

RISK FACTORS FOR THE OCCURRENCE OF ACCIDENTS IN TEACHING AND RESEARCH LABORATORIES IN A BRAZILIAN UNIVERSITY (2012)

FATORES DE RISCO PARA A OCORRÊNCIA DE ACIDENTES EM LABORATÓRIOS DE ENSINO E PESQUISA EM UMA UNIVERSIDADE BRASILEIRA (2012)

FACTORES DE RIESGO PARA LA INCIDENCIA DE ACCIDENTES EN LABORATORIOS DE INVESTIGACIÓN Y ENSEÑANZA DE UNA UNIVERSIDAD BRASILEÑA (2012)

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ABSTRACT

This study aimed to analyze the main factors associated with the occurrence of accidents involving biological, chemical, or perforating-cutting agents in laboratories at the Federal University of Minas Gerais (UFMG), Belo Horizonte, Brazil. A cross-sectional and analytical study was conducted applying a questionnaire to 271 lab employees at three academic units of the university in 2012. Screening procedures to determine some characteristics potentially associated with the occurrence of accidents was performed by univariate statistical tests. The verification of main risks or protective factors for the occurrence of accidents was performed by means of the fit of multivariate models ($p \leq 0.05$). It was verified that a range of 70.5% to 97.3% people were exposed to risk factors, and 48.0% of the respondents were accident victims in the School of Veterinary Sciences, 34.4% were injured in the Dental School, and 23.0% were injured in the Medical School. Factors, such as the individuals' job, hours worked per day, years worked in the lab, working under pressure and stress conditions, the providing of instructions regarding laboratory procedures, knowledge about the operational flow adopted in the case of accidents, and the knowledge about protocols to report accidents were quantified as main risk factors influencing the occurrence of some accidents. It was therefore concluded that the occurrence of accidents is most commonly associated with the characteristics regarding conduct in laboratory activities, followed by the influence of structural factors.

Keywords: Biological Accidents and Events; Accidents and Events with Hazardous Materials; Chemical Accidents and Events; Occupational Health; Occupational Risks.

RESUMO

O estudo teve o objetivo de analisar os principais fatores associados à ocorrência de acidentes envolvendo agentes biológicos, materiais perfurocortantes ou compostos químicos em laboratórios de ensino e pesquisa de uma universidade brasileira. Trata-se de estudo transversal e analítico, com aplicação de questionário a 271 indivíduos que desenvolviam atividades laboratoriais em três unidades acadêmicas da Universidade Federal de Minas Gerais em 2012. A triagem de características potencialmente associadas à ocorrência de acidentes foi realizada por testes estatísticos univariados. A verificação dos principais fatores de risco ou proteção para a ocorrência de acidentes foi feita por modelos de análise multivariada ($p \leq 0,05$). Constatou-se que 70,5 a 97,3% dos indivíduos estavam expostos aos riscos estudados, com 48,0% dos entrevistados acidentados na Escola de Veterinária, 34,4% na Faculdade de Odontologia e 23,0% na Faculdade de Medicina. Os principais fatores relacionaram-se a práticas tais como a função dos indivíduos, quantidade de horas trabalhadas por dia, número de anos trabalhados em laboratório, trabalho em condições de pressão psicológica e estresse, fornecimento de orientações sobre os procedimentos laboratoriais, conhecimento do fluxo operacional caso ocorram acidentes e conhecimento sobre os protocolos para notificação desses agravos. Concluiu-se que a ocorrência de acidentes está associada às condutas adotadas no desenvolvimento de atividades laboratoriais e, secundariamente, à influência de características estruturais.

Palavras-chave: Acidentes e Eventos Biológicos; Acidentes e Eventos com Materiais Perigosos; Acidentes e Eventos Químicos; Saúde do Trabalhador; Riscos Ocupacionais.

RESUMEN

El objetivo de este estudio fue analizar los principales factores vinculados a la incidencia de accidentes con agentes biológicos, objetos punzocortantes o productos químicos en laboratorios de enseñanza e investigación de una universidad brasileña. Se realizó un estudio transversal y analítico con un cuestionario a 271 personas que trabajaban en los laboratorios de tres facultades de la Universidad Federal de Minas Gerais (2012). La detección de características potencialmente relacionadas a la incidencia de accidentes fue realizada mediante la utilización de pruebas univariadas. Se efectuó la verificación de los principales factores de riesgo y de protección para la incidencia de accidentes por los modelos de análisis multivariados ($p \leq 0.05$). Entre 70,5% y 97,3% de las personas estuvieron expuestas a los riesgos estudiados. El 48,0% de los accidentados era de la Facultad de Veterinaria, el 34,4% de la Facultad de Odontología y el 23,0 % de la Facultad de Medicina. Se confirmó que los principales factores están relacionados con las prácticas: tales como la función de los individuos, la cantidad de horas de trabajo por día y de años trabajando en el laboratorio, trabajo en condiciones de presión psicológica y/o estrés, orientaciones sobre procedimientos, disponibilidad de orientaciones sobre procedimientos y operaciones en el laboratorio, conocimiento de protocolos de notificación de accidentes. Se llegó a la conclusión que la incidencia de accidentes está relacionada con las conductas adoptadas en el desarrollo de actividades de laboratorio y, también, con la influencia de las características estructurales.

Palabras clave: Accidentes y Eventos Biológicos; Accidentes y Eventos con Materiales Peligrosos; Accidentes y Eventos Químicos; Salud Laboral; Riesgos Laborales.

INTRODUCTION

Teaching and research institutions have a relatively high number of researchers, faculty members, students, workers, and interns. This group of individuals develops activities that handle biological, chemical, or perforating-cutting materials.¹⁻⁸ In this context, the biological risk is characterized by the handling of pathogenic microorganisms, animal carcasses, and materials contaminated by them. The perforating-cutting risk stems from the handling of objects and perforating-cutting materials. The chemical risk is characterized by the handling of toxic and hazardous chemical substances and waste from these substances.¹ In some cases, the accidents in laboratories involving the aforementioned risks can lead to the transmission of infectious and contagious diseases in individuals who work in laboratory environments.⁹⁻¹⁶

Accident prevention is one of the main premises to be dealt with in high-risk activities in the field of healthcare, where many accidents are caused by human error, most likely resulting from a deficient educational system and the lack of a safety culture.¹³⁻¹⁹ To prevent accidents, what is needed is a broad range of knowledge related to risk factors and protection in laboratory activities. In this sense, the analysis of work processes is important, as it allows one to identify the transformations that need to be introduced in a laboratory environment in order to improve its working and health conditions.^{6,20,21} However, the majority of studies concerned with risk factors and the prevention of accidents tend to give priority to incidents in public health, clinical, and hospital laboratories. The events registered in the laboratories of teaching and research institutions, as well as the respective factors associated with these occurrences, are scarce in the literature. For this reason, the development of studies on the accidents that occur in teaching and research laboratory environments are essential, in an attempt to provide better knowledge of these and, consequently, to improve prevention strategies.

The characteristics of laboratory environments and the activities developed within them can influence the occurrence of accidents, be they of biological, perforating-cutting, or chemical etiology. Nevertheless, few studies have assessed these characteristics jointly to quantify and verify the main risks and protection factors, which constitutes a problem in combating them. The present study was formulated in an attempt to verify the influence of these factors on the occurrence of accidents, aimed at identifying the main environmental and operational factors associated with these occurrences in the teaching and research laboratories of the Federal University of Minas Gerais (UFMG).

MATERIALS AND METHODS

The present study follows an observational, cross-sectional, and analytical design developed at UFMG in the teaching and research laboratories of three academic units (School of Veterinary Sciences, Dental School, and Medical School) between 2012 and 2013, with prior authorization from the three units for the development of this study on their premises.

The definition of the number of interviewed participants was formulated and stratified according to the number of individuals involved in the laboratories and according to the results of a pilot trial carried out at the School of Veterinary Sciences (UFMG). This trial confirmed the general expected prevalence of 30% of accidents, which was used to define the number of individuals for the sample to reach a confidence interval of 95% and a standard deviation of 20%. A total of 40% of the individuals from each laboratory was recruited in a randomized sample for all categories that work in the teaching, research, and extension laboratories from the chosen units. Thus, 271 individuals were interviewed, with 75 from the School of Veterinary Sciences, 93 from the Dental

School, and 61 from the Medical School. None of the invited individuals refused to participate in the study.

A semi-structured questionnaire was drawn up, aimed at verifying the risk factors that existed within the teaching and research laboratories and at identifying the accidents that had occurred. The questionnaire contained a total of 52 questions, including dichotomous questions related to the laboratory environment and to the performance of laboratory activities. The questions referent to the perception of individuals as regards the aspects inherent to the risks that exist in the laboratory environment, followed the Likert scale.^{8,12,22} Some of the questions contained another variable, in turn formulating a databank containing 88 variables. The research project was submitted to and approved by the UFMG Research Ethics Committee and is duly logged under protocol number CAAE - 01849512.0.0000.5149 527. The questionnaire was applied in a location that respected privacy and confidentiality during data collection. The interviewed participants signed a Free and Informed Consent Form immediately before the questionnaire was applied.

The simultaneous assessment of the different factors related to the occurrence of accidents in the laboratories was conducted based on multivariate models of logistic regression and Poisson regression, which, respectively, provided the odds ratios (OR) and prevalence ratios (PR), as well as their confidence intervals of 95% (CI 95%). The procedures for statistical design were executed in a manner similar to that demonstrated by Dohoo et al.⁵, using the Stata® 12.0 software (StataCorp, USA). Three models were constructed, with one for accidents with biological agents, one for accidents with perforating-cutting materials, and another for accidents involving chemical compounds.

This study conducted a preliminary screening of the variables to be inserted in the logistic models through the Pearson chi-squared test, the Fisher exact test, and the univariate logistic regression (valor $p \leq 0.20$). Variables selected in this screening were included in the preliminary models of logistic regression or of Poisson regression. The variables that presented a significant OR ($p \leq 0.05$) or whose removal would lead to a mismatch in the final model were maintained. The verification of the adjustment of these models was performed using the Wald test ($p \leq 0.05$) and the Hosmer-Lemeshow test ($p > 0.05$). Other parameters were also adopted here, such as the verification of the area under the curve of the Receiver Operating Characteristic (ROC), as well as the selection of the largest pseudo-coefficients of determination, sensitivity, and specificity of the models. In the Poisson regression model, the coefficient values of determination and Pearson's chi-squared test were considered to verify the model's adjustment quality.

RESULTS

Considering the three academic units, the occurrence of 102 accidents was observed, given that some of the individuals were involved in more than one accident. In this light, 82 (35.62%) individuals had suffered at least one accident in a laboratory. Of these, 19 (18.62%) accidents involved biological agents, 67 (29.13%) involved perforating-cutting materials, and 16 (6.95%) involved chemical compounds.

The non-occurrence of accidents among individuals that were not exposed to biological risks resulted in the removal of the exposure to biological agents variable from the logistic models. Table 1 presents the variable included in the definitive logistic regression model referent to accidents with biological agents. This model shows the main factors associated with the occurrence of accidents with infectious and/or biological materials in laboratories.

Table 1 - Characteristics predisposed to the occurrence of accidents with biological and infectious agents in employees of teaching and research laboratories at UFMG. 2012

Characteristic	Odds Ratio (Confidence Interval, 95%)	P-value
Working under psychological pressure and stress conditions	21.09 (3.56-124.81)	0.001
Academic unit	3.41 (1.19-9.77)	0.022
Occurrence of accidents with chemical agents	2.98 (0.32-27.62)	0.336
Interviewed participant's job	1.76 (0.95-3.27)	0.071
Number of hours worked in the laboratory per day	1.22 (1.007-1.49)	0.042
Knowledge about the operational flow in case of accidents	0.34 (0.16-0.72)	0.005
Individual vaccinated against hepatitis	0.14 (0.003-0.59)	0.008

Number of valid observations: 169.

P-value for the model's adjustment quality in the Wald test: < 0.001.

P-value for the model's adjustment quality in the Hosmer-Lemeshow test: 0.2983.

Area under the Curve of the Receiver Operating Characteristic (ROC): 90.36%.

Table 2 presents the variables included in the definitive logistic regression model with the main factors associated with the occurrence of accidents with perforating-cutting materials. Some variables, though they in fact lost their significance, were maintained so that the definitive logistic model would not be mismatched.

The main risk factors for the occurrence of accidents with chemical compounds were selected by the Poisson regression model due to the lesser frequency of occurrence of this type of accident in the studied environments (Table 3).

Table 2 - Characteristics predisposed to the occurrence of accidents with perforating-cutting materials in employees of teaching and research laboratories at UFMG, 2012

Characteristic	Odds Ratio (Confidence Interval, 95%)	P-value
Work under pressure and stress	10.35 (2.14-49.96)	0.004
Occurrence of accident with infectious and biological agents	5.39 (0.87-33.07)	0.069
Notion that the perforating-cutting materials represent a risk	3.30 (1.07-10.11)	0.036
Interviewed participant's job	1.49 (1.02-2.18)	0.036
Number of years worked in the laboratory	1.03 (0.98-1.09)	0.163
Existence of protocols to report accidents	0.26 (0.10-0.71)	0.009
Knowledge about the operational flow in case of accidents	0.20 (0.09-0.43)	<0.001

Number of valid observations: 135.
 P-value for model's adjustment quality in the Wald test: < 0.001.
 P-value for model's adjustment quality in the Hosmer-Lemeshow test: 0.1241.
 Area under the Curve of the Receiver Operating Characteristic (ROC): 90.77%.

Table 3 - Characteristics predisposed to the occurrence of accidents with chemical compounds in employees of teaching and research laboratories at UFMG, 2012

Characteristic	Odds Ratio (Confidence Interval, 95%)	P-value
Working when exhausted	3.27 (1.03 a 10.34)	0.043
Provide instructions regarding laboratory operations per colleague	2.28 (1.07 a 4.86)	0.032
Existence of protocols to report accidents	0.52 (0.23-1.15)	0.110
Knowledge of operational flow in case of accidents	0.35 (0.17-0.72)	0.005

Number of valid observations: 210.
 P-value in the Pearson's chi-squared test for model's adjustment quality: 1.000.
 Coefficient of determination: 1.100.

DISCUSSION

The frequency of occupational accidents observed in the present study is in agreement with findings from another study,²³ which suggests that the frequency of occupational accidents involving students can be considered high. Nevertheless, information regarding the occurrence of laboratory accidents involving students from higher education courses in Brazil is sparse, since the majority of investigations on this type of accident are done by the nursing staff in large hospitals, where hospital infection control commissions execute the role of surveillance and maintain the preventive measures for occupational accidents and the control of the risk of crossed infections.³ The present work observed that the accidents in laboratories that happened more frequently were those involving perforating-cutting materials, as observed in other studies.^{17,18}

The results of the present study disagree with those described in a survey conducted from 1998 to 2002 in public health laboratories, which found that the most common type of accident was that involving biological materials, followed by those caused by perforating-cutting materials.¹⁹ The accidents are often related, since an accident with perforating-cutting materials can also characterize a scenario of chemical or biological risk owing, respectively, to the release of chemical and toxic reagents or to contamination by pathogenic microorganisms. This high degree of association between the types of accidents may well be the cause of differences in the occurrence rate of these, as can be observed in the cited studies.

Statistical analyses showed that the "availability of personal protection equipment" (PPE) and of "collective protection equipment" (CPE) had no influence on the occurrence of accidents, which suggests that the availability of PPE and CPE in the laboratories is insufficient to prevent accidents. Other requirements, such as the correct and complete use of such equipment and instructions for the proper use of these, can be more important in the prevention of accidents, as shown in other studies.^{19,21}

The non-reporting of accidents in individuals who are not exposed to biological risks demonstrates that the respondents are aware of this exposure. This indicates that the unawareness of risk can contribute to the underreporting of accidents when one considers that the occurrence stems from reasons that are not related to the laboratory activities. In this sense, assessment performed by individuals who are not employees of the laboratories, even if they are employees of the institution, could contribute to the improvement of the assessment and prevention of accidents.

This study demonstrated that in some academic units the risk of accidents with biological agents is greater (Table1), which is most likely due to the specific characteristics of the activities developed in each one, which can lead to a greater occurrence of a specific type of health condition. Moreover, each academic unit can offer more or less strategies geared towards the prevention of accidents.

The importance of the "individual's job in the laboratory" in models for accidents with biological or perforating-cutting materials (Tables 1 and 2) suggests that certain functions have a greater chance of suffering accidents of this nature when compared to others. These results may come from the fact that, in many cases, a larger number of employees and interns execute the operational functions than do faculty members and researchers, who, many times, are placed in charge of administrative functions and the coordination of lab employees.

It was also found that the greater the number of hours worked per day, the greater the chance of accidents with biological agents (Table 1), which is in agreement with another study developed in public health laboratories.²⁰

"Working under of psychological pressure and stress conditions" was considered a risk factor for accidents with biologi-

cal agents and with perforating-cutting materials (Tables 1 and 2), which indicates that this characteristic should be the target of corrective actions aimed at preventing accidents. "Working when exhausted" was characterized as a factor that increases the risk of chemical accidents (Table 3), since stress, psychological pressure, and exhaustion can lead individuals to absent-mindedness and the careless and reckless execution of activities, which can favor the occurrence of accidents. This finding may well be related to other characteristics of those who perform specific activities, such as drowsiness during work, which can lead to accidents.²⁰ In this sense, according to that defended by other authors, the prevalence of psychological disturbances in the workplace represents a serious health risk for the employees.²

The relationship that exists among one's occupation, organizational conditions, and the social environment contributes to the origin or worsening of psychological suffering in the work environment. The organizational conditions, such as repetitive work, a low level of autonomy, physical demands related to the environment, individual psychological efforts, emotional demands caused by the rhythm of work, and work load can all lead to suffering, tension, and stress.¹⁰ Occupations are related to higher or lower levels of anguish and stress, which can favor or augment the risk of accidents.¹⁰ However, qualitative investigations regarding the social perceptions and representations of individuals that lead to the sensation of psychological pressure were not within the scope of this study.

The "vaccination of individuals against hepatitis" was a factor which diminished the chances of accidents with biological agents (Table 1), given that its OR was less than one, which may well be a cause for concern regarding biosafety and the health condition of the lab employees, leading to the reduction in the probability of accidents. The "exposure to biological agents" and the "exposure to perforating-cutting" materials were removed from the respective models due to the perfect failure indicating that the exposure to these materials was a necessary condition for this type of accident to occur.

The fact that the individual knew about the operational flow in the case of accidents reduces his/her chances of being affected by accidents with biological agents, perforating-cutting materials, and chemical compounds (Tables 1, 2, and 3), most likely because it is an indicator of the adoption of other measures and protective factors. After the accident, with the exposure to agents, such as the Hepatitis C virus, the notification should be executed in such a way as to provide support to the accident victims, including medical care and laboratory exams for the patients involved.¹⁶

The "existence of protocol to report accidents" was also classified as a protective factor against accidents with perforating-cutting materials (Table 2), which most likely reflects better instruction for the individuals who know about the opera-

tional flow when accidents occur and who are aware of the proper protocol to report accidents. This result corroborates with studies that have indicated that the underreporting of this source of knowledge is common in Brazil, due to lack of knowledge regarding the existence of these protocols, due to the belief that these health conditions are less serious, due to a lack of time, and due to the fear of retaliations.^{14,15}

The "providing of instructions regarding laboratory procedures per colleague" was considered a risk factor for accidents with chemical compounds (Table 3), which reiterates the importance of the role of formal instruction to minimize the distribution of inadequate information regarding the work process. The results from the present study uphold those from another study, also conducted at the UFMG Medical School, which demonstrated that the students had a low level of knowledge of the biological risks that they were exposed to as well as of proper biosafety measures.⁷ The results from the present study coincide with findings from other authors who emphasize the importance of educating those who will work in laboratories to prevent occupational and environmental risks resulting from the use of chemical agents.⁴ Taking this result into account, it is recommended that each laboratory train one person to be responsible for safety in the workplace, who will act in all situations within this space, will document the information, and will not authorize any individual to handle hazardous materials before having received proper training.^{9,11}

CONCLUSIONS

The main factors associated with accidents in teaching and research laboratories observed in this study were related to the conditions and practices executed in the development of laboratory activities. In this sense, what was observed were some profiles of individuals who were more susceptible to suffering accidents in teaching and research laboratories. In general, individuals exposed to risk scenarios, who work for excessively long hours, who have recently joined the teaching institutions, and/or who are under stress and psychological pressure have a greater chance of being involved in accidents. The individuals with less time worked in the laboratory environment, and consequently with less experience, also have more chances of being involved in accidents when compared to those who have been working longer in the field.

On the other hand, it was also observed that individuals who exercise their activities in laboratories where there is an accident notification protocol and knowledge of the operational flow to be adopted in case of accidents have a lesser risk of being involved in accidents, most likely because these factors are indicators of attention and concern for employee safety and for the activities performed by them in the laboratories.

Thus, geared towards the prevention of accidents in laboratories, it is recommended that greater attention be allotted to the aforementioned aspects, as well as to the individuals and laboratories with risk profiles, in an attempt to provide better instructions and better conditions in which to work and teach.

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