial agents that can cause occupational hazards is still not handled in the correct way, due to the lack of practice and control of biosafety standards.

Conclusions

- The results of the investigation show that none of the biological agents involved exceed the LEB, which is a positive aspect since the workers are not under intolerable risks according to the method applied.
- The bacterium that causes tuberculosis (Mycobacterium tuberculosis) was identified as exceeding the biological action level (BAT) because it belongs to a high-risk group, does not have a vaccine, and its routes of infection are airborne and direct.
- Covid-19, despite the fact that all workers were vaccinated against this virus, exceeded the NAB because it belongs to a high-risk group, its incidence rate was high, and its means of transmission can be direct, indirect and airborne. Covid-19 is a relatively new virus, however, hygienic measures have already been issued and can be used to reduce the level of risk.
- The influenza virus also exceeded the NAB, despite the fact that workers were vaccinated against this virus, it still represents a risk within the laboratory area due to the fact that transmission can be area, indirect and direct, and also because of the high incidence rate it had. In this case it is essential to provide quality equipment and raise awareness among workers for its correct use.

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