Research, Society and Development, v. 14, n. 11, e207141150191, 2025
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v14i11.50191

Occupational hazards in autopsy laboratories: An integrative analysis of biosafety measures

Riscos ocupacionais em laboratórios de necropsia: Uma análise integrativa das medidas de biossegurança

Riesgos ocupacionales en laboratorios de necropsia: Un análisis integrador de las medidas de bioseguridad

Received: 11/18/2025 | Revised: 11/23/2025 | Accepted: 11/23/2025 | Published: 11/24/2025

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Abstract
The present study aimed to analyze the biosafety measures implemented in autopsy laboratories, with emphasis on identifying the main occupational risks and evaluating the preventive strategies adopted to reduce professionals' exposure to infectious agents and potentially hazardous biological materials. An integrative literature review was conducted with a search in the Medline/PubMed database. Eight articles that directly addressed biosafety measures in autopsies were selected. The analysis revealed a diversity of risks, highlighting the generation of aerosols, sharps accidents, and exposure to chemical agents and pathogens, including SARS-CoV-2. The analysis of the studies evidenced that biological risks, particularly the inhalation of aerosols generated by oscillating saws and liquid aspiration, are predominant. Inadequate infrastructure, such as the lack of negative pressure rooms (Biosafety Level 3 - BSL-3), and failures in the use of Personal Protective Equipment (PPE) and waste management amplify these dangers. Effective strategies include proper facility design, the adoption of additional physical barriers (such as the "craniotomy box"), controlled ventilation, and permanent staff education. It is concluded that the rigorous adoption of biosafety measures, aligned with international guidelines and supported by adequate infrastructure and continuous training, is imperative to mitigate occupational risks in autopsy laboratories. Such actions are essential to ensure professional safety, the quality of forensic procedures, and the protection of public health.
Keywords: Biosafety; Autopsy; Occupational Hazards; Clinical Pathology Service; Safety Measures.

Resumo
O presente estudo objetivou analisar as medidas de biossegurança implementadas em laboratórios de autópsia, com ênfase na identificação dos principais riscos ocupacionais e na avaliação das estratégias preventivas adotadas para reduzir a exposição dos profissionais a agentes infecciosos e materiais biológicos potencialmente perigosos. Realizou-se uma revisão integrativa da literatura com busca na base Medline/PubMed. Foram selecionados oito artigos que abordavam diretamente medidas de biossegurança em necrópsias. A análise revelou uma diversidade de riscos, com destaque para a geração de aerossóis, acidentes perfurocortantes e a exposição a agentes químicos e patógenos, incluindo SARS-CoV-2. A análise dos estudos evidenciou que os riscos biológicos, particularmente a inalação de aerossóis gerados por serras oscilatórias e a aspiração de líquidos, são predominantes. A inadequação da infraestrutura, como a falta de salas com pressão negativa (nível de Biossegurança 3 - NBS-3), e falhas no uso de Equipamentos de Proteção Individual (EPI) e no gerenciamento de resíduos amplificam esses perigos. Estratégias

eficazes incluem o projeto adequado das instalações, a adoção de barreiras físicas adicionais (como a "caixa de craniotomia"), a ventilação controlada e a educação permanente da equipe. A adoção rigorosa de medidas de biossegurança, alinhadas a diretrizes internacionais e suportadas por infraestrutura adequada e treinamento contínuo, é imperativa para mitigar os riscos ocupacionais em laboratórios de necrópsia. Tais ações são essenciais para garantir a segurança dos profissionais, a qualidade dos procedimentos forenses e a proteção da saúde pública.
Palavras-chave: Biossegurança; Necrópsia; Riscos Ocupacionais; Serviço de Patologia Clínica; Medidas de Segurança.

Resumen
El presente estudio tuvo como objetivo analizar las medidas de bioseguridad implementadas en los laboratorios de autopsia, con énfasis en la identificación de los principales riesgos laborales y en la evaluación de las estrategias preventivas adoptadas para reducir la exposición de los profesionales a agentes infecciosos y materiales biológicos potencialmente peligrosos. Se realizó una revisión integradora de la literatura con búsqueda en la base Medline/PubMed. Se seleccionaron ocho artículos que abordaban directamente medidas de bioseguridad en necropsias. El análisis reveló una diversidad de riesgos, con destaque para la generación de aerosoles, los accidentes cortopunzantes y la exposición a agentes químicos y patógenos, incluyendo SARS-CoV-2. El análisis de los estudios evidenció que los riesgos biológicos, particularmente la inhalación de aerosoles generados por sierras oscilatorias y la aspiración de líquidos, son predominantes. La inadecuación de la infraestructura, como la falta de salas con presión negativa (nivel de Bioseguridad 3 - NBS-3), y las fallas en el uso de Equipos de Protección Individual (EPI) y en la gestión de residuos amplifican estos peligros. Estrategias efectivas incluyen el proyecto adecuado de las instalaciones, la adopción de barreras físicas adicionales (como la "caja de craniotomía"), la ventilación controlada y la educación permanente del equipo. La adopción rigurosa de medidas de bioseguridad, alineadas con directrices internacionales y respaldadas por una infraestructura adecuada y capacitación continua, es imperativa para mitigar los riesgos ocupacionales en los laboratorios de necropsia. Tales acciones son esenciales para garantizar la seguridad de los profesionales, la calidad de los procedimientos forenses y la protección de la salud pública.
Palabras clave: Bioseguridad; Necropsia; Riesgos Laborales; Servicio de Patología Clínica; Medidas de Seguridad.

1. Introduction

Biosafety comprises a set of measures, training programs, and procedures designed for the protection of workers, the community, and the environment, through the prevention and control of occupational risks associated with biological, chemical, physical, ergonomic, and accident-causing agents (Hinrichsen, 2004; Teixeira et al., 2020; Bertelli et al., 2021; Santos et al., 2023; Morales et al., 2024; Oliveira et al., 2024). These measures aim to minimize an individual's exposure to specific environmental risks through containment actions, control practices, and continuing education on occupational health and safety (Hinrichsen, 2004).

The transmission of infectious biological agents in laboratories, often associated with the inadequate adoption of biological sample handling protocols, underscores the necessity for standardizing and implementing biosafety norms (Gomes & Caldas, 2019; Oliveira et al., 2024; Santos et al., 2019; Souza et al., 2019). These guidelines have been progressively extended to laboratories engaged in higher-risk activities, such as autopsy, where exposure to potentially infectious biological materials is considerably elevated. In these environments, the implementation of advanced systems, such as air sterilization and equipment decontamination areas, has proven to be fundamental for reducing occupational risks and creating safer workspaces (Brasil, 2005; Souza et al., 2019; Bertelli et al., 2021).

Autopsy, as a technical-scientific procedure for determining the cause of death, has applications in clinical, sanitary, and forensic contexts, with significant repercussions for public health and legal security (Daitx, 2020; Duarte-Neto et al., 2021; Morales et al., 2024). From an operational perspective, professionals work in autopsy rooms and are permanently exposed to pathogens, including multidrug-resistant bacteria, bloodborne viruses, opportunistic fungi, and parasites, demanding the systematic implementation of rigorous biosafety measures aimed at preventing occupational contamination and preserving the health of the technical team (Alves, 2012; Gonçalves et al., 2019; Bertelli et al., 2021).

The occupational risks inherent to activities in the autopsy laboratory can be categorized into direct exposures, such as

sharps accidents with instruments contaminated by blood or bodily fluids, and indirect exposures, such as the inhalation of aerosols generated during procedures like evisceration, organ washing, or tissue manipulation, representing a high potential for biological contamination (Gonçalves et al., 2019; Teixeira et al., 2020; Tomão et al., 2021). Therefore, the systematization of preventive measures, including the rigorous use of Personal Protective Equipment PPE appropriate for the risk class, the application of surface decontamination protocols, and the execution of continuous professional training programs, constitutes a fundamental strategy for reducing the biological risks associated with these procedures (Bertelli et al., 2021; Gomes & Nascimento, 2021; Nogueira et al., 2023).

In the prevention of occupational accidents in autopsy environments, the adequate management of Health Service Waste RSS is an essential component, primarily in the handling of sharps, which are among the main sources of occupational exposure to pathogens (Silva Junior et al., 2015; Soares et al., 2019; Uehara & Veiga, 2019). Factors such as the absence of specific training, the inadequate use of PPE, and deficiencies in the segregation, packaging, and disposal procedures for Health Service Waste significantly contribute to the increase of biological risks, compromising professional safety (Gomes & Caldas, 2019; Souza et al., 2019; Gomes & Nascimento, 2021; Oliveira et al., 2024).

Given this scenario, the present study aimed to analyze the biosafety measures implemented in autopsy laboratories, with emphasis on identifying the main occupational risks and evaluating the preventive strategies adopted to reduce professionals' exposure to infectious agents and potentially hazardous biological materials.

2. Methodology

An integrative analysis was carried out (Snyder, 2019), of a quantitative nature in relation to the quantity 7 (seven) articles and, qualitative in relation to the analysis carried out on these articles (Pereira et al., 2018).

This integrative literature review was conducted following the methodological protocol proposed by Whittemore & Knafl 2005, which comprises six stages: 1 identification of the research problem; 2 literature searches; 3 data evaluation; 4 data analysis; 5 interpretation of the results; and 6 presentations of the review.

The search strategy was executed in the Medical Literature Analysis and Retrieval System Online Medline/PubMed database. For the retrieval of studies, a combination of controlled descriptors indexed in the Health Science Descriptors DeCS and Medical Subject Headings MeSH was used, connected by the Boolean operator AND: "Biosafety", "Autopsy", "Necropsy", "Necropsy Techniques" and "Autopsy Techniques".

Original articles published in English between January 2000 and December 2024 were considered eligible. Studies deemed fundamental or classic for the field, as per the researchers' judgment based on the literature, were included regardless of their publication year to guarantee the necessary historical context.

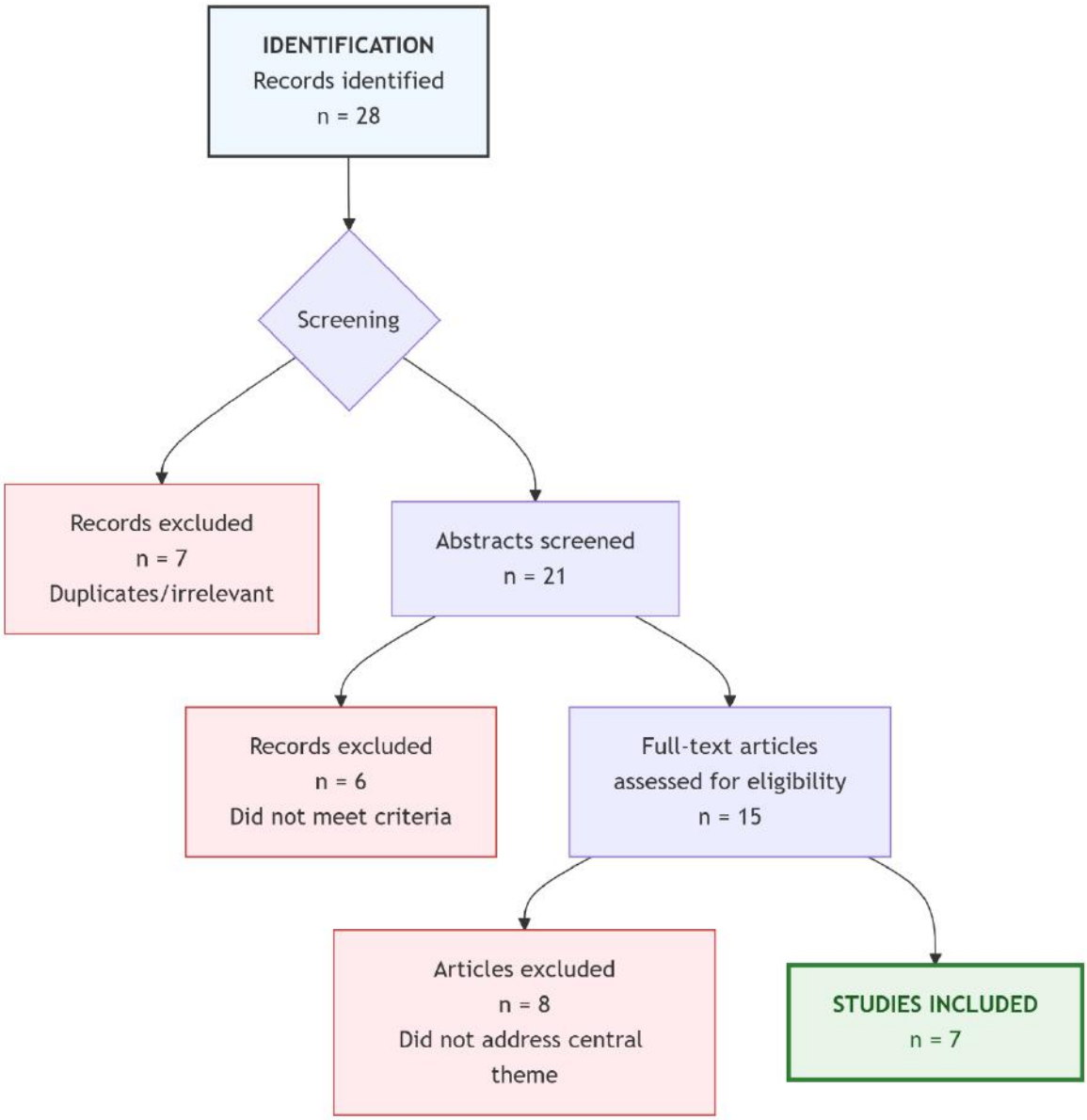
Inclusion and exclusion criteria were established to ensure rigor in the selection of the analysis corpus. Studies that explicitly addressed protocols, measures, challenges, risks, or assessments related to biosafety in human autopsy laboratories were included. Editorials, letters, guidelines and recommendations, opinion polls, monographs, dissertations, theses, and isolated case studies unrelated to biosafety procedures were excluded. Also excluded were articles whose primary focus was thanatopraxy, and studies conducted exclusively on non-human animals.

The study selection process was carried out independently and in pairs by two researchers to minimize selection bias. Initially, the articles identified in the databases were consolidated into a single spreadsheet using Microsoft Excel® software, where duplicates were removed. Subsequently, titles and abstracts were screened based on the eligibility criteria, and articles considered potentially relevant underwent full-text reading. Any disagreements between the researchers during the screening

phases were resolved by consensus or, when necessary, by a third researcher.

The initial search resulted in the identification of twenty-seven publications. After the removal of duplicates and articles deemed clearly irrelevant through title analysis, twenty-one studies proceeded to abstract screening. Of these, six were excluded for not meeting the inclusion criteria, leaving fifteen articles for full-text reading. After thorough assessment, eight articles were selected to constitute this review, as they directly address the central theme of biosafety in the autopsy context. The article selection flow was summarized in a diagram, following the PRISMA model (Figure 1), ensuring transparency of the process.

Figure 1. Flow of the selection of scientific articles from the Medline/PubMed database published between 2000 and 2024.



Source: Research data (2025).

For data extraction and synthesis, a standardized instrument was developed containing the following information: author, year of publication, country of origin, type of study, objective, main results, and conclusions. The extracted data were organized in a narrative and analytical manner, allowing for the identification of convergences, divergences, and gaps in the existing knowledge on the subject, which substantiated the critical and integrative discussion presented in this study.

3. Results and Discussion

Given the applied inclusion and exclusion criteria, a table was prepared outlining the characteristics of the main selected articles (Table 1). It was observed that all studies published in 2020 reflected the impact of the COVID-19 pandemic and the scientific production on biosafety in autopsies. Among these, research addressing new protocols for reducing environmental risks, with an emphasis on post-mortem procedures involving emerging pathogens, stands out. The final review corpus, consisting of seven articles, exhibited diverse geographical origins, encompassing nations from three continents: North America USA: 1, Europe Austria: 1; Italy: 2; Netherlands: 1, and Asia China: 1; Malaysia: 1.

Table 1. Characteristics of the selected articles on biosafety and autopsy practices.

AUTHOR/ YEAR	COUNTRY OF ORIGIN	TITLE	TYPE OF STUDY	OBJECTIVE	MAIN RESULTS	CONCLUSION
Nolte et al., 2002	United States	Biosafety considerations for autopsy	Narrative Review	To discuss the biological, chemical, toxic, and radiological hazards associated with autopsies and to propose biosafety measures to protect personnel.	-Autopsy personnel face significant risks from infectious agents transmitted via percutaneous injury, aerosols, and droplets. -Exposure to toxic chemicals like formaldehyde, cyanide, and organophosphates is common, and radionuclides from medical treatments pose a radiation hazard. -The use of personal protective equipment PPE, safe autopsy procedures, proper facility design, and vaccination is essential for risk mitigation.	Autopsies present multiple occupational hazards, but these risks can be substantially reduced through proper risk assessment, strict adherence to biosafety protocols recommending Biosafety Level 3 as the standard, appropriate PPE, and well-designed facilities.
Li et al., 2005	China	Biosafety level 3 laboratory for autopsies of patients with severe acute respiratory syndrome: principles, practices, and prospects	Original Article	To describe the design, operating principles, and effectiveness of a specially constructed Biosafety Level 3 BSL-3 autopsy laboratory for performing autopsies on patients with severe acute respiratory syndrome SARS.	-A BSL-3 autopsy laboratory with specific zones, negative pressure gradients, HEPA filtration, and downdraft ventilation was successfully constructed and tested. -The facility effectively contained a simulated aerosol sarin simulant, preventing its detection in clean areas. -16 complete autopsies on suspected or confirmed SARS patients were performed. None of the 23 participating staff members became infected.	The application of BSL-3 laboratory principles to autopsy procedures for highly infectious diseases like SARS can effectively safeguard personnel and the environment. Strict engineering controls, personal protective equipment, decontamination protocols, and administrative controls are essential for safety.
Fusco et al., 2016	Italy	A 2009 cross-sectional survey of procedures for post-mortem management of highly infectious disease patients in 48 isolation facilities in 16 countries: data from EuroNHID	Cross-sectional Survey	To assess the preparedness and resources for the safe post-mortem management including autopsy of patients with Highly Infectious Diseases HIDs in designated European isolation facilities.	-While 81.2% of the 48 facilities had written procedures for general human remains management, only 56.2% had specific procedures for performing autopsies on HID patients. -Only 16.6% of facilities had a Biosafety Level 3 BSL-3 autopsy room, and 18.7% had specific devices for safe autopsies. -Only 4 facilities 8.3% had all the features necessary for safe post-mortem management.	The level of preparedness for the post-mortem management of HID patients in surveyed European isolation facilities was largely insufficient in 2009. Significant improvements in procedures, specialized facilities BSL-3 rooms, and equipment are needed to safely manage corpses and perform autopsies, which are high-risk procedures.
Pluim et al., 2018	Netherlands	Aerosol production during autopsies: The risk of sawing	Original Article	To investigate the effects of saw blade frequency and contact load on the	-Higher saw blade frequencies and lower contact loads produced significantly more aerosol particles. -The smallest particles 0.3-5.0 µm dominated the total	To minimize aerosol production when using an oscillating saw, the saw blade frequency should be as low as possible and the contact

		in bone		production and size of airborne bone particles aerosols during simulated autopsy sawing of dry human bone.	particle count. -Even the optimal settings lowest frequency and highest load still produced a high number of respirable particles, posing a potential inhalation risk.	load as high as possible, within practical limits. However, due to the high particle counts in all scenarios, the use of personal protective equipment like respirators is essential.
Basso et al., 2020	Italy	Feasibility of postmortem examination in the era of COVID-19 pandemic: the experience of a Northeast Italy University Hospital	Original Article	To describe the procedure for the first series of autopsies at the COVID center of the University Hospital of Padua, Italy.	-SARS-CoV-2 was detected via RT-PCR in all 22 autopsied cases, and viable virus was cultured from a lung sample even 6 days postmortem. -The quality of histopathological and ultrastructural specimens remained optimal despite postmortem intervals of up to 6 days. -No autopsy operators or lab technicians developed COVID-19 or tested positive, confirming the procedure's safety under the implemented protocols.	Full autopsies are safe when performed with strict biosafety measures and are essential for understanding COVID-19 pathogenesis, as they provide crucial systemic information that minimally invasive techniques cannot. Therefore, discouraging autopsies in COVID-19 patients is not scientifically justified and hinders the collection of vital data for research and public health.
Hasmi et al., 2020	Malaysia	The craniotomy box: an innovative method of containing hazardous aerosols generated during skull saw use in autopsy on a COVID-19 body	Technical Report	To describe the use and effectiveness of a custom-made “craniotomy box” for containing aerosols generated during skull sawing in autopsies on COVID-19 positive bodies.	-A transparent, floorless plastic box with arm ports was placed over the head during craniotomy. -A swab from inside the box tested positive for SARS-CoV-2 after the procedure, confirming it contained the infectious aerosols and bone dust. -The box did not impede the procedure and could be easily disinfected for reuse.	The craniotomy box is an effective, practical, and reusable additional barrier that significantly reduces the risk of personnel exposure to infectious aerosols during high-risk autopsy procedures, such as skull sawing on COVID-19 cases.
Loibner et al., 2021	Austria	Biosafety requirements for autopsies of patients with COVID-19: example of a bsl-3 autopsy facility designed for highly pathogenic agents	Review Article / Case Study	To compare BSL-3 requirements from different organizations, summarize specific recommendations for COVID-19 autopsies, and describe the design and operational experience of a specialized BSL-3 autopsy facility.	-Autopsies are crucial for pandemic response but pose biosafety risks, leading to initial reluctance during COVID-19. -SARS-CoV-2 is classified as a Risk Group 3 pathogen, requiring BSL-3 precautions. -The described BSL-3 facility incorporates enhanced safety features inspired by BSL-4 standards. -Different levels of Personal Protective Equipment “PPE light” for autopsies, “PPE heavy” for high-titer virus work were implemented and validated. -The facility successfully supported COVID-19 autopsies and related research.	A BSL-3 autopsy facility with enhanced protection features is essential for safely conducting autopsies and research on high-risk pathogens like SARS-CoV-2. Key lessons include the need for trained personnel, adequate PPE stocks, flexible operational procedures, and specialized infrastructure to ensure a rapid and effective response to future pandemics.

Source: Research data (2025).

Risk factors and safety measures in autopsy laboratories

The Centers for Disease Control and Prevention CDC and the National Institutes of Health NIH have established a framework of guidelines for laboratories, termed Biosafety Levels BSL (Connell, 2011; Beeckman & Rüdelsheim, 2020). This framework comprises four hierarchical levels, classified from 1 to 4 according to the potential risk associated with infectious agents or toxins (Soares et al., 2019; Duarte-Neto et al., 2021; Nogueira et al., 2023; Santos et al., 2023). BSL-1 corresponds to the most basic containment level, applicable to agents with minimal or no transmission risk, whereas BSL-4 represents the maximum biosafety level, reserved for highly pathogenic and transmissible microorganisms, requiring rigorous containment protocols (CDC, 2020; Duarte-Neto et al., 2021). This classification has been widely employed as a global reference for the implementation of biosafety practices in academic, laboratory, and health institutions (CDC, 2020; WHO, 2020; Teixeira et al., 2020; Gomes & Nascimento, 2021; Nogueira et al., 2023).

Autopsy laboratories present a diversity of occupational risks (Nolte et al., 2002) that demand systematic attention to ensure the protection of professionals working in these environments. Among the main risk factors, the inadequacy of the physical layout, high humidity, and the presence of exposed electrical wires stand out as conditions that significantly increase the probability of occupational accidents (Nolte et al., 2002; 2021). Additionally, these environments favor the proliferation of pathogenic microorganisms, intensifying the biological risk (Cardoso et al., 2020; Nolte et al., 2021). As mitigating measures, the installation of waterproof electrical outlets positioned above workbenches, the implementation of efficient drainage systems for liquid waste, and the use of non-slip floors are suggested. Such interventions aim to reduce the occurrence of falls, control humidity levels, and prevent the dissemination of infectious agents, thereby contributing to a safer and more salubrious work environment (Guerra, 2024; Cardoso et al., 2020).

The main occupational risks associated with laboratory activities in autopsies are presented in Table 2. Tomão et al. (2021) identified that, in addition to traditional biological risks, new threats are emerging in autopsies, emphasizing the need for enhanced safety practices for the involved professionals. Furthermore, ergonomic risks are intrinsically related to the laboratory routine, particularly the handling of heavy equipment and the transportation of corpses, which lead to considerable physical strain, especially among autopsy assistants. Consequently, the adoption of mechanical assistance devices, such as hoists or transfer systems, which function as conveyor belts between the stretcher and the autopsy table, is recommended (Pasa et al., 2015; Cardoso et al., 2020). Scientific evidence indicates that the improper use of physical force in moving bodies can trigger occupational musculoskeletal disorders (Alexandre & Rogante, 2000).

Table 2. Classification of occupational risks in autopsy: agents, sources of exposure, and control measures.

Sector	Risk	Examples	Preventive Solutions
Structure and Layout	Inadequate layout	Electrical wires on the floor, high humidity, insufficient drainage	Elevated, waterproof electrical outlets, non-slip floors, efficient drainage systems
	Adverse environmental conditions	Poor lighting, insufficient ventilation	Install adequate lighting and mechanical ventilation systems
Ergonomics	Physical overload	Manual movement of corpses, heavy equipment	Use conveyor belts and specific carts
	Inadequate postures	Working for extended periods in uncomfortable positions	Height-adjustable tables and regular breaks
Sharp Instruments	Injuries	Use of scalpels, knives, and saws with a high risk of cuts	Use of reinforced gloves, cut-resistant aprons, and training in the safe handling of instruments
	Inadequate storage	Instruments left exposed or poorly organized	Store in specific holders and perform periodic inspection
Biological Risk	Exposure to infectious	Direct contact with bodily fluids,	Use of PPE gloves, PFF2 or PFF3 masks, protective

	agents	contaminated aerosols	goggles, physical barriers, and safety cabinets
	Environmental contamination	Lack of adequate site hygiene	Regular cleaning with appropriate disinfectants and correct disposal of biological waste
Aerosol Risks	Generation of contaminated particles	Use of oscillating saws, aspiration of liquids, lung dissections	Local exhaust ventilation, use of high-protection masks PFF2 or PFF3
	Inhalation of particles	Small aerosols <5 µm reaching the respiratory tract	Install air filtration systems and training for safe handling

Source: Research data (2025).

Another critical aspect concerns the handling of sharp instruments, such as scalpels, scissors, forceps, knives, and saws, which represent a significant occupational risk factor, given that accidental injuries can compromise the integrity of the skin barrier, exposing professionals to infectious agents (Nolte et al., 2002). There are reports of accidental cuts to the hands during autopsies, with 38% involving assistants and 12% involving forensic pathologists. Approximately 67% of these injuries occurred on the distal fingers, index and middle, of the non-dominant hand (Cardoso et al., 2020). This underscores the necessity for stringent biosafety protocols to prevent accidents and contamination in clinical biomedical laboratories (Santos et al., 2019).

Biological risk was intensively studied during the pandemic and remains a persistent concern in autopsy rooms, making it imperative to correct structural flaws and install protective devices that minimize exposure to infectious agents (Oliveira et al., 2023; Tomão et al., 2021; Franklin et al., 2009). The generation of aerosols during procedures represents one of the primary contamination mechanisms, mainly due to their diameter of between 1 and 5 µm, which allows for inhalation, while larger particles contaminate the mucous membranes. Hanley et al. (2020) demonstrated that SARS-CoV-2 remains viable in cadaveric tissues for up to 72 hours, while (Nolte et al. 2021) identified that oscillating saws and liquid aspirators are responsible for producing 5,700 particles/mL in the respiratory zone, and knives used in lung dissection can generate contaminating aerosols capable of carrying pathogens with high infectious potential (Kim et al., 2018; Cardoso et al., 2020; Hanley et al., 2020; Nolte et al., 2021).

As established by Hinrichsen (2004), environments with a high risk of infection transmission are classified as critical zones; therefore, the management of autopsy laboratories must be guided by the principles of biosafety, with an emphasis on the continuous assessment of environmental risks and the strict observance of current health regulations. The adoption of rigorous protocols and the ongoing training of professionals are fundamental to ensuring a safe working environment that complies with the best biosafety practices.

Post-mortem practices and management

Autopsy procedures conducted in laboratory settings can be categorized into two main modalities: 1 forensic autopsy, requested by judicial authorities to elucidate the cause and circumstances of deaths under investigation, and 2 hospital autopsies, conducted voluntarily for academic and research purposes, aiming to deepen the knowledge of rare diseases or pathogenic mechanisms. Regardless of the nature of the procedure, the application of rigorous biosafety protocols is essential to minimize biological risks and ensure the protection of the involved professionals. This guarantees the preservation of the workers' physical integrity and ensures the reliability of the results obtained for both justice and scientific advancement (Santos et al., 2019; Abdullah et al., 2024).

In the forensic field, during post-mortem investigations, the immediate performance of an autopsy is crucial to prevent alterations in the concentrations of toxic substances within the organism, which can be influenced by processes such as

autolysis and putrefaction. Furthermore, the adequate conservation of the body through controlled refrigeration preserves its morphological and biochemical characteristics, ensuring the accuracy of toxicological examinations (Pritsch, 2020). This reinforces the necessity of adhering to strict protocols and underscores the importance of biosafety in protecting professionals from potential exposures to chemical and biological agents during the procedures (Pritsch, 2020; Oliveira et al., 2023).

The transmission of infectious diseases is conditioned by the epidemiological triad composed of an infectious agent, a route of exposure, and a susceptible host. The study by Uehara et al. (2019) confirmed that failures in the proper management of waste, lack of training and infrastructure, as well as good practices impact waste management; therefore, efficient policies for the segregation, storage, and disposal of waste must be implemented. The human corpse harbors a diversity of biological agents, many with pathogenic potential, which can remain viable even after death. Consequently, given this scenario, the adoption of biosafety measures becomes imperative to reduce the probability of occupational contamination and guarantee a safe work environment (Cardoso et al., 2020).

Cleaning and disinfection in autopsy laboratories, including mortuaries, involve the use of chemical agents such as enzymatic detergents, 70% alcohol, and sodium hypochlorite, applied according to validated techniques. The adequate sterilization of surgical instruments, preferably by autoclave or chemical methods, is fundamental for preventing cross-contamination between corpses during forensic analyses. Such practices, when integrated into a quality management system, are decisive for maintaining biological safety and preventing the dissemination of pathogenic microorganisms in the laboratory environment (Conceição, 2020).

Additionally, the autopsy laboratory must be meticulously planned with infrastructure to ensure compliance (Conceição, 2020), as well as to optimize cleaning and disinfection, reduce exposure to biological agents, and guarantee occupational safety. The installation of negative pressure ventilation systems, smooth and impermeable surfaces that are easy to clean, and segregated areas for the disposal of biological waste according to regulatory norms is recommended. The rational layout of spaces, including demarcated zones for specific activities, contributes to operational efficiency and the reduction of occupational risks (Brasil, 2005; Nolte et al., 2021).

Therefore, the rigorous application of biosafety protocols, associated with standardized practices for cleaning, disinfection, and body conservation, constitutes a fundamental pillar for the safety of professionals and the quality of results in post-mortem procedures. The ongoing training of staff, coupled with the adequacy of physical facilities and the constant updating of procedures, represents an indispensable strategy for the prevention of biological risks and the maintenance of a safe, efficient work environment in compliance with current health guidelines. The synergy between these elements not only protects the health of professionals but also ensures the technical and scientific excellence of the processes carried out in autopsy laboratories.

Biosafety and training in forensic work

Occupational risks present in the laboratory environment can be classified as physical, chemical, biological, ergonomic, and accident-related. Professionals working in these environments are permanently exposed to situations potentially harmful to their health, requiring the implementation of effective preventive measures (Tomão et al., 2021). Particularly relevant are risk analysis and the monitoring of exposure to chemical agents, whose importance has grown proportionally to the increased use of chemical substances in production, storage, and transportation processes. This reality has led to significant consequences for both the environment and human health, stemming from both direct occupational exposure and secondary environmental pollution (Faria, 2011; Conceição, 2020).

In the specific context of autopsy laboratories, technical procedures are performed by specialized professionals who meticulously execute dissection, collect samples of organs and tissues for examination, as well as bodily reconstruction, hygiene, and dressing of the corpses for subsequent release to families or to meet legal requirements. Abdullah et al. (2024) emphasize that autopsy training should be mandatory for medical undergraduates to promote a deeper understanding of the causes of death, contributing to more precise and efficient forensic medicine. It is important to note that necropsy examination protocols vary between teams and institutions, with significant differences observed among the various states of the Federation. The composition of the technical team can also be adapted according to the particularities of each case and the specific needs of each procedure (Silva, 2014; Abdullah et al., 2024). The systematic identification of occupational risks highlights the indispensability of applying appropriate occupational safety and health measures. In this context, biosafety emerges as a fundamental discipline, offering the necessary theoretical and practical framework for the implementation of preventive actions. Its scope ranges from the control to the eradication of risks, with special emphasis on biological hazards. Historically, the concept of biosafety originated from the need to manage risks in laboratories handling biological agents, evolving to become an essential pillar in the protection of occupational health (Gao et al., 2025; Renault et al., 2021).

Although they may seem generic in a preliminary analysis, biosafety strategies prove to be highly specific when applied to the various contexts within the healthcare field. Their importance becomes particularly evident in environments such as hospitals, dental offices, clinical analysis laboratories, and mortuaries, where the diversity and magnitude of risks are considerable. This reality demands that educational processes in biosafety be carefully structured from a pedagogical standpoint, aiming to develop the necessary competencies for healthcare professionals at all hierarchical levels to perform their duties safely and effectively (Costa, 2004).

The implementation of continuous training programs, associated with the rigorous adoption of safety protocols, proves fundamental for the prevention of occupational accidents. Studies demonstrate that permanent education in biosafety can significantly reduce the occurrence of workplace incidents in healthcare environments (WHO, 2021). Such measures should be complemented by periodic assessments of work environments and constant review of safety protocols, adapting them to new scientific evidence and institutional realities. Furthermore, waste management requires greater institutional attention; although specific legislation exists, the persistence of operational failures such as the absence of correct signage and classification necessitates practical training and periodic evaluations (Uehara et al., 2019). This underscores the need for governance structures that link clear protocols with monitoring and accountability.

Although the COVID-19 pandemic heightened risks, it also offered an opportunity to rethink and reinforce the foundations of biosafety. The exposed fragilities demand a robust institutional response, with investments in infrastructure, an adequate supply of PPE, and the construction of an environment that promotes a sense of value and protection for professionals.

4. Final Considerations

The rigorous adoption of biosafety measures in autopsy laboratories is imperative for the protection of professionals and the maintenance of a safe work environment. The results of this study highlight the prevalence of biological, chemical, and physical risks inherent to forensic activities, primarily due to the handling of cadaveric material and potentially infectious substances.

The implementation of specific regulations aligned with international practices, combined with the proper use of Personal Protective Equipment PPE and the provision of adequate infrastructure, is crucial. Emphasis must be placed

particularly on controlled ventilation systems, waste disposal protocols, and laboratory ergonomics. The continuous training of teams through innovative pedagogical approaches also constitutes a key strategy for consolidating safe practices.

The consolidation of evidence-based biosafety policies reflects an institutional commitment to the physical integrity of workers and the excellence of forensic analyses. These findings reinforce the strategic importance of biosafety for forensic activities, providing input for the improvement of risk management and underscoring the need for sustainable investments in infrastructure, permanent education, and technological innovation. This becomes a fundamental pillar for the sustainability of forensic work and for the protection of public health.

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