Laboratory acquired infections (LAI) are all infections obtained during laboratory work, divided into several types, according to the manner of occurrence. The aim of this paper was to summarize data of LAI and possible reasons that lead to LAI emergence, according to the answers of the employees, in the public health microbiological laboratories in the Republic of Macedonia. A cross-sectional study was conducted in a period of two months (March-April 2014) by distributing a questionnaire to 187 employees in these laboratories. According to the employees’ responses, institutions are not sufficiently equipped with alert systems leading to LAI. The most frequent reports of LAI are from laboratory technicians and employees with longer working experience. There is a clear need for continuous education of the personnel, raising awareness for their protection and job security, as well as implementation of mandatory preventive care.

Abstract

Laboratory acquired infections (LAI) are all infections obtained during laboratory work, divided into several types, according to the manner of occurrence. The aim of this paper was to summarize data of LAI and possible reasons that lead to LAI emergence, according to the answers of the employees, in the public health microbiological laboratories in the Republic of Macedonia. A cross-sectional study was conducted in a period of two months (March-April 2014) by distributing a questionnaire to 187 employees in these laboratories. According to the employees’ responses, institutions are not sufficiently equipped with alert systems leading to LAI. The most frequent reports of LAI are from laboratory technicians and employees with longer working experience. There is a clear need for continuous education of the personnel, raising awareness for their protection and job security, as well as implementation of mandatory preventive care.
INTRODUCTION

Laboratory workers and co-workers employed in microbiological laboratories are at an occupational risk of every-day exposure to microbial pathogens during daily activities, which can cause various infections – ranging from in-apparent to life-threatening infectious diseases.

Laboratory-acquired infections (LAI) are all infections obtained during laboratory work, regardless of their clinical or subclinical manifestations. Since the beginning of the last century, several generations of scientists were aware of the health risk involved with certain microbial agents. For the first time attention to these infections was mentioned by the two German workers, Paneth and Kisskalt, in 1915 and 1929. Until 1978, Pike and Sulkin published four studies describing a total of 4079 cases of LAI between 1930 and 1978, out of which 168 ended with death. These studies concluded that the ten most common causes of LAI among workers in microbiological laboratories were: Brucella spp., Coxiella burnetii, hepatitis B virus (HBV), Salmonella typhi, Francisella tularensis, Mycobacterium tuberculosis, Blastomyces dermatitidis, Venezuelan equine encephalitis virus, Chlamidia psittaci and Coccidioides immitis. The authors emphasize that these cases do not represent all LAI that occurred in that period because many cases were not reported due to asymptomatic or subclinical infections, as well as due to not having always effective monitoring system.

After the publication of Sulkin and Pike, a series of studies followed in the next 20 years; in 1995 Harding and Lieberman published the results of 375 infections or seroconversions that had occurred in 23 laboratories11 while Harding and Byers presented 1267 infections with 22 deaths12. In that period, often isolated cases of LAI were Mycobacterium tuberculosis, Salmonella spp., Shigella spp., and virus B and C hepatitis. The same agents were also encountered at the beginning of this century: shigellosis, salmonellosis, tuberculosis and hepatitis B and C were the top five most common diseases acquired in the microbiological laboratories. In all these reports, only a small percentage of cases were associated with known specific incident or accident in the workplace. In most cases, known data are only contacts with the microbial agent, presence in or around the lab and presence around infected animals.

Jacobson et al. described an annual incidence of about 3 cases per 1000 employees in hospital laboratories. Comparing the data of the first and second half of the last century, when the laboratories started to apply the principles and guidelines for safe laboratory work, as well as security, the number of LAI decreased. However, with insufficient information on the actual number of infections and the population at risk, it is difficult to determine the true incidence of LAI with any degree of certainty. LAI reports should serve as a lesson about the importance of establishing and maintaining safe working conditions in microbiological laboratories, as well as adherence to the basic principles of working from biological biosafety manuals.

According to some authors, laboratory accidents are on the second place as a source of LAI and parenteral inoculation of infectious material as a leading cause. Only needlesticks and cuts represent 25.2% and 15.9% of all types of accidents that result in infection, respectively. However, the fact that the largest number of LAI (80%) are with unknown way of transmission, and due to not provided information about the accident in the workplace, suggest that aerosol particles, invisible to the naked eye, pose the greatest danger. Often, in the laboratory there are possible ways of infection not inherent in the general population. An example of this is brucellosis, which among the general population is commonly obtained by consuming unpasteurized milk and/or cheese from infected animals, while in the laboratory almost always it is acquired through inhalation of aerosols that are released during the manipulation with infectious materials. Also, the eyes are rarely a
front door for entrance of the infection outside the laboratory, but there is an impressive list of infections acquired in this way by laboratory workers. Table 1 shows the routes of exposure that are associated with LAI.

Table 1  Routes of exposure associated with laboratory acquired infections

<table>
<thead>
<tr>
<th>Route of Exposure</th>
<th>Laboratory procedures and / or accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhalation</td>
<td>Spinning, pouring, spraying, blending, grinding, cutting, opening of samples</td>
</tr>
<tr>
<td>Ingestion</td>
<td>Mouth pipetting, eating, drinking, smoking, putting hands in the mouth (eating the nails) and other items (pens, etc.)</td>
</tr>
<tr>
<td>Stinging inoculation</td>
<td>Pin - pricks, cuts from sharp objects, bites from animals or insects, scratches</td>
</tr>
<tr>
<td>Percutaneous or mucosal contamination and intake</td>
<td>Spill, contact with contaminated surfaces, transfer from the hands of the person</td>
</tr>
</tbody>
</table>

There is a lack of official data about LAI in the Republic of Macedonia (RM), hence this information will help the authorities to make decisions on the improvement of the established system for biological safety.

The aim of this study was to summarize the data for LAI and possible factors that could be responsible for occurrence of LAI among employees in the public health microbiological laboratories in RM, according to answers obtained from the employees / laboratory workers and in correlation with their foreknowledge about LAI and biological safety.

**Material and methods**

Data from survey for laboratory safety conducted among employees in public health microbiology laboratories were used as material for this research. The respondents answered a questionnaire where among others, there were 6 questions related to occupational diseases:

(I) “During your years of service, have you got any contagious disease that you would associate with your workplace”;

(II) “Have you been out of work for a longer period because of occupational infectious disease”;

(III) “Is there an evidence in your laboratory for occupational diseases, work injuries or deaths during work”;

(IV) “Is there a reporting system in your laboratory for injuries or accidents during work”;

(V) “Are the first aid boxes in your laboratory easily accessible” and

(VI) “Are you vaccinated against hepatitis B”?

Design of the study, population group and research sample

This cross-sectional study approved by the management of microbiology laboratories all around the country, targeted a total of 213 employees. Number of respondents on the questionnaire from the microbiology laboratories were as followed: (i) in the 10 Centres for Public Health in the cities of: Skopje (21 respondent), Bitola (13), Prilep (10), Ohrid (7), Stip (9), Kumanovo (12), Tetovo (12), Kocani (7), Strumica (6) and...
Veles (8), as well as their regional offices in Kavadarci (4), Gevgelija (4), Debar (3), Struga (4), Gostivar (10), Kicevo (2) and Berovo (3); (ii) the Institute of Public Health of the Republic of Macedonia - Skopje (26) and (iii) the Institute of Microbiology and Parasitology, Faculty of Medicine, University “Ss Cyril and Methodius”, Skopje (26). A total of 173-187 employees out of 213 answered the selected questions (response rate – 81.2 - 87.9 %). The survey was conducted over a period of two months (March-April 2014). Respondents were grouped according to gender, age, education, and work experience.

Statistical analysis

Categorical variables are presented in absolute numbers and frequencies displayed by quantitative descriptive parameters (mean, SD, minimum and maximum). Statistical significance of differences between categorical variables was tested using the Pearson’s Chi-square test, and between numeric sets, Student’s t-test.

Results

Out of total 187 respondents, according the gender most of them - 156 (83.4 %) were female. According the workplace and work duties, 111 (61.3 %) were laboratory technicians, while 37 (20.4 %) were specialists in microbiology and 33 (18.3 %) laboratory staff with other university diploma.

Only 34 (18.7 %) members of the staff gave information about the history of contagious disease probably associated with workplace (question I) (Table 2). Longer absence from work because of occupational disease (infection) could be one of the parameters for LAI, but in our study (question II) only 5.5 % of the participants gave a positive answer (Table 2).

Table 2  Occupational diseases, organization of the evidence of LAI and working conditions

<table>
<thead>
<tr>
<th>Question</th>
<th>Total respondents / Groups</th>
<th>Yes N (%)</th>
<th>No N (%)</th>
<th>I don’t know N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N=182</strong></td>
<td>34 (18.7)</td>
<td>144 (79.1)</td>
<td>4 (2.2)</td>
<td></td>
</tr>
<tr>
<td>Management</td>
<td>0 (0.0)</td>
<td>18 (100)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
<tr>
<td>Microbiologists/University diploma (n=44)</td>
<td>6 (13.6)</td>
<td>35 (79.6)</td>
<td>3 (6.8)</td>
<td></td>
</tr>
<tr>
<td>Laboratory technicians (n=120)</td>
<td>28 (23.3)</td>
<td>91 (75.9)</td>
<td>1 (0.8)</td>
<td></td>
</tr>
<tr>
<td><strong>Pearson Chisquare</strong>: 12.19 df=4 p=0.016</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Length of service ± SD (years)</strong></td>
<td>27.25 ± 10.2</td>
<td>19.83 ± 11.59</td>
<td>18 ± 2.83</td>
<td></td>
</tr>
<tr>
<td><strong>Variation analysis (yes/no)</strong></td>
<td>t = 3.3</td>
<td>p=0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>N=182</strong></td>
<td>10 (5.5)</td>
<td>170 (93.4)</td>
<td>2 (1.1)</td>
<td></td>
</tr>
<tr>
<td><strong>N=178</strong></td>
<td>53 (29.8)</td>
<td>85 (46.6)</td>
<td>42 (23.6)</td>
<td></td>
</tr>
<tr>
<td><strong>N=183</strong></td>
<td>36 (19.7)</td>
<td>143 (78.1)</td>
<td>4 (2.2)</td>
<td></td>
</tr>
</tbody>
</table>
Respondents with LAI have an average length of service of 27.25 ± 10.2 years versus 19.83 ± 11.59 years of respondents who deny infection at the workplace. The difference of 7.45 years of experience between participants with and without occupational disease is statistically highly significant (p = 0.001) (Table 2). Staff with LAI has a significantly longer length of service, which is a risk factor by itself for getting LAI because of the longer exposition time and perhaps considerably worse safety working conditions in the past years. Briefly, laboratory technicians and employees with longer service gave more often data for existing contagious disease probably associated with the workplace (Pearson Chi-square: 12.19 df=4 p=0.016).

There were highly significant differences in the level of education of respondents with LAI (laboratory technicians, microbiology specialists and other employees with university degree (25.9 %, 8.1 % and 6.1 % respectively) (Pearson Chi-square: 15.25 df=4 p = 0.004) (Figure 1).

Work position of participants such as managers, laboratory staff with university diploma and laboratory technicians significantly affect the incidence of occupational diseases (p = 0.016) (0 %, 13.6 % and 23.3 %, respectively) (Table 2). Workers on the managerial positions are rarely directly involved in the laboratory work. They have more responsibilities for the organization of the work.

Regarding the answers to question (IV) “Is there a reporting system in your laboratory for injuries or accidents during work”, institutions are not sufficiently equipped with alert systems in case of injury at the workplace. More than half of the respondents (55.1 %) deny the existence of such system and 16.0 % do not know (Figure 2). These figures suggest that maybe the injuries actually are not adequately reported.

Positive answers to the question about the first aid boxes existing on the strategic locations in the laboratory (question V), were given by only 36 (19.7 %) of 183 respondents (Table 2).

The results of this survey have shown no statistically significant variability in vaccination status to HBV in different working positions such as managers, microbiologists / university diploma staff and laboratory technicians (55.6 %, 50.0 % and 41.0 %, respectively) (Figure 3).
In our study, which was a part of a larger investigation about risk assessment in the microbiology laboratories in our country, 85 (69.1%) of laboratory technicians reported that they were given an explanation for the possible risks associated with the workplace before being assigned to it, while that percentage was higher among respondents with university diplomas and management functions (72.7% and 88.9%, respectively).

Our survey shows similar results as the reports of Jacobson et al. and Harding and Lieberman which means the LAI are underestimated and paid not enough attention. Difficulties in monitoring of occupational diseases arise if the damage is not evidenced or reported immediately. It is often forgotten, because of the long incubation period of some infectious diseases and the emerged symptoms later that cannot be easily linked or associated with the incurred damage.

The research from Japan in 2004 concluded that the most likely reason for the occurrence of infections and diseases related to laboratory work was the lack of biological safety cabinets (BSC). Other risk factors were lack of experience and skills, ignorance or clumsy handling of the equipment. Recently reported case of laboratory-acquired dengue virus in South Korea microbiological laboratory is an example how vector-born disease can easily be transmitted by needle stick injury. Wearing only gloves is not sufficient for the biosafety of laboratory workers in clinical diagnostic laboratories, concluded Duman et al. in their research. Also, a survey conducted in Nigeria explained the disregard of the precautionary measures and embarrassment of reporting injuries as a reason for not reporting. According to these data, only 1.5% of the employees are willing to report accidents at work.

Manuals for working with biological agents as well as the Article 16 paragraph 3 of the “Regulation for the rules on minimum requirements for safety and health at work for employees on risks related to exposure to biological agents (pathogens)” clearly indicates the need to provide appropriate effective vaccines that are available and can prevent disease in staff working with potentially infectious materials.

Newest achievements in microbiology, such as serotyping and PFGE, can be used as supplement for traditional case investigation techniques whenever a microbiologist is injured to validate or refute suspected transmission scenarios or can expose the source of a laboratory-acquired infection.

Conclusions

Only 34 (18.7%) of the employees in the microbiological laboratories in the Republic of Macedonia gave an information about the history of occupational infection during their work experience; most of them were laboratory technicians and staff with longer working service. This fact leads to a conclusion that the lower level of education is often associated with the occurrence of specific diseases. It is often forgotten that these workers are much more and directly exposed to samples with potentially infectious material. More attention should be paid to training the staff with secondary school education.

There is neither effective system to monitor workplace incidents nor first aid boxes at strategic locations, quickly and easily accessible in the microbiology laboratories in RM. Establishment of an effective monitoring system will enable simple chronological tracking of possible infections among employees, and overcome the difficulties associated with incubation time of infections and diseases.

Although vaccination against hepatitis B is compulsory for the exposed persons and available at the same time, a very small percentage of respondents were vaccinated. By raising awareness of the staff for their safety and care in the workplace, hopefully the number of immunized will increase.
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