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CAUSES GENERATING WORK ACCIDENTS IN THE COLOMBIAN ELECTRICAL SECTOR A COMPREHENSIVE ANALYSIS

CAUSAS GENERADORAS DE ACCIDENTES TRABAJO EN EL SECTOR ELÉCTRICO COLOMBIANO UN ANÁLISIS INTEGRAL

Herminio Pabón Trujillo
Corporación Universitaria Minuto de Dios, Colombia

Sergio Andrés Rojas Páez
Corporación Universitaria Minuto de Dios, Colombia

Yurmarly Quintero Suárez
Corporación Universitaria Minuto de Dios, Colombia

Juan Carlos Castillo
Corporación Universitaria Minuto de Dios, Colombia

Angie Dayana Rangel
Corporación Universitaria Minuto de Dios, Colombia

Ronald Edinxon Angarita Bautista
Corporación Universitaria Minuto de Dios, Colombia

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Causes Generating Work Accidents in the Colombian Electrical Sector a Comprehensive Analysis

Herminio Pabón Trujillo[1]
herminio.pabon.t@uniminuto.edu.co
https://orcid.org/0000-0001-5636-4813
Corporación Universitaria Minuto de Dios
Colombia- Cúcuta

Sergio Andrés Rojas Páez
sergio.rojas-p@uniminuto.edu.co
https://orcid.org/0009-0003-8447-9257
Corporación Universitaria Minuto de Dios
Colombia- Cúcuta

Yurmarly Quintero Suárez
yurmarly.quintero@uniminuto.edu.co
https://orcid.org/0009-0007-5790-2098
Corporación Universitaria Minuto de Dios
Colombia- Cúcuta

Juan Carlos Castillo
Juan.castillo-h@uniminuto.edu.co
https://orcid.org/0009-0004-7011-537X
Corporación Universitaria Minuto de Dios
Colombia-Cúcuta

Angie Dayana Rangel
Angie.rangel-p@uniminuto.edu.co
https://orcid.org/0009-0003-2583-292X
Corporación Universitaria Minuto de Dios
Colombia-Cúcuta

Ronald Edinxon Angarita Bautista
Ronald.angarita@uniminuto.edu.co
https://orcid.org/0009-0004-8835-8935
Corporación Universitaria Minuto de Dios
Colombia-Cúcuta

[1] Autor principal
Correspondencia: herminio.pabon.t@uniminuto.edu.co

ABSTRACT

Introduction: The Colombian electricity sector represents one of the highest risk work environments, where constant exposure to electrical energy, the handling of specialized equipment and complex operating conditions significantly increase the probability of occupational accidents. Despite advances in safety regulations and management systems, accidents continue to be a relevant challenge, with consequences ranging from minor injuries to the loss of human lives. Recent research shows that factors such as immediate or mediated interaction with energized sources, high-voltage electric shock, improper handling of equipment, failure to comply with protection standards, and limited training of technical personnel are the most recurrent causes of these incidents. Comprehensive analysis of these causes allows not only to identify the predominant risk factors, but also to understand the impact they have on the protection of the physical condition of employees and the operation of companies in the sector. In this context, the understanding of occupational accidents in the Colombian electricity sector becomes a fundamental step for the formulation of effective preventive strategies, the phenomenon of a preventive environment and the reduction of the incidence of serious and fatal accidents. This article addresses in detail the factors that cause accidents in the national electrical labor field, contributing to the knowledge and actions defined for the protection of human resources and the continuous improvement of working conditions. **Objective** To identify the main sources of occupational accidents in the Colombian electricity sector. **Methodology:** The proposed methodology is quantitative and descriptive, aimed at identifying the origins that generate occupational accidents in the Colombian electricity industry. The collection and statistical study of information is used to establish relationships between the types of accidents and their main causes. The group analyzed will be composed of workers in the electrical sector and accident report forms, interviews with workers, supervisors, and documentary review of previous investigation reports will be used. **Results:** Among the most relevant factors that cause accidents in the electricity sector in Colombia are: Direct and indirect contact with energized sources, violation of safety distances, improper handling of equipment and networks, unsafe acts and omission of personal protection implements, electric arc, overconfidence and lack of training, organizational and management factors

Keywords: occupational accident, unsafe act, prevention measures, electrical hazard, electric arc

Causas Generadoras de Accidentes Trabajo en el Sector Eléctrico Colombiano Un Análisis Integral

RESUMEN

Introducción: El sector eléctrico colombiano representa uno de los entornos laborales de mayor riesgo, donde la exposición constante a la energía eléctrica, la manipulación de equipos especializados y las condiciones operativas complejas incrementan significativamente la probabilidad de accidentes de trabajo. A pesar de los avances en normativas y sistemas de gestión en seguridad, la accidentalidad sigue siendo un desafío relevante, con consecuencias que van desde lesiones leves hasta la pérdida de vidas humanas. Las investigaciones recientes evidencian que factores como la interacción inmediata o mediada con fuentes energizadas, la descarga eléctrica de alto voltaje, la manipulación inadecuada de equipos, la omisión a normas de protección y la limitada formación del personal técnico son las causas más recurrentes de estos incidentes. El análisis integral de estas causas permite no solo identificar los factores de riesgo predominantes, sino también comprender el impacto que tienen sobre el resguardo del estado físico de los empleados y la operación de las empresas del sector. En este contexto, la comprensión de la accidentalidad laboral en el sector eléctrico colombiano se convierte en un paso fundamental para la formulación de estrategias preventivas eficaces, el fenómeno de un entorno preventivo y la reducción de la incidencia de accidentes graves y fatales. Este artículo aborda de manera detallada los factores que originan siniestros en el campo laboral eléctrico nacional, contribuyendo al conocimiento y las acciones definidas a la protección del recurso humano y la mejora continua de las condiciones laborales. **Objetivo** Identificar los principales orígenes de accidentes ocupacionales en el sector eléctrico colombiano. **Metodología:** La metodología propuesta es de enfoque cuantitativo y descriptivo, orientada a identificar, los orígenes generadores de siniestros laborales en la industria eléctrica colombiana. Se emplea la obtención y estudio estadístico de información para establecer relaciones entre los tipos de accidentes y sus causas principales, el grupo analizado estará compuesto por los trabajadores del sector eléctrico y se utilizarán formularios de reporte de accidentes, entrevistas a trabajadores, supervisores, y revisión documental de informes de investigación previos. **Resultados:** Dentro los factores más relevantes que originan siniestros en el sector eléctrico en Colombia se destacan: Contacto directo e indirecto con fuentes energizadas, violación de distancias de seguridad, manipulación inadecuada de equipos y redes, actos inseguros y omisión de implementos de resguardo personal, arco eléctrico, exceso de confianza y falta de capacitación, factores organizacionales y de gestión

***Palabras clave**:* accidente de trabajo, acto inseguro, medidas de prevención, peligro eléctrico, arco eléctrico

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INTRODUCTION

The Colombian electrical sector is characterized as one of the work environments with the highest level of risk, due to the constant exposure of workers to electrical energy, the handling of specialized equipment, and the complexity of operational conditions. Despite advances in regulations and safety management systems, occupational accidents continue to pose a significant challenge for organizations in the sector, with consequences ranging from minor injuries to the loss of human life.

Recent studies and national statistics show that the most predominant factors in workplace accidents in the industry include direct or indirect interaction with energized sources, electric arcs, improper handling of equipment and networks, negligence in wearing personal protective equipment, and violations of safety distances established by current regulations. These factors, combined with deficiencies in training and preventive management of fatality, increase the likelihood of dangerous situations that affect both the physical safety of personnel and the operational continuity of companies.

Understanding the root causes of accidents in the Colombian electrical sector is essential for establishing preventive action plans, strengthening the safety culture, and reducing the frequency of serious and fatal incidents. This article presents a comprehensive analysis addressing the common causes of occupational accidents in the national electrical sector, providing essential data for the formulation of policies aimed at protecting human resources and promoting continuous workplace improvement.

Despite advances in regulation and the implementation of safety protocols, the lack of rigorous enforcement of regulatory standards and an insufficient culture of prevention continue to increase worker vulnerability. This situation not only has severe effects on employee well-being, but also impacts the operational efficiency and sustainability of companies in the sector. Therefore, analyzing the root causes of incidents in the Colombian electrical industry is necessary to identify predominant risk areas and propose effective risk mitigation and control plans, thus contributing to the protection of human resources and the continuous optimization of working conditions.

Background

In Colombia, occupational accidents remain a significant challenge for occupational health and safety, with figures that, although showing declines in some recent periods, continue to be a major concern in high-risk sectors such as the electrical industry. In 2023, 522,160 occupational accidents were reported

in the country, recording 4.42 incidents per 100 workers, and an associated mortality rate of 5.88 deaths per 100,000 workers-the highest since 2017. While sectors such as healthcare, civil works, and mining account for the highest number of accidents and deaths, the electrical sector stands out for the severity of its incidents, especially those related to electrocutions, electric arcs, and failures to comply with safety regulations.

The analysis and research are based on current Colombian regulations, including Decree 1072 of 2015, Decree 1295 of 1994, Decree 2463 of 2001, and the Technical Regulation of Electrical Installations (RETIE), which establish guidelines for the prevention, reporting, and investigation of occupational accidents.

Colombian regulations, led by the Ministry of Mines and Energy and agencies such as the CREG (Energy and Gas Regulatory Commission), have established strict rules for the prevention of electrical accidents. The Technical Regulation of Electrical Installations (RETIE) and the Colombian Electrical Code (NTC 2050) set technical and safety requirements aimed at minimizing the inherent risks of the electrical process from its origin to consumption. These regulations require the use of personal protective equipment, safe work procedures, and ongoing worker training to ensure safe and efficient work environments.

However, despite the existence of these regulations and advances in electrical risk management, accidents in the sector persist due to factors such as improper handling of equipment, non-compliance with protocols, lack of specialized training, and omission of preventive measures. Studying the causal elements of accidents in the Colombian electrical industry is essential to identify predominant risk factors and guide the formulation of effective prevention and control strategies, thus contributing to the protection of human resources and the continuous improvement of industry conditions.

In Colombia, occupational accidents are a persistent and high-impact issue, especially in sectors considered high risk, such as the electrical sector. In 2023, 561,977 work-related incidents were reported in the country, with an annual rate of 4.40 accidents per 100 workers. Although the electricity supply sector represents a small percentage of the national total (1,192 accidents, equivalent to 0.23% of occupational accidents in 2023), the severity and potential lethality of electrical incidents make it a priority sector for risk management.

Geographically, departments such as Magdalena, Caldas, Antioquia, Meta, and Risaralda have the highest rates of occupational accidents, while Bogotá D.C. records the highest absolute number of reported events. The data show that, although the frequency of incidents in the electrical industry is lower compared to other sectors like construction, the risks associated with handling energy infrastructure and exposure to energized sources maintain high levels of mortality and serious injuries.

Strict compliance with safe work procedures and technical standards, such as the Technical Regulation of Electrical Installations (RETIE), has been key to maintaining a low frequency of accidents in the electrical sector. However, factors such as the high level of subcontracting, business competitiveness, and productivity pressures can affect adherence to these standards, increasing the vulnerability of personnel exposed to electrical hazards.

In this context, studying the reasons behind workplace incidents in the Colombian electrical sector is essential to identify predominant risk factors and strengthen preventive measures aimed at preserving the integrity and well-being of workers and improving safety conditions in the industry.

The low frequency of accidents in the electrical sector, compared to other sectors such as construction, is attributed to the development and strict compliance with safe work procedures and operating standards, with the Technical Regulation of Electrical Installations (RETIE) being a key reference for the prevention of serious incidents. However, factors such as the high level of subcontracting and competitive pressure can affect adherence to these regulations, increasing workers' vulnerability to electrical risks.

Therefore, although the number of workplace incidents in the electrical field is proportionally low, the severity and potential lethality of these events justify the need to strengthen risk management and supervision of regulatory compliance regarding electrical safety in Colombia.

If you need this translation adjusted for a particular context or shortened for a summary, let me know!

METHODOLOGY

The research employs a quantitative and descriptive approach, aimed at identifying the root causes of incidents in the Colombian electrical sector. This approach allows for measuring the frequency and impact of the causes, as well as establishing relationships between the types of accidents and their triggering factors. The information collected will include details about the type of accident, environmental conditions, equipment involved, and actions taken prior to the event. Interviews will be conducted with workers and supervisors, along with a documentary review of previous investigation reports. Historical and current data on occupational accidents of electrical origin in companies within the sector will be gathered, using internal records, official reports, and accident report forms. The data will be processed using statistical tools (frequencies, percentages, graphs) to determine the incidence and relevance of each identified cause. Based on the results, safety protocols and action plans will be designed to mitigate and manage the most relevant factors. Preventive and corrective measures will be proposed in alignment with current regulations and best practices in the sector. The study population consists of workers in the electrical sector, and the sample may include all workers involved in electrical projects in one or several companies, depending on the scope of the study.

RESULTS AND DISCUSSION

The study of the origins of occupational accidents in the Colombian electrical sector reveals a combination of technical, organizational, and human factors that contribute to the occurrence of workplace accidents, many of which have severe or even fatal consequences. The results of various studies and projects make it possible to identify patterns and propose preventive actions.

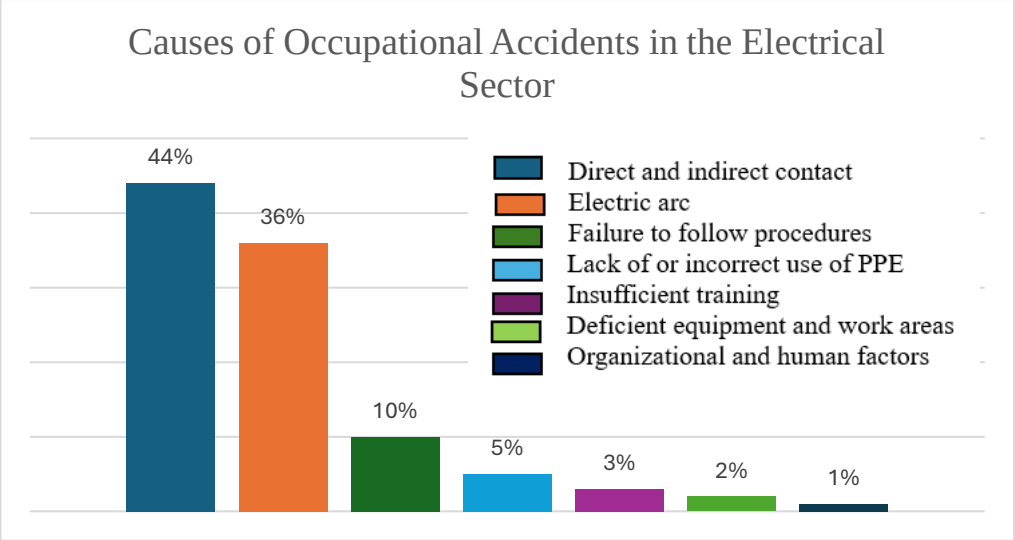
Among the most common causes behind workplace accidents in the Colombian electrical sector are: contact with energized parts-in any form, whether immediate or secondary-which is considered one of the most frequent causes of accidents, including electric arcs and the improper handling of electrical tools and systems. Additionally, non-compliance with safety procedures, such as entering restricted areas and failing to observe minimum safety distances, is a recurring factor in accident reports. Likewise, many accidents originate from workers not following the procedures established by the company, despite the existence of specific regulations and training, such as those outlined in Resolution 5018 of 2019.

The lack of PPE (Personal Protective Equipment) or its incorrect use is one of the most common immediate causes, along with inadequate supervision and training. Poor conditions in the work area, machines, or tools, and a lack of proper maintenance also increase the risk of accidents. It is important to highlight organizational and human factors, which include low motivation, pressure to work at high speed, and a lack of commitment to safety by employees.

The main causes of occupational accidents in the electrical sector are as follows: direct and indirect contact, electric arc, non-compliance with procedures, lack of or incorrect use of PPE, insufficient training, deficient equipment and work areas, and organizational and human factors.

Direct and indirect contact 44%, electric arc 36%, failure to follow procedures 10%, lack of or incorrect use of PPE 5%, insufficient training 3%, deficient equipment and work areas 2%, organizational and human factors 1%

Figure 1. Causes of Workplace Accidents in the Electrical Sector



Fuente: Pabon,H.(2025)

The current regulations applicable to work in the electrical sector in Colombia to ensure the implementation of legal and safety guidelines mainly include:

Law 142 of 1994: Public Utilities Law, which regulates the provision of essential public services, including electricity, establishing principles of regulation, rights and obligations of users and providers, and the subsidy regime.

Law 143 of 1994: Specific law for the electrical sector that defines the functions of the Ministry of Mines and Energy, sector planning, the structure and functions of the Energy and Gas Regulatory Commission (CREG), and energy transaction mechanisms. It also establishes the separation of activities in the electricity production chain (generation, transmission, distribution, commercialization).

Decree 1073 of 2015: Single Regulatory Decree of the Administrative Sector of Mines and Energy, which compiles and regulates provisions for the energy sector, including specialized, operational, and safety details.

Recent decrees and resolutions (2025) that add and update the regulation, such as: Decree that regulates the Colombia Solar Program and the self-generation of solar energy for certain socioeconomic strata. Resolution 40024 of 2025, which establishes temporary provisions to optimize energy infrastructure and guarantee the availability and security of supply. CREG Resolution 101 070 of 2025, which regulates the use of connection assets for generation and demand in the National Interconnected System. These standards make up the legal framework that obliges companies and workers in the electrical sector to comply with safety, efficient operation, and maintenance standards.

In 2019, the accident rate due to electrical risk in Colombia was 11.7%, with 1,029 cases of incidents related to electrical failures reported nationwide, of which 372 occurred in Bogotá and 22 resulted in deaths

In studies of specific companies, such as Industelc and Postobón S.A., it was identified that the majority of accidents are related to the absence of individual safety equipment, inadequate supervision and insufficient training

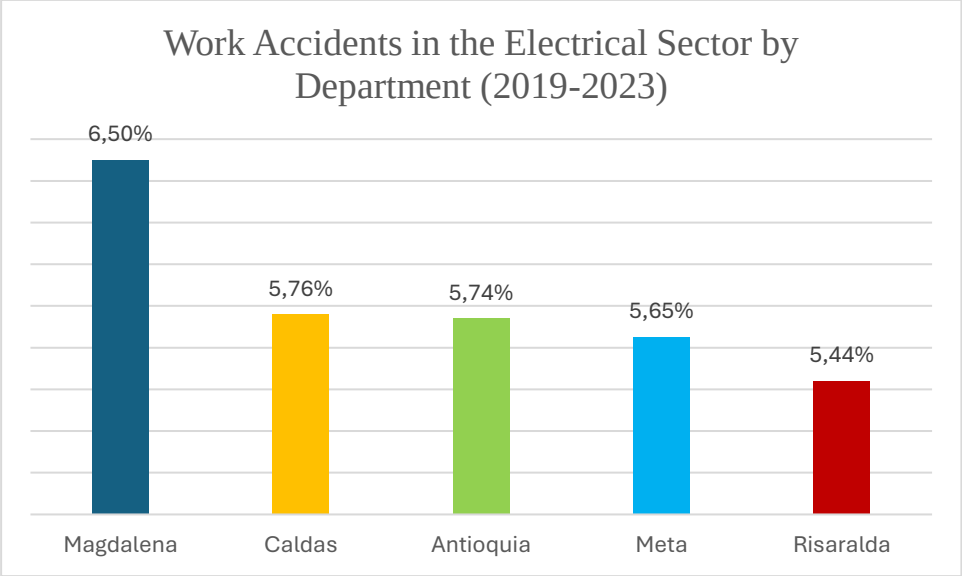
In the Department of Cauca, 21 deaths were reported due to electrical accidents between 2016 and 2020, with direct contact, violation of restricted areas and unsafe acts being the main causes.

The information available on the percentages of work accidents in the electrical sector by department in Colombia (2019-2023) allows us to identify the departments with the highest relative incidence of work accidents, although the specific data by department for the electrical sector is limited and is generally presented in conjunction with related sectors (electric, gas and water).

Based on the information available for the period 2019-2023, the departments with the highest percentage or rate of work accidents in the electrical sector and related sectors in Colombia are:

Magdalena: Increase in the frequency of work accidents in general, registering 6.50 accidents per hundred employees in 2023, remaining in first place for five consecutive years. Caldas: Second highest rate with 5.76 accidents per 100 workers. Antioquia: Third with 5.74 accidents per 100 workers. Goal: 5.65 accidents per 100 workers. Risaralda: 5.44 accidents per 100 workers.

Figure 2 Work Accidents in the Electrical Sector by Department (2019-2023)



Fuente: Pabon,H.(2025)

To mitigate risks and avoid the recurrence of serious or fatal accidents in the electrical sector in Colombia, the following specific actions are recommended: Perform work without voltage whenever possible, applying lockout and marking procedures (LOTO) to eliminate electrical risk before starting work, train and certify employees according to their level of competence (users, authorized, qualified) to ensure that only qualified personnel perform live or high-risk work, control the level and duration of contact with sources of electrical risk through controls administrative and adequate work planning.

Properly use and maintain self-protection elements such as dielectric gloves, insulating helmets, harnesses, reinforced boots and face protectors, adapted to each type of task, plan and organize the work considering the prior risk assessment, avoiding unsafe conditions such as humidity, defective cables or areas without adequate signage. Maintain electrical installations, tools and equipment in optimal conditions through rigorous preventive and corrective maintenance in order to prevent errors that cause electric arcs or discharges. Develop awareness about security and self-protection, prohibiting unsafe

practices such as removing safety devices, operating equipment without authorization or performing maintenance on energized networks.

Implement supervision, task observation and incident reporting programs to continually improve preventive measures and avoid the repetition of accidents. Train and endorse knowledge in safe practices when working at heights, given that many activities in the sector involve risks of falling, complementing electrical prevention with specific measures for heights.

These comprehensive actions, based on current regulations and good practices, contribute to significantly reducing serious and fatal accidents in the national electrical environment.

Within the Colombian electricity industry, a comprehensive analysis is reflected that identifies multiple interrelated factors that contribute to the high accident rate in this sector. Among the most relevant points, the human factor stands out as the main cause: between 74% and 90% of accidents are attributed to human errors, unsafe acts and behaviors that fail to comply with established procedures, which shows a low risk awareness and lack of adequate training in electrical safety.

Non-compliance with technical standards and safety distances: Many incidents are related to neglect of mandatory protection spaces and ignorance or non-compliance with current regulations, which increases exposure to electrical risks. Unsafe conditions and failures in the maintenance of defective equipment, poor maintenance, rust accumulation and carelessness in maintenance work are frequent causes that generate electrical arcs, short circuits and other failures that cause accidents.

Direct contact with energized parts and indirect contact due to insulation or grounding failures are common sources of accidents, often aggravated by the lack of personal protective equipment or its improper use. The presence of humidity, adverse weather conditions and locational risks also influence the occurrence of accidents, increasing the danger of activities. Low training and lack of awareness about electrical risks among workers and employers is noted as a critical factor that must be addressed to reduce mortality and accident frequency. The application of regulations such as Resolution 1401 of 2007 to investigate root causes and establish corrective measures is essential to understand and mitigate risks in the sector.

CONCLUSIONS

The frequency of accidents in the Colombian electrical professional environment is not solely due to direct electrical risk, but to a combination of associated factors, such as lack of training, non-compliance with procedures, poor maintenance of equipment, inadequate supervision and incorrect use of personal protective elements.

A significant percentage of accidents are related to professional negligence and lack of solid protection habits within companies. Workers' overconfidence and lack of knowledge about preventive protocols increase the likelihood of serious or fatal incidents.

Statistics show that accidents due to electrical risk represent a significant proportion of the total accident rate in the sector, with consequences that can range from minor injuries to death, especially when combined with other sources of danger such as working at heights.

The implementation of occupational health and safety (OSH) management systems, as required by Colombian regulations (e.g., Resolution 5018 of 2019), is essential, but their effectiveness depends on continuous training, constant supervision and rigorous application of safe work procedures.

It is essential to adopt a comprehensive approach to risk management, which includes the detection and regulation of all existing hazards in electrical activities, not just electrical risk, to achieve a real and sustainable reduction in workplace accidents.

It is recommended to strengthen the training and awareness of workers, improve preventive maintenance programs, reinforce supervision and promote the active commitment of each person and the group in forecasting

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