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Risk assessment in biomedical laboratories – occupational safety and health aspects

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ABSTRACT

Introduction: Laboratory personnel (LP) represent a high-risk group of healthcare workers for whom the primary laboratory environment and specific work activities are a major source of potential exposure to health hazards. This study aimed to evaluate the developed matrix and assess risk based on self-assessment.

Methods: This multicenter, qualitative, and cross-sectional study was conducted on LP employed in biomedical laboratories. The respondents were divided into groups according to their territorial affiliation. The data collection tool used was a six-area questionnaire distributed online through a network of professional associations. For the risk assessment, a matrix was developed with scores ranging from 0 to 650, dividing the risk level into four categories. Descriptive and inferential statistical methods were used for the statistical analysis.

Results: The developed model combined the classification of risk and risk factors with a certainty of $p < 0.001$. The regression analysis showed that working conditions had the greatest influence on overall risk, followed by physical, biological, and chemical hazards. Of the 640 respondents, the medium risk category was the highest in European Union (EU) countries (81.2%). Comparing the values in the high-risk category between the Bosnians and Herzegovinians (BiH) group and the Republic of Serbia, Republic of Northern Macedonia, and Montenegro (SCM) group with the EU group, a doubling (16.6%: 36.7%) and tripling (16.6%: 52.1%) of the proportion was found, respectively ($p < 0.001$). Overall, 1.7% of the LPs from BiH fell into the high-risk category.

Conclusions: The designed matrix provides a reliable basis for identifying risk predictors in the study population and can serve as a useful tool for conducting risk assessments in biomedical laboratories. The results of the risk assessment indicate significant differences between the studied groups and highlight the need for increased control of BiH workplaces through new regulatory requirements.

Keywords: Laboratory personnel; risk assessment; risk analyses; occupational health; occupational safety

INTRODUCTION

Laboratory environments and work activities are constant sources of potential exposure to numerous hazards for Laboratory personnel (LP) (1). The term hazard encompasses a wide range of physical, chemical, biological, mechanical, and environmental health hazards associated with common practices. According to the National Institute of Occupational Safety and Health, there are 29 physical, 25 chemical, 24 biological, 10 ergonomic, and six psychosocial health hazards (2). The health consequences of exposure can vary in severity and depend on the nature of the hazard, route and duration of exposure, protective measures used, and the health status of LP (3-5). Occupational exposure in laboratories often cannot be eliminated but can be minimized by implementing hierarchical control measures (6). Hazards can also arise owing to procedural errors in the laboratory, inadequate preventive measures, knowledge and skills, and inefficient laboratory equipment (3). Furthermore, modern laboratory technologies and the automation of work processes have brought about undeniable positive changes in terms of increased effectiveness and productivity; however, they have not had a significant impact on creating safer environments and controlled

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exposure in laboratories. Research suggests a link between working in modern automated laboratories and additional health problems in the form of non-communicable diseases, particularly musculoskeletal disorders, cognitive overload, and emotional overload (7,8). According to a World Health Organization report, occupational exposure accounts for 37% of back pain, 16% of hearing loss, 13% of chronic obstructive pulmonary disease, 11% of asthma, 8% of injuries, 9% of lung cancer, 2% of leukemia, and 8% of depression (9). As a result, absenteeism from work has increased, and economic losses are in average 4–6% of the GDP. Research shows that preventive health activities in the workplace can contribute to a 27% reduction in absences from work and health-care costs, by an average of 26%. Prevention programs aimed at reducing the negative consequences of occupational exposure can significantly affect mortality rates, especially in underdeveloped countries where 12.2 million people die annually during their active working life (10).

Risk assessment is the basis for determining the category of high-risk workplaces, which are defined as workplaces where, despite fully or partially applied protective measures, circumstances exist that may endanger the safety and health of workers (11). The Risk Assessment Act covers the assessment of work organization, work processes, work requirements, and equipment for personal protection to eliminate risks in the workplace that may lead to injuries, occupational diseases, or work-related illnesses (11,12). For chemical, physical, and radiological hazards, the classification of hazards and risks is simpler and can be determined by measurements (13), whereas for biological agents, it is more challenging, expensive, and often qualitative (14-16). However, despite the preventive measures applied, the susceptibility to injuries in laboratories can be attributed to the inability of LP to recognize a dangerous situation, their reduced awareness of risk exposure over time, or excessive immediate risk exposure. Irresponsible behavior also significantly affects the level of occupational risk in the workplace. People who knowingly take risks, as well as those who ignore preventive measures, not only suffer the consequences of their actions, but also pose a danger to their colleagues, families, and friends (1,17). Risk management in laboratories is a major challenge because the concept of workplace safety, as an imperative of modernity, is an essential, absolute, but unmeasurable property (1). Scientific research in this area is sparse and usually focuses on high-risk groups or larger groups of healthcare workers, mostly nurses and physicians. Few researchers have focused on LP although laboratories have been identified in the literature as high-risk areas for hazard exposure. Most often, researchers evaluate specific hazards, work activities, or routes of exposure (18-25). To the best of our knowledge, studies of occupational risk assessment for this profession are not conducted in BiH. Given the importance of the problem, non-compliance with regulatory requirements, and insufficiently developed awareness of the importance of occupational risk assessment, this study aimed to evaluate the developed matrix and assess risk based on the self-assessment of LP employed in biomedical laboratories.

METHODS

The Ethics Committee of the University of Sarajevo, Faculty of Health Studies approved this multicenter, qualitative, and cross-sectional study. The study was conducted from November 2019 to February 2020 and included LP of all profiles employed in biomedical laboratories in most European countries. The territorial affiliation of the respondents was used as the basis for forming the study groups. The first group included LP from BiH, the second SCM group LP from neighboring countries, and the control group LP from EU countries. The sample size for the territory of BiH was calculated using the Sample Size Calculator software based on the numerical values from the reports of the entities' public health facilities (n = 355). The criteria for participation in the survey applied to the SCM and EU groups. These included voluntary participation in the survey and an active working relationship in public or private laboratories in the study area. Voluntary completion and return of the form were considered consent to participate in the study and to use the data. The exclusion criteria were as follows: The respondent was a LP without an active working relationship in a biomedical laboratory in the study area, the LP did not want to voluntarily participate in the study, and the LP did not return the completed questionnaire.

As a data collection tool in this study, we used a bilingual and anonymous questionnaire with 150 closed-ended questions divided into six basic areas: Sociodemographic characteristics, general issues, work process organization and protective measures in the laboratory, and knowledge, attitude, and practice of LP about workplace hazards. The questionnaire was pretested and validated by 10 experts. The reliability and validity of the instrument were evaluated with Cronbach's alpha and content validity indices of 0.742 and 0.97, respectively (4). Distribution in Google Forms was through networks of professional associations, whose consent had been obtained beforehand. In EU countries, distribution was done through the network of the European Association for Professions in Biomedical Science and the Western Balkans through the networks of the Chamber of Graduate Medical Health Engineers in FBiH and the Association of Laboratory and Sanitary Health Professionals in BiH. To avoid duplicate responses when creating Google forms for each email address, the number of responses was limited to one. An important component of the electronic version was a cover letter describing the importance and purpose of the survey. Because LP is a small and hard-to-reach population, random sampling and the snowball method were used to collect sufficient data.

The starting point for creating a qualitative risk assessment matrix was to form four domains and to group the collected data. Three domains were formed for biological, chemical, and physical hazards and included self-assessed exposure to individual hazards and LP knowledge, attitudes, and practices related to these hazards. The fourth area addressed the equipment and organization of work in the laboratories and focused on available protective measures.

The Risk Assessment Calculator and Risk Score Calculator software (26,27) were used to establish a baseline score (0-10) for each hazard, supplemented by data the on the frequency of exposure, available control measures in the laboratories, and potential health consequences, following the ISO 17025:2017 guidelines. For example, 10 points were assigned for self-reported high and frequent exposure to formaldehyde and 0 points for respondents who had no exposure. The matrix also includes ratings of respondents' knowledge, attitudes, and practices, which are important individual factors in risk assessment. Scoring in this segment was one point for correct responses. Good knowledge was rated with more than 75% correct answers, an average of 50–75%, and inadequate knowledge with < 50%. Accordingly, in the risk assessment matrix for each hazard group, respondents with insufficient knowledge were assigned a maximum of 10 points, an average of 7.5 points, and good 5 points. Points for variables in the fourth domain were assigned in the same manner. If the laboratory was not equipped with a biosafety cabinet or fume hood, 10 points were assigned; otherwise, 0 points were assigned. LPs who worked overtime in shifts were assigned 10 points, 5 points for occasional overtime, and 0 points for no overtime. The range of points in the created matrix ranged from 0 to 650, with 0–100 points individually assigned to the areas of self-assessed exposure; respondent knowledge, attitude, and practice related to biological and chemical hazards; physical hazards 0–165; and laboratory equipment and work organization 0–270. Occupational risk LP was based on the score obtained and was divided into four categories: low (0-154), medium (155-307.5), high (307.6-460), and very high (≥461).

After conducting the study, the collected data were entered into an electronic database created using Microsoft Excel 2016. Categorical variables were represented by frequencies as absolute numbers or percentages. Descriptive statistical analysis results are presented as percentiles. The Chi-square test was used to examine the differences between the expected and observed values. The Kruskal–Wallis H test was used to test for differences in the sum of risk values. Linear regression was used to test and model the relationships between a variable labeled Y and one or more variables on X. The statistical program IBM SPSS Statistics 26.00 (IBM Corporation, Armonk, New, United States of America) was used for statistical data processing. Statistical significance was set at $p \leq 0.05$.

RESULTS

A total of 640 LP participated in this study (Table 1). The majority of respondents were women ($p = 0.003$), with up to 5 years of service ($p = 0.351$), and public sector employees ($p = 0.111$). About one-third of the respondents in the BiH and EU groups were between 26 and 35-years-old and in the SCM group between 36 and 45 years ($p = 0.168$). Statistically significant differences were found in the educational levels of the respondents ($p < 0.001$). More than half of the respondents in the BiH and EU groups (63.4% and 62.4%, respectively) had a university degree, and 44.9% in the SCM group had a high school degree. Half of the respondents in the BiH and SCM groups were employed in biochemical laboratories and in the EU group approximately one-third (29.3%) in microbiological laboratories ($p < 0.001$). More than half of the respondents in the SCM and EU groups reported that risk assessment in their working institution was previously performed (55.1% and 57.5%, respectively), and on the BIH territory for about a quarter of the respondents (24.7%) ($p < 0.001$).

TABLE 1. Sociodemographic characteristics of the respondents

Variables	BiH (%)	SCM (%)	EU (%)	χ^2 test	*p*-value
Gender					
Male	24.7	26.5	12.7	11.862	0.003
Female	75.3	73.5	87.3		
Age (years)					
18–25	9.4	5.1	7.2	11.649	0.168
26–35	35.2	33.7	28.7		
36–45	29.1	34.7	26.5		
46–55	17.7	15.3	26.9		
56–65	8.6	11.2	11.6		
Education level					
High school	32.7	44.9	11.0	91.497	<0.001
College	3.9	16.3	26.5		
University	63.4	38.8	62.4		
Length of service (year)					
0–5	35.7	31.6	29.8	8.897	0.351
6–10	15.0	7.1	14.4		
11–20	21.9	26.5	26.0		
21–30	18.3	21.4	17.1		
>30	9.1	13.3	12.7		
Laboratory					
Biochemical	52.9	55.1	20.4	62.927	<0.001
Microbiological	20.8	15.3	29.3		
Histopathological	6.9	10.2	11.6		
Environmental	6.6	10.2	14.4		
Other	12.7	9.2	24.3		
Sector					
Public	80.1	89.8	83.8	4.403	0.111
Private	16.1	10.2	16.1		
Risk assessment					
Conducted	24.7	55.1	57.5	89.108	< 0.001
Not conducted	54.3	26.5	18.8		
For certain workplaces	15.8	17.3	19.3		
For certain hazards	19.0	1.0	4.4		

Table 2 shows the percentiles for hazard groups; knowledge, attitude, and practice of respondents; working conditions in laboratories; and the total score obtained for occupational hazards. Analysis of the scores obtained showed that BiH respondents had the highest mean scores for five categories (biological Q2 = 48.5, physical Q2 = 50.0, ergonomic Q2 = 30.0; knowledge, attitude, and practice of respondents Q2 = 187.5; and working conditions Q2 = 115.0). The SCM group had the highest mean scores for chemical hazards (Q2 = 45.0), whereas the EU group had the lowest scores for the same variables. For psychosocial hazards, the mean score was equal in all groups (Q2 = 16.0). The overall mean risk was highest in the BiH group, with 304.5, 283.9, and 252.0 points in the neighboring and EU groups, respectively. Using the Kruskal–Wallis H test, statistically significant differences were found between the groups in terms of individual risks. Statistically significant differences at the $p = 0.001$ level were found for chemical hazards (H = 16.868), physical hazards (H = 43.429), the knowledge, attitude, and practice of respondents (H = 21.798), working conditions (H = 120.570), and

TABLE 2. Percentile of hazard groups and risk score

Variables	BiH			SCM			EU		
	Q_1	Q_2	Q_3	Q_1	Q_2	Q_3	Q_1	Q_2	Q_3
Chemical	32.5	40.0	57.5	27.5	45.0	65.0	27.5	35.0	47.5
Biological	40.0	48.5	63.5	37.5	47.5	60.0	40.0	45.0	52.5
Physical	37.5	50.0	60.0	30.0	42.5	57.5	27.5	37.5	50.0
Ergonomic	24.0	30.0	34.0	23.0	28.0	32.0	26.0	29.0	32.0
Psychosocial	11.0	16.0	23.0	11.0	16.0	21.0	11.0	16.0	23.0
Knowledge, attitude and practice	156.0	187.5	221.0	156.5	178.0	216.0	146.5	174.5	193.0
Working conditions	90.0	115.0	145.0	75.0	95.0	115.0	60.0	75.0	100.0
Total risk score	265.0	304.5	347.0	246.5	283.0	319.5	215.0	252.0	283.0

overall risk (H = 97.517). For biological hazards, the *p*-value was 0.013 (H = 8.694), whereas there were not statistically significant differences in ergonomic and psychosocial hazards ($p = 0.147$, H = 3.828, $p = 0.800$, and H = 0.445, respectively).

According to the results presented in Table 3, a statistically significant difference was observed based on the distribution of respondents by risk category in the study groups ($p < 0.001$). The low-risk category was found in 0.3% of the respondents in the BiH, 1.0% in SCM countries, and 2.2% in the EU group. The medium-risk category was highest in the EU (81.2%), whereas it was lower in the other groups (46.0% and 62.2%). In the EU group, 16.6% of respondents were in the high-risk category, in the SCM group 36.7%, while in the BiH 52.1% were represented. Comparing the values in the high-risk category between the BiH and SCM groups with the EU, a double (16.6%: 36.7%) and triple (16.6%: 52.1%) increase in representation was noticeable. Overall, 1.7% of BiH laboratory professionals were in the extremely high-risk category.

Table 4 shows the results of risk categorization by educational level and seniority of LP. In all groups studied, the lowest representation was observed in the low-risk categories, regardless of professional qualification (0.0-2.7%) and seniority (0.0-14.3%). The medium-risk category has the lowest representation in BiH and the highest in the EU, whereas an inverse distribution is observed in the high-risk category, regardless of professional qualification. In the EU group, the proportion of high-risk individuals ranged from 12.5% with a higher vocational education to 20.0% with an intermediate vocational education. In the SCM group, about a quarter of the respondents with higher education were at higher risk than half of the respondents with higher education. A total of 45.4% of the respondents with higher education in BiH were in the high-risk category, 61.9% had secondary education, and 78.6% had higher education. Very high risk was found among LP in BiHs with secondary and higher education (3.4% and 0.9%, respectively) and work experience of 6–10 years and 21–30 years (2.5% and 6.1%, respectively). The category of medium risk was also least represented in BiH (31.8-66.7%), except for the group of respondents with 6-10 years of work experience in neighboring countries (42.9%). The medium-risk category is the most represented in the EU (69.6-85.2%), while the opposite distribution is observed in the high-risk category. In the SCM group, the percentage of high-risk individuals ranged from 15.4% in the group of respondents with more than 30 years of work experience to a fourfold increase (71.4%) in the group of 21 to 30-years-old. High risk was lowest in 33.3% of respondents with 6–10 years of service in Bosnia and Herzegovina, and highest (60.6%) in the groups of 21–30-year-olds and those with more than 30 years of service.

According to the results presented in Table 5, the lowest representation in the low-risk (0.3-2.8%) and extremely high-risk (0.0-2.0%) categories was found in public sector laboratories. The medium-risk category is more represented in the private sector (60.3-86.1%) than in the public sector, while an inverse distribution was found in the high-risk

TABLE 3. Classification of occupational risk in the studied groups

Group	Risk category (%)				χ^2 test	*p*-value
	Low	Medium	High	Very high		
BiH	0.3	46.0	52.1	1.7	73.887	<0.001
SCM	1.0	62.2	36.7	0.0		
EU	2.2	81.2	16.6	0.0		

TABLE 4. Classification of occupational risk according to level of education and duration of work experience

Variable	Group	Risk category (%)			
		Low	Medium	High	Very high
Education level					
High school	BiH	0.8	33.9	61.9	3.4
	SCM	0.0	59.1	40.0	0.0
	EU	0.0	80.0	20.0	0.0
College	BiH	0.0	21.4	78.6	0.0
	SCM	0.0	50.0	50.0	0.0
	EU	2.1	85.4	12.5	0.0
University	BiH	0.0	53.7	45.4	0.9
	SCM	2.6	71.0	26.3	0.0
	EU	2.7	79.6	17.7	0.0
Length of service (years)					
0–5	BiH	0.0	49.6	50.4	0.0
	SCM	0.0	74.2	25.8	0.0
	EU	3.7	85.2	11.1	0.0
6–10	BiH	0.0	66.7	33.3	0.0
	SCM	14.3	42.9	42.9	0.0
	EU	3.8	73.1	23.1	0.0
11–20	BiH	0.0	40.5	57.0	2.5
	SCM	0.0	69.2	30.8	0.0
	EU	2.1	85.1	12.8	0.0
21–30	BiH	1.5	31.8	60.6	6.1
	SCM	0.0	28.6	71.4	0.0
	EU	0.0	83.9	16.1	0.0
>30	BiH	0.0	39.4	60.6	0.0
	SCM	0.0	84.6	15.4	0.0
	EU	0.0	69.6	30.4	0.0

category. In both sectors, the share of the high-risk category is approximately twice as high when comparing the EU and SCM and 3 times as high when comparing the EU and BiH. The lowest proportion of the low-risk category was found in biochemical laboratories in the SCM group (1.9%), and in environmental laboratories in the BiH (4.2%) and EU groups (3.8%). The exceptionally high-risk category was found in biochemical (0.5%), microbiological (2.7%), and histopathological and molecular laboratories (12.0%) in the territory of BiH. The distribution of respondents in the medium-risk category was lowest in BiH in all laboratories (38.7-70.8%) and highest in the EU (79.2-82.8%). In the high-risk category, the opposite distribution of representation was observed. In BiH, the proportion of high-risk laboratories ranged from 25.0% in environmental laboratories to 60.7% in biochemical laboratories, while in the SCM group, about one-third of respondents in all laboratories fell into this category. In the EU group, the prevalence of high risk ranged from 15.1% in microbiological laboratories to 19.0% in histopathological laboratories.

A model of the influence of the individual factors was established (Table 6). Based on the Analysis of variance test, the created model, with a certainty of $p < 0.001$, connects the classification of risk and risk factors. The strength of the relationship is at the level of 0.834 and describes 69.6% of the risk variance.

TABLE 5. Categorization of occupational risk by sector and type of laboratory

Variable	Group	Risk category (%)			
		Low	Middle	High	Very high
Sector					
Public	BiH	0.3	43.2	54.5	2.0
	SCM	1.1	60.2	38.6	0.0
	EU	2.8	80.0	17.2	0.0
Private	BiH	0.0	60.3	39.7	0.0
	SCM	0.0	80.0	20.0	0.0
	EU	0.0	86.1	13.9	0.0
Laboratory					
Biochemical	BiH	0.0	38.7	60.7	0.5
	SCM	1.9	55.6	42.6	0.0
	EU	0.0	83.8	16.2	0.0
Microbiological	BiH	0.0	50.7	46.7	2.7
	SCM	0.0	73.3	26.7	0.0
	EU	0.0	79.2	15.1	0.0
Environmental	BiH	4.2	70.8	25.0	0.0
	SCM	0.0	70.0	30.0	0.0
	EU	3.8	80.8	15.4	0.0
Histopathological	BiH	0.0	40.0	48.0	12.0
	SCM	0.0	70.0	30.0	0.0
	EU	0.0	81.0	19.0	0.0
Others	BiH	0.0	58.7	41.3	0.0
	SCM	0.0	66.7	33.3	0.0
	EU	0.0	81.8	18.2	0.0

Regression analysis showed that working conditions had the highest influence on overall risk, followed by physical, biological, and chemical hazards (Table 7). Working conditions had the highest degree of association with risk categorization. The Pearson classification showed a degree of association of 0.655 ($p < 0.001$) with joint growth.

DISCUSSION

The main variables in the overall risk assessment are the activities in the laboratory, deficiencies in the design of the facility, and elements of the safety program such as staff training and the characteristics of the preventive barriers implemented. It is impossible to eliminate all risk factors to which LP is exposed, but it is possible to assess the risk and focus efforts on reducing the most dangerous factors. According to the results of the qualitative risk assessment, more than half of the respondents from the territory of BiH were in the category of “high risk” and 1.7% were in the category of “very high risk.” As the most important predictors in risk assessment, we found a lack of laboratory equipment and organization of the work process. These results are significant because according to the current guidelines the characteristics of the work facility are a mandatory category in risk assessment (28). Our results can be related to the study conducted in Croatia, where risk assessment is focused on individual workplaces according to the acquired professional qualifications. Despite the differences in risk assessment matrices, most variables were used in both studies. All workplaces were identified as high risk for biological agents and medium risk for mechanical hazards, chemical agents, and statodynamic and psychophysiological stress. These workplaces were classified as potentially high-risk for which theoretical and practical training in safe work must be provided. We agree with the researchers that standardized operating procedures and the use of personal protective equipment are essential for safe work in laboratories and that an assessment of the work process is necessary to declare tasks with special working conditions (29). Due to the lack of studies aimed at assessing the overall risk and presenting the results of hazard exposure, we were able to correlate our results with the results of risk assessment for individual hazards because the same variables were assessed. In addition, the lack of publications can be justified by the recent legislation, especially in BiH, as the new Occupational Safety Law was adopted in 2020. From this point of view, the new law has brought many improvements in terms of defining the methodology for risk assessment and improving working conditions, and we expect that research in this area will be more numerous in the future. In addition, part of the available publications was based on different models of risk assessment in laboratories, and they were not compatible for comparison (30-32).

Our results are consistent with several studies, even though they focused on different hazards or work activities. Taheri

TABLE 6. Regression analysis of the risk assessment model

Model	R	R^2	Stand. R^2	SE	Changes in model-statistic				
					R^2	F	df1	df2	p
1	0.834	0.696	0.694	0.29232	0.696	363.123	4	635	0.000

Predictors: (Constant), physical hazards, working conditions, chemical hazards, biological hazards

TABLE 7. Testing the coefficients of the model

Model 1	Coefficients							
	Unstandard coeff.		Stand. coeff.	t	Sig.	Correlations		
	B	SE	Beta			Zero order	Partial	Part
Constant	0.460	0.054		8.530	0.000			
Working conditions	0.008	0.000	0.529	23.191	0.000	0.655	0.677	0.508
Biological hazards	0.007	0.001	0.207	8.304	0.000	0.450	0.313	0.182
Chemical hazards	0.006	0.001	0.193	8.254	0.000	0.400	0.311	0.181
Physical hazards	0.007	0.001	0.294	11.067	0.000	0.606	0.402	0.242

Dependent variable: Risk category

et al. (33) compared quantitative and qualitative methods for assessing the health risks posed by LP when exposed to carcinogenic and non-carcinogenic chemicals. In their study, both methods established the presence of high risk, but the authors recommended comparative use to obtain accurate results. Their conclusion supports the statement that no single method is considered correct (34). Davardoost and Kahforoushan (35) conducted a quantitative risk assessment of exposure to volatile organic compounds to evaluate air quality in laboratories. Health risks were assessed by comparing measured levels with permissible exposure levels. Based on the above parameters and the modeling results 8 h after emission, it was found that the levels were several times higher than the permissible levels. Due to the high risk, long-term laboratory work was not recommended for LP, while a minimum distance of 1.8–3 m from the chemical source was recommended for short-term exposure of 1 h. In a study by Peng et al. (36), although no independent risk assessment was conducted, in the light of scientific studies, they considered that the key to reducing the high risk is the implementation of special education and training of LP in the handling of hazardous biological agents, the need to apply work procedures, and the existence of protective barriers. Agrawal et al. (24) reported a risk assessment for the occurrence of musculoskeletal disorders in a population of interest. Among subjects without diseases, high risk was found in 83.9% of LP who worked in a standing position, 83.8% of subjects who pipetted, 80% who were not assigned specific tasks, and 76.4% who were required to work behind a microtome. The high risk of LP for musculoskeletal disorders ranged from 16% for standing tasks to 50% for microscopy.

Although our research did not focus on the current COVID-19 pandemic, it is important to emphasize that it revealed organizational shortcomings and unpreparedness of health care systems around the world (37), but additionally importance of risk assessment and risk management in laboratories. Lessons learned from the previous pandemics have demonstrated the importance of strengthening laboratory capacity to create the conditions for safe handling of unknown pathogens (38), but also the importance of risk assessment in crisis situations (25). With tremendous effort, the characteristics of the Sars-CoV-2 virus were demystified relatively quickly. At the same time, recommended safety measures for working with an emerging pathogen were successively modified. It is now known that certain procedures can be performed at the biosafety Level II when diagnosing an emergent pathogen classified in the risk Group III, effective disinfectants and the necessary protective equipment are known, and the risk for diagnostic procedures when manipulating various biological specimens has been evaluated. The importance of controlled air exchange and appropriate high-efficiency particulate air filters to reduce the occupational risk of aerosol transmission of SARS-CoV-2 virus in laboratories was particularly emphasized (25,38,39). We support the conclusion of Vijayan (25) that health-care facilities in non-pandemic times need to have developed strategies that can be implemented quickly and reviewed regularly. The aim of the activities should be to protect the health of LP so that they can make a comprehensive professional contribution.

CONCLUSIONS

The designed matrix provides a reliable basis for identifying risk predictors in the study population and can serve as a useful tool for conducting risk assessments in biomedical laboratories. According to the research results, more than half of the laboratory workers in BiH fall into the category of high and very high risks in the workplace. Significant differences in the level of risk between the examined groups indicate the necessity of taking urgent measures with the aim of protecting health and preserving the functional capacity of LP in BiH. These results are a direction to the management of health-care facilities in BiH to take control measures to reduce undesirable consequences of occupational exposure. In addition, we consider it necessary to harmonize legislation with the EU acquis, which would provide a basis for timely risk assessments.

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DECLARATION OF INTERESTS

There are no conflicts of interest to declare by any of the authors of this study.

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