

ASSESSMENT OF ELECTRICAL HAZARDS EXPOSED TO ELECTRICITY USERS IN MATHARE SLUM

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ABSTRACT

Electrical hazards in informal settlements pose severe risks to residents, yet systematic assessments of their prevalence and underlying causes remain limited. This study assessed electrical hazards exposed to electricity users in Mathare informal settlement, Nairobi County, Kenya. A descriptive research design was adopted, with data collected from 341 household respondents selected through simple random sampling and 17 Kenya Power and Lighting Company staff through a census approach. Structured questionnaires, interviews, and technical measurements of earth and insulation resistance were used for data collection. Findings revealed that 63.9% of residents experienced electric shocks, 45.7% encountered electrical fires, and 58.1% witnessed electrocutions. Arcing and sparking affected 78.3% of residents. Illegal connections, poor wiring, and circuit overloading were identified as the dominant causal factors. The study concludes that urgent interventions targeting electrical safety awareness, infrastructure upgrading, and regulatory enforcement are necessary to reduce electrical accidents in informal settlements.

Keywords: *Electrical hazards, informal settlements, electric shock, illegal connections, earthing systems, Mathare, Kenya*

1.1 Introduction

The rapid growth of urban populations in the developing world has significantly outpaced the capacity of governments to provide formal housing and essential services, resulting in the proliferation of informal settlements characterized by inadequate infrastructure, overcrowding, and limited access to safe electricity (Lemaire & Kerr, 2016). In Kenya, approximately 60% of Nairobi's population of 4.4 million people reside in low-income settlements, with the country

recording an annual urban influx of approximately 250,000 people (World Bank, 2020). Mathare informal settlement, the second largest slum in Kenya after Kibera, is home to 206,564 people at a population density of 68,941 persons per square kilometre, making it a critical context for examining electricity-related safety challenges (KNBS, 2019). The settlement's dense and largely unplanned built environment creates conditions where electrical hazards pose severe risks to residents, with substandard wiring, illegal connections, and absence of protective devices being widespread (Njoroge et al., 2020).

Electrical hazards in informal settlements arise from a combination of systemic infrastructure deficiencies and limited safety awareness among residents. Electricity is often described as a silent killer because it cannot be perceived through ordinary senses, yet causes death or personal injury through electric shock, burns, arcing, explosions, and fires when mishandled (Cadick et al., 2006). According to Kenya Power's Safety, Health and Environment report, 345 people were electrocuted nationally between June 2018 and June 2020, with 74% of these deaths attributed to unsafe public practices including illegal connections, poor wiring, and wayleave encroachments predominantly in slum areas (Kenya Power SHE, 2020). Despite this documented toll, assessments of the specific hazards that electricity users in Mathare are exposed to remain limited, underscoring the need for a systematic investigation to inform targeted safety interventions in the settlement (MacKinnon, 2010).

1.2 Statement of the problem

Electrical hazards in Kenyan informal settlements represent a critical public safety challenge that has continued to claim lives and destroy property despite growing electrification efforts. Kenya Power's Safety, Health and Environment report recorded 345 electrocutions nationally between June 2018 and June 2020, with 74% attributed to unsafe public practices including illegal connections, poor wiring, and wayleave encroachments predominantly in slum areas, while 104 deaths were recorded in the 2018/2019 fiscal year alone and 241 in 2019/2020 (Kenya Power SHE, 2020). In Mathare informal settlement, 93% of households were connected to the national grid, yet 50% of these connections were illegal and unmetered, significantly elevating hazard levels through the use of substandard materials and chronic circuit overloading (Njoroge et al., 2020). The antagonism between informal electricity resellers and Kenya Power has further prevented households from accessing formal connections, leaving residents dependent on unsafe supply arrangements that have been associated with electrically induced fires and fatal electrocutions (Christley et al., 2021). Despite the magnitude of this problem, there remained a critical gap in empirical assessments of the specific electrical hazards that electricity users in Mathare slum are exposed to, the level of safety awareness among residents, the adequacy of existing control measures, and the state of electrical protection installations, necessitating this study.

1.3 Objectives of the Study

To assess electrical hazards exposed to electricity users in Mathare slum.

1.4 Research Questions

What are the electrical hazards that electricity users in Mathare slums are exposed to?

2.1 Theoretical Principles

The growth in urban populations in the developing world has rapidly overtaken the capacity of national and municipal governments to provide formal housing and servicing to urban and peri-urban populations, resulting in high growth of informal settlements with specific electrification challenges (Lemaire & Kerr, 2016). In Nairobi, Kenya Power has deployed prepaid technologies as a "technological fix" to solve challenges of cost recovery and limited network coverage, taking cue from South Africa's leadership in prepaid technological innovation since 1988 (Guma, 2019; Guma & Monstadt, 2021). However, this has further complicated slum residents' access to power, resulting in illegal connections that residents can pay monthly at flexible fees to cartels. Due to difficulties that towns, municipalities, and counties face in providing electricity services to informal communities, rates of electricity theft among residents are often high, with an estimated 40% of Sub-Saharan African urban informal settlement dwellers making use of illegal electricity connections as of 2011 (Lemaire & Kerr, 2016).

MacKinnon (2010) emphasized that the presence of electricity is increasing in modern life, and with more electricity usage comes greater potential for electrical hazards, making electrical safety awareness necessary for users. Most electrical accidents occur due either to carelessness or lack of awareness of basic safety rules that should be observed when using electricity (Cadick, Capelli-Schellpferffer & Neitzel, 2006). Hazards can be defined as any potential or actual threat to the wellbeing of people, equipment, machinery, or environment, including naked electric wires, electrical gadgets not switched off, unprotected installations, and overloaded socket outlets. The effects of electric shock range from stoppage of the heart or breathing muscles, burns, bleeding, neurological damage, and ventricular fibrillation, with severity depending on the amount of current passing through the body (Saba, 2014). A properly designed earthing system is of utmost importance in ensuring safety because it serves as a safety valve for leakage current and should have low electrical resistance to earth, high corrosion resistance, and continuous high current-carrying capacity (Igweonu, 2006; Gaétan et al., 2012).

2.1.2 Empirical Review

According to Njoroge, Ambole, Githira, and Outa (2020), 93% of Mathare households in their survey were connected to the national grid; however, 50% of these connections were illegal and unmetered, as they were not provided directly by Kenya Power and Lighting Company. This high number of illegal connections increases hazards and risk levels because of poor quality materials used and overloading. Christley, Ljungberg, Ackom and Nerini (2021) noted that tensions remain between informal electricity resellers and Kenya Power, with their antagonism preventing households from gaining formal connections as the utility refuses to enter the perceived hostile environment, risking worker safety. This exacerbates the problem, stigmatizing residents as untrustworthy or criminal, with basic service utilities reluctant to improve access, particularly in Kibera, fearing commercial loss. Yet informal connections are a cause of concern for many residents who report cases of electrically-induced fires and electrocutions leading to serious and fatal injuries.

Research on electrical safety awareness in other developing contexts reveals similar challenges. Saba (2014), researching electrical safety awareness in Nigeria, found that many residents or users of electricity are not well informed or aware about electricity hazards and safety measures. Similarly, Hernandez (2018) concluded that a significant percentage of people from Puerto Princesa City urban areas are still not aware of electrical safety practices, demonstrating a widespread need to assess the level of awareness of electrical hazards specific to slum areas and safety measures that need to be applied to save lives by avoiding electrical accidents. Von Caues, Herbst and Wadee (2018), in their report on fatal electrocution cases in South Africa, noted that out of 39 cases, the geographical area most affected by electrocution deaths was the informal settlement Khayelitsha (56.4% of cases), with primary injuries mainly burn wounds (87.2%) and most injuries to the upper limbs. This indicates how informal settlements are particularly prone to electrical hazards compared to formal housing areas.

2.2 Conceptual Framework

The conceptual framework aids the reader to see at a glance the proposed relationships between the variables in the study graphically or diagrammatically. Figure 1 depicts the relationship between hazards safety measures.

Independent Variable



Dependent Variable

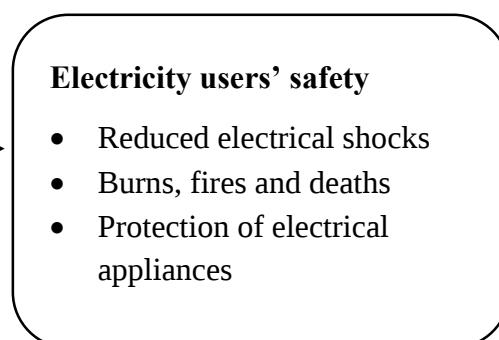


Figure 1: Conceptual Framework

3.1 Research Methodology

This study adopted a descriptive research design to systematically assess electrical hazards and safety measures within Mathare informal settlement in Nairobi County. The target population comprised electricity users drawn from four villages within the settlement, namely Mabatini, Mathare 10, Mlango Kubwa, and Kosovo, which together accounted for 36,615 households according to the Kenya National Bureau of Statistics census data (KNBS, 2019). Using the Yamane (1967) simplified formula, a sample of 396 households was determined and proportionally allocated across the four villages through simple random sampling to ensure equal probability of selection and minimize bias. In addition, all 17 Kenya Power and Lighting Company staff assigned to Mathare Sub County, comprising Operations Engineers, Maintenance Technicians, and Customer Service Officers, were included through a census approach given the small and specialized nature of this technical population. Primary data was

collected using structured questionnaires administered to household respondents with the assistance of research assistants, and structured interview schedules administered to KPLC technical personnel either face to face or via telephone. To address the fourth objective on the adequacy of electrical protection, technical measurements of earth resistance and insulation resistance were conducted at household meter board intake points using certified earth resistance testers and insulation resistance testers, with results compared against KPLC and IEEE standards to determine compliance levels.

4.1 Findings and Discussion

A total of 396 households were targeted, out of which 341 questionnaires were filled and returned, representing a response rate of 86%. This response rate was considered sufficient representation and reliable for data analysis. All 17 Kenya Power staff members assigned to Mathare Sub County participated in the structured interviews, providing a 100% response rate from the technical personnel.

4.2 Demographic Statistics

The demographic analysis revealed that males constituted the majority of respondents at 73.0%, while females represented 27.0%, which could be attributed to cultural and social factors where males are often the primary decision-makers in households regarding electrical installations and utilities. The age distribution showed that the majority of respondents (36.4%) were aged between 21-30 years, followed by those aged 31-40 years at 28.7%, with these two groups representing 65.1% of all respondents, indicating that the study largely captured perspectives of young and middle-aged adults who are typically primary household decision-makers. Geographically, respondents were distributed across four villages with Mlango Kubwa having the highest representation at 35.5%, followed by Mathare 10 (27.3%), Mabatini (21.1%), and Kosovo (16.1%), broadly reflecting the population density patterns within Mathare informal settlement. The 17 Kenya Power staff who participated comprised Customer Service Officers (41.2%), Maintenance Technicians (35.3%), and Operations Engineers (23.5%), with the majority having 6-10 years of experience (41.2%), providing a balanced perspective combining fresh insights from newer staff with the seasoned expertise of veteran personnel.

4.3 Electrical hazards exposed to electricity users in Mathare slum

In line with the first research objective of assessing electrical hazards exposed to electricity users in Mathare slum, this section examines the prevalence and types of electrical hazards that residents encounter in their daily lives. The analysis covers direct personal experiences with electrical hazards including electric shocks, burns, and fires, as well as witnessed incidents such as electrocutions in the community. The section also explores common electrical problems like arcing/sparking and other frequently reported issues that pose risks to residents. Through both quantitative survey data and qualitative observations from technical inspections, this section provides a comprehensive picture of the electrical safety challenges faced by settlement dwellers.

The study first examined the prevalence of electric shock incidents among residents. Table 1 presents the findings regarding personal experiences with electric shocks.

Table 1: Experience of Electric Shock among Residents

Response	Frequency	Percentage (%)
Yes	218	63.9
No	123	36.1
Total	341	100

The findings reveal a concerning pattern where nearly two-thirds (63.9%) of respondents reported having experienced an electric shock, while only 36.1% had not experienced such incidents. This high prevalence of electric shock experiences indicates a significant safety concern within the settlement. The fact that majority of residents have experienced electric shocks suggests widespread exposure to unsafe electrical conditions and potentially hazardous installations in their living environments.

The study also investigated the occurrence of electrical burns among residents, as these represent a serious form of electrical injury. Table 2 presents the findings on electrical burn experiences.

Table 2: Experience of Electric Burns

Response	Frequency	Percentage (%)
Yes	89	26.1
No	252	73.9
Total	341	100

The data shows that while the majority of residents (73.9%) had not experienced electrical burns, a significant portion (26.1%) reported having suffered from such injuries. This represents approximately one in four residents who have experienced electrical burns, which is a notably high figure considering the severity of such injuries. While lower than the prevalence of electric shocks, the fact that over a quarter of residents have experienced electrical burns indicates serious safety deficiencies in the electrical installations within the settlement.

The occurrence of electrical fires was another critical hazard investigated in the study, given their potential for widespread damage in densely populated settlements. Table 4.6 presents the findings regarding experiences with electrical fires.

Table 3: Experience of Electric Fire

Response	Frequency	Percentage (%)
Yes	156	45.7
No	185	54.3
Total	341	100

The results reveal an alarming situation where nearly half (45.7%) of the respondents reported having experienced an electrical fire, while 54.3% had not. This high incidence of electrical fires is particularly concerning given the settlement's dense population and predominantly temporary structures. With almost every second household having experienced an electrical fire, this represents a severe safety risk not only to individual households but to the entire community, given how quickly fires can spread in informal settlements.

The study further examined residents' experiences with witnessing electrocutions in their area, providing insight into the severity of electrical hazards in the community.

Table 4: Witnessed Electrocutions in the Area

Response	Frequency	Percentage (%)
Yes	198	58.1
No	143	41.9
Total	341	100

Table 4 shows that a majority (58.1%) of respondents had witnessed electrocutions in their area, while 41.9% had not. This high percentage of witnessed electrocutions is deeply concerning, indicating that fatal or severe electrical accidents are not isolated incidents but rather a recurring safety issue within the settlement. The fact that more than half of the residents have witnessed such serious incidents underscores the urgent need for improved electrical safety measures and proper installation practices in the area.

The study assessed the prevalence of arcing and sparking incidents, which are often precursors to more serious electrical accidents and indicators of faulty installations. Table 5 presents the findings on residents' experiences with these electrical phenomena.

Table 5: Experience of Arcing/Sparking

Response	Frequency	Percentage (%)
Yes	267	78.3
No	74	21.7
Total	341	100

The data reveals a high incidence of arcing/sparking, with 78.3% of respondents reporting having experienced such events, while only 21.7% had not. This overwhelming majority of residents experiencing arcing or sparking is particularly alarming as these phenomena often indicate serious electrical faults that could lead to fires or other dangerous situations. Since more than three-quarters of residents have witnessed these warning signs suggests widespread issues with electrical installations and connections throughout the settlement.

The study sought to identify the most common electrical problems experienced by residents to better understand the range and frequency of electrical challenges in the settlement. Table 6 presents the distribution of commonly reported electrical problems.

Table 6: Common Electrical Problems Reported

Problem Type	Frequency	Percentage (%)
Blackouts	98	36.7
Voltage fluctuations	65	24.3
Short circuits	45	16.9
Overheating of wires	35	13.1
Power trips	24	9
Total	267	100

The findings show that blackouts were the most frequently reported problem, affecting 36.7% of respondents, followed by voltage fluctuations at 24.3%. Short circuits accounted for 16.9% of reported problems, while overheating of wires and power trips represented 13.1% and 9.0% respectively. This distribution of problems suggests significant issues with power quality and reliability in the settlement, with particular concerns around the high incidence of voltage fluctuations and short circuits which can damage appliances and pose serious safety risks.

To assess the extent of professional documentation and monitoring of electrical safety issues within Mathare informal settlement, the study examined KPLC's record-keeping practices regarding electrical hazards and accidents in the area. Systematic record-keeping is essential for understanding the scope and frequency of electrical incidents, identifying trends, and developing targeted interventions. Table 7 presents the findings on whether KPLC staff maintain formal records of electrical hazards and accidents occurring in Mathare settlement.

Table 7: KPLC Record Keeping of Electrical Hazards in Mathare

Maintains Records	Frequency	Percentage (%)
Yes	14	82.4
No	3	17.6
Total	17	100

The findings indicate that the majority of KPLC staff (82.4%) confirmed that they maintain records of electrical hazards and accidents occurring in Mathare informal settlement, while only 17.6% reported that they do not keep such records. This high level of record-keeping suggests that KPLC has established systematic documentation practices for tracking electrical safety incidents in the settlement. The substantial proportion of staff maintaining records provides confidence in the reliability of subsequent data on accident frequencies and hazard types reported by KPLC personnel. However, the fact that nearly one in five staff members do not maintain records indicates potential gaps in documentation consistency, which could affect the comprehensiveness of incident tracking and the development of evidence-based safety interventions in the settlement.

Based on their professional experience and record-keeping practices, KPLC staff were asked to identify the most common types of electrical hazards they encounter or receive reports about in Mathare informal settlement. This professional assessment provides valuable validation of the hazard types identified through the household survey and offers insights into the frequency and severity of different electrical safety challenges from a utility company perspective. Table 8 presents the distribution of the most commonly reported electrical hazards according to KPLC staff observations and records.

Table 8: Most Common Electrical Hazards Reported by KPLC

Hazard Type	Frequency	Percentage (%)
Electric shocks	15	88.2
Electrical fires	13	76.5
Electrocutions	11	64.7
Equipment damage	9	52.9

Note: Multiple responses allowed, percentages based on total respondents (17)

The professional assessment by KPLC staff reveals a consistent pattern of electrical hazards that aligns closely with the household survey findings. Electric shocks emerged as the most frequently reported hazard, identified by 88.2% of KPLC staff, followed by electrical fires at 76.5%. Electrocutions were reported by 64.7% of staff, while equipment damage was noted by 52.9% of respondents. This professional validation confirms that the hazards identified by residents are indeed significant safety concerns recognized by utility personnel. The high prevalence of electric shocks and electrical fires in both household and professional assessments underscores the severity of electrical safety challenges in Mathare settlement. The fact that nearly two-thirds of KPLC staff have encountered or received reports of electrocutions further emphasizes the life-threatening nature of electrical hazards in the informal settlement, validating the urgent need for comprehensive safety interventions.

To quantify the magnitude of electrical safety challenges in Mathare informal settlement, KPLC staff were asked to provide specific numbers of electrical accidents they had recorded or encountered over the past year. This quantitative data provides concrete evidence of the frequency and scale of electrical incidents, moving beyond general observations to documented cases that demonstrate the real impact of electrical hazards on the community. Table 9 presents the aggregated data on electrical accidents recorded by KPLC staff in Mathare settlement.

Table 9: Electrical Accidents Recorded by KPLC

Accident Type	Total Reported	Average per Respondent
Electric shocks	127	7.5
Electrical fires	89	5.2
Electrocutions	23	1.4

The quantitative analysis reveals a substantial burden of electrical accidents in Mathare informal settlement, with KPLC staff collectively reporting 127 cases of electric shocks, 89 electrical fires, and 23 electrocutions over the past year. On average, each KPLC staff member encountered or recorded 7.5 electric shock incidents, 5.2 electrical fires, and 1.4 electrocution cases. These figures translate to significant safety challenges, with electric shocks occurring at a rate that suggests nearly weekly encounters for individual staff members. The high frequency of electrical fires (averaging over 5 per staff member annually) is particularly concerning given the dense housing conditions and flammable construction materials common in informal settlements. While electrocutions showed the lowest frequency, the average of 1.4 cases per staff member annually represents a serious public health concern, as these incidents often result in fatalities or severe injuries. The consistency of these professional records with household survey findings validates the severity of electrical safety challenges identified in the settlement.

To understand the underlying factors contributing to electrical accidents in Mathare informal settlement, KPLC staff were asked to analyze and categorize the primary causes of incidents based on their professional records and field experience. This causal analysis is crucial for developing targeted interventions and identifying the most critical areas requiring immediate attention. Understanding the root causes enables stakeholders to prioritize resources and design effective prevention strategies. Table 4.13 presents the distribution of primary causes of electrical accidents as documented in KPLC records and assessed by technical staff.

Table 4.13: Primary Causes of Accidents According to KPLC Records

Cause	Average Percentage	Range
Illegal connections	45.2%	35-60%
Poor wiring	32.8%	25-45%
Overloading	22.0%	15-35%

The professional analysis by KPLC staff identifies illegal connections as the predominant cause of electrical accidents, accounting for an average of 45.2% of incidents, with individual staff estimates ranging from 35% to 60%. Poor wiring practices emerged as the second leading cause at 32.8%, with estimates ranging from 25% to 45%. Circuit overloading was identified as responsible for 22.0% of accidents on average, with a range of 15% to 35%. These findings highlight the systemic nature of electrical safety challenges in the informal settlement, where unsafe practices and substandard installations create multiple pathways to accidents. The dominance of illegal connections as a causal factor underscores the significant safety risks associated with unauthorized power tapping and non-compliant electrical installations. The substantial contribution of poor wiring practices (nearly one-third of accidents) reflects the widespread use of unqualified personnel and substandard materials in electrical installations. The variation in staff estimates, as indicated by the ranges, suggests that while these three causes are consistently identified as primary factors, their relative contributions may vary across different areas within the settlement or over time.

The assessment of electrical installations and load patterns revealed concerning trends in the informal settlement. Most households reported using high-power domestic appliances including electric cookers, water heaters, and multiple power extensions, despite inadequate wiring capacity. The interview findings indicated that approximately 70% of the installations used substandard electrical accessories, with many having loose connections, broken socket outlets, and exposed live parts. Common issues included use of incorrect wire gauges, overloaded socket outlets, and makeshift connections that significantly increased fire risks.

The state of wiring installations was particularly alarming, with over 65% of the observed cases showing signs of deterioration and unsafe practices. Key concerns included use of single-insulated cables for fixed wiring, unprotected overhead cables running between structures, and improper joints wrapped with insulation tape instead of proper connection boxes. The assessment also revealed that many residents had modified their original installations by adding more connection points without considering load capacity, leading to overheating and increased risk of electrical fires. These findings corroborate the high incidence of electrical hazards reported in the household survey.

The high prevalence of electrical hazards documented in this study aligns with findings from previous research on electrical safety in informal settlements. The fact that 63.9% of residents experienced electric shocks and 45.7% encountered electrical fires corroborates Von Caues et al. (2018), who found that informal settlements, particularly Khayelitsha in South Africa, were disproportionately affected by electrocution deaths, with 56.4% of fatal electrocution cases occurring in informal settlement areas. Similarly, the KPLC professional records documenting 127 electric shocks and 89 electrical fires annually validate Kenya Power's SHE (2020) report, which recorded 345 electrocutions nationally between June 2018 and June 2020, with 74% attributed to unsafe public practices including illegal connections and poor wiring predominantly in slum areas. The consistency between household experiences and professional documentation strengthens the validity of these findings and confirms that Mathare settlement faces electrical safety challenges comparable to other informal settlements across Sub-Saharan Africa.

The dominance of illegal connections (45.2%) and poor wiring (32.8%) as primary accident causes, as identified by KPLC staff, substantiates Lemaire and Kerr's (2016) assertion that illegal electricity connections in informal settlements create significant fire and electrocution hazards due to lack of access to safety-tested equipment and potential for current overload. This finding is further reinforced by Christley et al. (2021), who reported that informal connections in Kibera informal settlement were a cause of concern, with residents reporting cases of electrically-induced fires and electrocutions leading to serious and fatal injuries. The high incidence of arcing/sparking (78.3% of residents) aligns with Campbell's (2021) finding that arcing served as the heat source in 63% of home fires involving electrical failure or malfunction, while Gabriel et al. (2019) similarly identified electrical wiring faults including poor arc wiring and short circuiting as major causes of electrical hazards. These corroborations demonstrate that the electrical safety challenges in Mathare are not isolated incidents but rather systemic issues characteristic of informal settlements where regulatory oversight is limited and economic constraints drive unsafe electrical practices.

5.1 Conclusions

The study concludes that electricity users in Mathare informal settlement are exposed to severe and life-threatening electrical hazards on a recurring basis. Nearly two thirds of residents experienced electric shocks, almost half encountered electrical fires, and more than half witnessed electrocutions within the settlement. Arcing and sparking affected over three quarters of residents, while blackouts, voltage fluctuations, and overheating of wires were widely reported. Kenya Power staff records corroborated these findings, documenting 127 electric shocks, 89 fires, and 23 electrocutions annually. Illegal connections, poor wiring, and circuit overloading were the dominant causal factors, with approximately 70% of installations using substandard materials and makeshift connections.

6.1 Recommendations

The study recommends that Kenya Power and Lighting Company, the Energy and Petroleum Regulatory Authority, and the Directorate of Occupational Safety and Health Services jointly develop and implement a comprehensive electrical safety awareness campaign targeting Mathare residents, focusing on hazard identification, safe installation practices, and proper appliance use. A structured programme for upgrading substandard electrical installations should be established, prioritising replacement of unsafe wiring, installation of proper protection devices, and construction of adequate earthing systems. Additionally, a licensing and certification framework for electricians operating within informal settlements should be enforced, accompanied by regular technical inspections to ensure ongoing compliance with established safety standards.

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