Epidemiology of Kerosene poisoning in Saudi Arabia: A retrospective analysis (#100993)

First submission

Guidance from your Editor

Please submit by **29 Jul 2024** for the benefit of the authors (and your token reward) .

Structure and Criteria
Please read the 'Structure and Criteria' page for guidance.

Author notes
Have you read the author notes on the guidance page?

Raw data check
Review the raw data.

Image check
Check that figures and images have not been inappropriately manipulated.

If this article is published your review will be made public. You can choose whether to sign your review. If uploading a PDF please remove any identifiable information (if you want to remain anonymous).

Files
Download and review all files from the materials page.

7 Figure file(s)
4 Table file(s)
3 Raw data file(s)

Structure and Criteria

Structure your review

The review form is divided into 5 sections. Please consider these when composing your review:

1. **BASIC REPORTING**
2. **EXPERIMENTAL DESIGN**
3. **VALIDITY OF THE FINDINGS**
4. General comments
5. Confidential notes to the editor

You can also annotate this PDF and upload it as part of your review

When ready submit online.

Editorial Criteria

Use these criteria points to structure your review. The full detailed editorial criteria is on your guidance page.

BASIC REPORTING

- Clear, unambiguous, professional English language used throughout.
- Intro & background to show context. Literature well referenced & relevant.
- Structure conforms to PeerJ standards, discipline norm, or improved for clarity.
- Figures are relevant, high quality, well labelled & described.
- Raw data supplied (see PeerJ policy).

EXPERIMENTAL DESIGN

- Original primary research within Scope of the journal.
- Research question well defined, relevant & meaningful. It is stated how the research fills an identified knowledge gap.
- Rigorous investigation performed to a high technical & ethical standard.
- Methods described with sufficient detail & information to replicate.

VALIDITY OF THE FINDINGS

- **Impact and novelty is not assessed.** Meaningful replication encouraged where rationale & benefit to literature is clearly stated.
- All underlying data have been provided; they are robust, statistically sound, & controlled.
- Conclusions are well stated, linked to original research question & limited to supporting results.

Standout reviewing tips

The best reviewers use these techniques

Tip	*Example*
Support criticisms with evidence from the text or from other sources	*Smith et al (J of Methodology, 2005, V3, pp 123) have shown that the analysis you use in Lines 241-250 is not the most appropriate for this situation. Please explain why you used this method.*
Give specific suggestions on how to improve the manuscript	*Your introduction needs more detail. I suggest that you improve the description at lines 57- 86 to provide more justification for your study (specifically, you should expand upon the knowledge gap being filled).*
Comment on language and grammar issues	*The English language should be improved to ensure that an international audience can clearly understand your text. Some examples where the language could be improved include lines 23, 77, 121, 128 – the current phrasing makes comprehension difficult. I suggest you have a colleague who is proficient in English and familiar with the subject matter review your manuscript, or contact a professional editing service.*
Organize by importance of the issues, and number your points	*1. Your most important issue* *2. The next most important item* *3. …* *4. The least important points*
Please provide constructive criticism, and avoid personal opinions	*I thank you for providing the raw data, however your supplemental files need more descriptive metadata identifiers to be useful to future readers. Although your results are compelling, the data analysis should be improved in the following ways: AA, BB, CC*
Comment on strengths (as well as weaknesses) of the manuscript	*I commend the authors for their extensive data set, compiled over many years of detailed fieldwork. In addition, the manuscript is clearly written in professional, unambiguous language. If there is a weakness, it is in the statistical analysis (as I have noted above) which should be improved upon before Acceptance.*

Epidemiology of Kerosene poisoning in Saudi Arabia: A retrospective analysis

Bassam M Hakami [Corresp., 1], **Randa M Nooh** [2], **Ali Ahmed Asiri** [3]

[1] Field Epidemiology, Ministry of Health, Riyadh, riyadh, Saudi Arabia

[2] Preventive Medicine & Public Health, ministry of health, Riyadh, riyadh, Saudi Arabia

[3] General Directorate of Environmental Health, ministry of health, Riyadh, Riyadh, Saudi Arabia

Corresponding Author: Bassam M Hakami
Email address: bassam7hakami@gmail.com

Background. Kerosene poisoning is a prevalent public health concern in Saudi Arabia, mostly caused by the extensive utilization of kerosene for lighting, warming, and food preparation. Although it is significant, there is a lack of thorough nationwide studies regarding the epidemiology of kerosene poisoning in Saudi Arabia.

Methods. This paper presents a retrospective cross-sectional investigation of recorded instances of kerosene poisoning in Saudi Arabia spanning from January 2019 to December 2021. The data acquired via the national poisoning surveillance system, which is managed by the Ministry of Health. Key variables summarized using descriptive statistics, and correlations and seasonal fluctuations explored using chi-square and Kruskal-Wallis tests.

Results. There was a total of 460 incidents of kerosene poisoning documented throughout the three-year period. Men constituted 60.9% of the cases, while children between the ages of 1 and 5 accounted for 87.6% of the cases. Most events took place in residential settings (90.7%) and involved the use of substances through the mouth (91.7%). The AlQurayat area had the greatest occurrence rate (53%), which notably rose during the colder months. The statistical study revealed substantial correlations between kerosene toxicity and variables such as gender, age group, and geography.

Conclusions. The study emphasizes the necessity of focused public health efforts to decrease occurrences of kerosene poisoning, particularly among young children and in places with a high risk. To address this public health concern, it is advisable to implement public awareness programs and enhance safety protocols for the storage and utilization of kerosene.

Epidemiology of Kerosene Poisoning in Saudi Arabia: A Retrospective Analysis

Bassam Mohammed Hakami [1], Randa Mohammed Nooh [2] and Ali Ahmed Asiri [3]

1 Ministry of Health, field epidemiology, Riyadh, Saudi Arabia

2 Consultant Epidemiology, Preventive Medicine & Public Health, Riyadh, Saudi Arabia

3 General Directorate of Environmental Health, Ministry of Health, Riyadh, Saudi Arabia

Corresponding Author:
Bassam Hakami [1]
Salman Alfarsi st, Riyadh, 13223, Saudi Arabia.
Email address: bassam7hakami@gmail.com

Abstract

Background. Kerosene poisoning is a prevalent public health concern in Saudi Arabia, mostly caused by the extensive utilization of kerosene for lighting, warming, and food preparation. Although it is significant, there is a lack of thorough nationwide studies regarding the epidemiology of kerosene poisoning in Saudi Arabia.

Methods. This paper presents a retrospective cross-sectional investigation of recorded instances of kerosene poisoning in Saudi Arabia spanning from January 2019 to December 2021. The data acquired via the national poisoning surveillance system, which is managed by the Ministry of Health. Key variables summarized using descriptive statistics, and correlations and seasonal fluctuations explored using chi-square and Kruskal-Wallis tests.

Results. There was a total of 460 incidents of kerosene poisoning documented throughout the three-year period. Men constituted 60.9% of the cases, while children between the ages of 1 and 5 accounted for 87.6% of the cases. Most events took place in residential settings (90.7%) and involved the use of substances through the mouth (91.7%). The AlQurayat area had the greatest occurrence rate (53%), which notably rose during the colder months. The statistical study revealed substantial correlations between kerosene toxicity and variables such as gender, age group, and geography.

Conclusions. The study emphasizes the necessity of focused public health efforts to decrease occurrences of kerosene poisoning, particularly among young children and in places with a high

risk. To address this public health concern, it is advisable to implement public awareness programs and enhance safety protocols for the storage and utilization of kerosene.

Introduction

The term injury refers to the physical harm that occurs when a person's body unexpectedly exposed to levels of power beyond the physiologic limit or is devoid of essential components such as oxygen. Energy can manifest in several forms, including thermal, mechanical, chemical-based, or radiative [1]. Based on their intent, injuries can be classified as either intentional or unintentional [2]. Intentional injuries, as the name suggests, refer to injuries with the intent of self-harm where unintentional injuries occur unexpectedly without the intentions of harm; unintentional injuries are a significant yet preventable public health problem that contributes to 3.16 million deaths every year [3]. Mortalities are a minuscule fraction of the overall impact of unintentional injuries, and nonfatal repercussions make up a substantial amount because a much greater percentage of unintended injuries lead to potentially permanent disability, serious psychological distress, and consequent financial detriment [4]. Children and teenagers are particularly vulnerable to this type of injury [5]. Half of young people who have accidental incidents and seek medical care at a hospital experience some type of impairment [4]. In 2015, the United Nations (UN) adopted the Sustainable Development Goals (SDGs), which are a worldwide call to all nations to eradicate poverty and improve the overall well-being of all people across the world. One of the primary goals of the United Nations (SDGs) is to eradicate preventable mortality among infants and children younger than five years by the year 2030, and aim to enhance the well-being of children worldwide [6]. Unfortunately, poisoning ranks among the primary factors contributing to unintended injuries. [2]. Term poisoning is used to describe an injury that occurs when a person is exposed to a chemical that comes from outside the body and causes damage or death to cells; these toxic substances can enter the body by inhalation, ingestion, injection, or absorption [7]. Unintentional poisoning is a persistent and significant worldwide public health threat [8]. As reported in the 2022 world health statistics, unintentional poisoning resulted in 84000 fatalities in 2019, with rates ranging from 0.6 to 1.8 per 100,000 individuals [9], resulting in the loss of 5 million disability-adjusted life-years [8]. As stated by the World Health Organization (WHO), countries with poor and moderate incomes account for more than 91% of unintentional injury fatalities and 94% of DALYs lost [4].

Unintentional poisoning poses a significant risk to most vulnerable children. For example, the American Association of Poison Control Centers (AAPCC) stated that, in 2015, the number of children exposed to poisonous substances was 1.3 million, 40% of whom were under the age of three[10]. Most hospitalizations due to pediatric poisoning in developing countries are caused by household chemical substances [11]. One of the primary causes of unintentional poisoning in low-income nations is kerosene, accounting for up to 70% of cases observed in pediatric emergency settings [12].

Kerosene ingestion is a prevalent type of unintentional intoxication that frequently affects children, especially those below the age of 6 years [7]. Kerosene referred to as paraffin, fuel no.1 or lighting lamp oil; kerosene belongs to the hydrocarbon group and is a blend of aliphatic and aromatic chemicals classed as paraffins, naphthenes, or aromatics [13]. Kerosene is a combustible light yellow or colorless heavy oily liquid with a unique smell that is widely used for lighting, heating, and cooking. Kerosene also utilized for commercial uses, such as a fuel for aviation, as well as in industry [14]. However, it contains harmful compounds that, if ingested or breathed in, can cause serious health problems [15], such as respiratory distress, neurological damage, and, in extreme cases, death [16].

The widespread utilization and availability of this substance in households across the world, along with the various applications in which people utilize kerosene for cooking fuel and for lighting and heating, coupled with inadequate storage practices such as using unlabeled containers or appealing bottles such as those used for fruit or soda, which may be easily accessible to children, collectively increase the likelihood of poisoning incidents in domestic settings[12, 17].

There are many disadvantages and health consequences to the use of kerosene; using it in the kitchen increases the likelihood of cardiovascular-related fatalities [14] and increases susceptibility to developing respiratory symptoms and diseases [18]. Since it effortlessly traverses the respiratory airways and distributes across a vast region of lung tissue because of its high volatility, minimal viscosity, and decreased surface tension, it can cause chemical pneumonitis, which is a common consequence of kerosene poisoning [19]. Rapid cough, rapid breathing, apparent chest retraction, heightened breathing effort, whistling, and cyanosis are indications of aspiration pneumonia caused by kerosene intake, and these respiratory symptoms usually appear soon after ingesting kerosene and might last up to six hours [20]. Substantial kerosene ingestion can result in gastrointestinal manifestations, including nausea, emesis, loose stools, and discomfort in the abdomen region. [21]. Additionally, either from inhalation or considerable ingestion, kerosene poisoning can cause neurological manifestations such as headache, fainting, exhaustion, agitation, lack of coordination, reduced respiration, seizures, unconsciousness, and, in certain cases, fatality [16]. Therefore, Kerosene poisoning is an important public health problem, with recorded cases occurring on a regular basis [16].

Supportive care is the main management approach for kerosene poisoning [22]. Prophylactic antibiotics have little effect on improving outcomes in children with mild respiratory disease following kerosene consumption [23]. Early detection and management of aspiration pneumonitis is essential for reducing kerosene poisoning mortality [24].

It is one of the most prevalent poisoning substances among children in many Asian and African nations [21, 24–28]. Unsafe storage, lack of supervision, socioeconomic disadvantage, maternal education deficiency, and lack of familial support have all been identified as potential causes of kerosene poisoning in children [12, 16]. Despite the ongoing use of kerosene at home, limited research has been performed to rigorously assess and characterize the public health burden associated with unintentional poisoning caused by this fuel source in Saudi Arabia. A study on

acute chemical poisoning cases documented in chemical poisoning surveillance from 2019 to 2021 in Saudi Arabia revealed that children between the ages of 1 and 5 years were the most affected age group, and most acute chemical poisoning cases were unintentional and occurred in people's homes [29]. According to reports from the Makkah region, Saudi Arabia, among 1216 cases of drug and chemical poisoning reported to the Environmental and Occupational Health Department at the Ministry of Health between 2014 and 2015, 63% were unintentional chemical poisoning, and more than half of these cases occurred in young people under the age of five[30]. Another study conducted in Jeddah investigating chemical poisoning cases over a 5-year period, from 2011 to 2015 revealed that among 994 cases of chemical poisoning, 55% were males, and 56% were children under the age of five. Most of the cases were unintentional [31]. Among pediatric poisoning cases that presented to King Khalid University Hospital in Riyadh between 2010 and 2016, chemical poisoning accounted for 29% of the cases [32].

While preliminary numbers of kerosene exposure cases have been recorded, comprehensive epidemiological data on kerosene poisoning nationwide are lacking, and a thorough examination of monitoring data is still lacking in Saudi Arabia. Despite the significance of this problem, nationwide scientific research on kerosene poisoning is lacking in Saudi Arabia. Epidemiological research to assess the incidence, risk factors, and health effects associated with kerosene poisoning is therefore crucial for directing both prevention and intervention programs in the country.

This information gap presents a challenge for establishing appropriate targeted and focused preventative strategies. By performing this study, we believe that our findings will contribute to tackling these obstacles and help close that knowledge gap. Understanding kerosene poisoning trends can help inspire and achieve focused preventative initiatives by utilizing available secondary data to understand the prevalence and risk factors for kerosene poisoning, which makes this a timely and low-cost approach.

Identifying the epidemiology, circumstances, clinical characteristics, and consequences of kerosene poisoning is of utmost importance for developing effective public health prevention interventions in Saudi Arabia.

Our study aimed to identify the key epidemiological characteristics of kerosene poisoning cases recorded in Saudi Arabia, as documented in the national poisoning surveillance database, and to investigate and understand epidemiological aspects of this important public health issue, the demographic profile of affected children, and the seasonal and geographical variations among affected children.

Materials & Methods

This was a retrospective cross-sectional study utilizing surveillance data on kerosene poisoning across Saudi Arabia reported between January 2019 and December 2021.The data for this study obtained from the chemical poisoning surveillance system preserved by the general department of environmental health at the ministry of health in Saudi Arabia. The study population include all the reported kerosene poisoning cases in Saudi Arabia from January 2019 to December 2021.Each Case presented to the emergency departments in any health facility documented using the Reporting Form for Chemical Poisoning OR Drug over Dosage Poisoning. The forms recorded by the public health department in each facility and afterwards they enter the reports onto the national surveillance. The environmental health department in each cluster reviews the data produces monthly reports, which subsequently forwarded to the general department of environmental health.

The information in the data included demographics, the circumstances of the poisoning incident (route and place of incidence), clinical presentation, management, and outcomes of the patients. IBM SPSS statistics version 23 used for data entry and analysis. Descriptive analyses performed to summarize key variables, including demographic characteristics, circumstances of exposure, clinical characteristics, and temporal and seasonal trends (number of cases per year/ per season). Means (SD) and medians used to summarize continuous variables. Frequencies and percentages used to present categorical variables. Chi square test was used to explore the Associations between kerosene poisoning and sex, age groups, regional distribution, and place of incidence. The Kruskal-Wallis test was performed to investigate the seasonal variations in kerosene poisoning cases across the four seasons. P-value set at < 0.05. This study utilized an existing dataset obtained from the general department of environmental health, and there was no direct interaction or interference with human beings. permissions and ethical approvals were granted from the ministry of health Saudi Arabia (IRB log No 24-23 M). The privacy and confidentiality of all the subjects were maintained throughout the research process.

The authors declare no conflicts of interest that could influence the research process.

Results

Over a span of three years, from January 2019 to December 2021, Saudi Arabia recorded a cumulative number of 460 cases of kerosene poisoning. In 2019, 32.2% of the total cases were recorded, which rose to 37.2% in 2020, while in 2020, 30.6% of the total cases were reported. (Figure 1).

There was a notable difference in the occurrence of kerosene poisoning between the two genders, with males accounting for 60.9% of all reported cases (Figure 2,3).

The results of the chi-square test indicated a statistically significant relationship between sex and kerosene poisoning. The Pearson chi-square value of 11.076 ($df = 1$, $p < 0.001$) suggested a

difference in the occurrence of kerosene poisoning between males and females. reported incidents revealed a greater prevalence of kerosene poisoning among males (60.9%) than among females (39.1%).

Most kerosene poisoning cases were reported among Saudi citizens, accounting for 97.6% (449 out of 460 cases).

Patients spanned a wide age range, from 0 years old to 75 years old. The average age of the affected individuals was approximately 3 years, with a mean of 2.98 years and a standard deviation of 6.257 years (Table 1). Those between the ages of 1 and 5 accounted for 87.6% (403 out of 460 cases) of all cases, followed by infants under 1 year old at 5.2% (24 cases) and children aged 6 to 12 years at 4.8% (22 cases) (table 2, figure 4). This emphasizes the younger population that is susceptible to kerosene poisoning. Statistical analysis using the chi-square test yielded a significant result (Pearson chi-square = 291.493, degrees of freedom = 6, $p < 0.001$), suggesting a significantly greater incidence of poisoning among children aged 1 to 5 years.

Most kerosene poisoning cases occur at home (90.7%). Only a handful of instances were reported in other locations, including farms (0.4%), schools (0.2%), and outdoors (0.2%), with 8.4% of the cases remaining unidentified.

Oral ingestion was the predominant route of exposure, accounting for 91.7% of the reported cases. This underscores the specific risk posed to children, who are especially susceptible to unintentionally consuming kerosene. Other routes of exposure were less prevalent, with inhalation (0.86%), cutaneous contact (0.2%), and undetermined pathways (7.1%).

A total of 41.3% of patients necessitated hospitalization, and 17.6% were discharged against medical advice (DAMA), demonstrating varying degrees of severity associated with the occurrence of kerosene poisoning. The administration of antidote treatment was observed in 23.7% of the patients, emphasizing the clinical management strategies employed.

Regional variations were found in the distribution of kerosene poisoning occurrences in Saudi Arabia between 2019 and 2021. The AlQurayat region had the highest number of recorded incidents, accounting for 53%. followed by the Northern Borders region with 18%, the AlJouf region with 15.7%, and the Hail region with 7% (Table 3, Figure 5).

The Pearson chi-square value obtained from the chi-square test was 2658.243 ($df = 20$, $p < .001$), suggesting that there are statistically significant differences in poisoning incidence among different regions.

Analyses of kerosene poisoning occurrence, by region and place of incidence, have identified considerable regional disparities. a chi-square test indicated that the distribution of poisoning cases in various settings, such as home, farm, outdoor, school, and other sites, differed depending on the geographical region ($\chi^2 = 96.029$, $df = 20$, $p < .001$). Most occurrences occurred in residential settings, and there was a distinct clustering of these instances in the northern region. This emphasizes that the home is the primary site for such accidents and shows that the northern region is a particularly high-risk area.

The monthly spread of the cases suggested a distinct seasonal trend, with most cases reported in March (16.3%), followed by February (13.3%), January (13.3%), and April (12.2%) (Table 4,

Figure 6,7). To further explore the seasonal variations, the Kruskal–Wallis test utilized to examine the possible variation in kerosene poisoning events over the four main seasons—winter, spring, summer, and autumn. The objective was to ascertain the presence of major variation in the seasonal distribution of these instances.

The test revealed substantial variations among the seasons, as shown by a Kruskal–Wallis H statistic of 18.072, with 3 degrees of freedom (df), and a p value below 0.001, indicating considerable variation in the frequency of poisoning cases across different seasons. These findings point to a seasonal clustering of kerosene poisoning cases, with a peak occurring during the early months of the year.

Discussion

This study examined the epidemiological characteristics of kerosene poisoning in Saudi Arabia by analyzing data from the National Poisoning Surveillance Database, which spans from January 2019 to December 2021. The objectives were to investigate and study the patterns and features of these episodes, with a focus on the epidemiological aspects, as well as the unique seasonal and geographical fluctuations found in these cases. Our aim was to investigate the current patterns of kerosene poisoning and provide a valuable contribution to the existing information needed to develop public health interventions and to focus on the necessity for targeted preventative interventions for affected groups in the community.

The year 2020 had the greatest number of reported kerosene poisoning cases in comparison to 2019 and 2021. This increase in kerosene poisoning cases could be affected by the COVID-19 pandemic lockdown, as Saudi authorities imposed 11 hours of partial curfew by the end of March 2020. Then, the full lockdown imposed by the 6th of April 2020 and continued until the 28th of May 2020; thereafter, by the 20th of June 2020, the lockdown was entirely removed [33]. If we compare the number of reported cases in the full lockdown period (April to May) in each of the years 2019, 2020 and 2021, we can note that the number of reported cases in 2020 was double the number of documented cases in each of 2019 and 2021. Households were the main location of kerosene incidence, which aligns with other studies conducted in Saudi Arabia [29–31, 34] and is consistent with global studies indicating that household contexts are the main locations for unintentional child poisoning [27]. This could further explain the increase in cases during 2020, as children during lockdowns are more prone to domestic accidents coupled with the availability of kerosene in households.

Our study's demographic analysis indicates that males and children, particularly those aged 1 to 5 years, have impacted the most by kerosene poisoning, which is in accordance with the current literature that suggests that children, particularly toddlers, are the most susceptible group to unintentional poisoning [1, 12].

The differences in various regions imply the variability of kerosene demand and need across Saudi Arabia, which is even notable in the local news that reports a surge in demand, especially north of the kingdom where kerosene used for heating and warmth. These findings are important because of the reported increase in kerosene poisoning cases in the northern regions of Saudi Arabia. This spatial distribution emphasizes the relationship between environmental factors and the occurrence of kerosene poisoning cases. This finding corroborates the hypothesis that regions with lower temperatures, where kerosene is frequently used for heating purposes, are more prone to incidents of kerosene poisoning. Considering the present geographical variations, it is necessary to develop a specific public health measure aimed at mitigating the risk of kerosene poisoning in the northern regions of Saudi Arabia.

Throughout the three years of 2019, 2020, and 2021, documented cases concentrated in the early months of the year (from January to April), indicating a recurrent pattern of these incidents, and indicating the increased demand for kerosene during the colder months.

Our study revealed a deficiency in the data on poisoning surveillance, specifically regarding the socioeconomic status and level of education of individuals impacted by kerosene poisoning. This deficiency presents a substantial barrier to fully understanding the entire spectrum of risk factors associated with these events.

In conclusion, it is essential to overcome this discrepancy to advance toward a more complete and inclusive strategy for reducing kerosene poisoning and enhancing public health. This study can provide a platform for more studies since there is a need for more investigations to further explore the status of kerosene poisoning in the kingdom. A recent systematic review on deaths among children due to poisoning in Saudi Arabia illustrates the need for more studies at both the regional and national levels [34].

strengths:

This study used a comprehensive dataset from the poisoning surveillance system, which offers a strong basis for assessing cases of kerosene poisoning throughout Saudi Arabia.

This research uses data that is regularly gathered across different healthcare facilities to reliably monitor public health and accurately analyze trends in kerosene poisoning cases.

This study is the first investigation of the epidemiology of kerosene poisoning at the national level in Saudi Arabia. This study contributes to the current understanding of this topic.

This study provides essential baseline epidemiological data that are crucial for developing and implementing specific preventative interventions to reduce the risks associated with kerosene poisoning.

Limitations:

The accuracy and completeness of the data rely on the precision and completeness with which healthcare practitioners document the information.

Underestimation of occurrences Because the study relies on reported data, there is a possibility of minimizing the actual magnitude of kerosene poisoning.

Unreported or mildly symptomatic cases of poisoning may not be included in the data, indicating that the true number of poisoning incidents might be greater.

Conclusions

Building upon all the information outlined in this study, our conclusion highlights the dynamics of kerosene poisoning in the Kingdom of Saudi Arabia. This study revealed a significant risk in certain demographic groups, particularly males and young children aged 1 to 5 years.
By analyzing the number of incidents in each season, a seasonal variation in kerosene poisoning incidents was observed, highlighting the increase in the incidence of kerosene poisoning during colder seasons. Moreover, the study highlights a substantial regional disparity, particularly in the northern regions of Saudi Arabia.
Both the regional and seasonal tendencies stress the necessity for focused public health awareness campaigns during these colder months and focused on the northern region of the kingdom, emphasizing the potential advantage of advocating the use of alter-native heating methods.
Information on the socioeconomic status and educational level of the patients and/or their guardians is of fundamental importance for developing a more comprehensive understanding of the risk factors associated with kerosene poisoning. Our investigation revealed the absence of the aforementioned information from the dataset, hence, we recommend adding details on both socioeconomic status and education level to the surveillance system to gather more thorough data on kerosene poisoning cases.
This study offers a step toward a broad and inclusive public health strategy to address kerosene poisoning in Saudi Arabia, and to advance future initiatives, it is pivotal to build strategies that encompass education, policy, and innovation, to significantly minimize the frequency and impact of kerosene poisoning and ensure the safety and well-being of the community.

Acknowledgements

We thank the Saudi Ministry of Health for providing access to the chemical poisoning surveillance data. Special thanks to the Department of Environmental Health for their support throughout this study.

References

1. Jullien, S. Prevention of Unintentional Injuries in Children under Five Years. BMC Pediatr. 2021, 21 (Suppl 1). https://doi.org/10.1186/S12887-021-02517-2.

2. Norton, R.; Ahuja, R. B.; Hoe, C.; Hyder, A. A.; Ivers, R.; Keay, L.; Mackie, D.; Meddings, D.; Rahman, F. Nontransport Unintentional Injuries. Disease Control Priorities, Third Edition (Volume 7): Injury Prevention and Environmental Health. 2017, 55–70. https://doi.org/10.1596/978-1-4648-0522-6_CH4.

3. World Health Organization. Injuries and Violence. Available online: https://www.who.int/news-room/fact-sheets/detail/injuries-and-violence (accessed on Oct 7, 2023).

4. Chandran, A.; Hyder, A. A.; Peek-Asa, C. The Global Burden of Unintentional Injuries and an Agenda for Progress. Epidemiol. Rev. 2010, 32 (1), 110. https://doi.org/10.1093/EPIREV/MXQ009.

5. Yin, X.; Ma, D.; Zhu, K.; Li, D. Identifying Intentional Injuries among Children and Adolescents Based on Machine Learning. PLoS One 2021, 16 (1). https://doi.org/10.1371/JOURNAL.PONE.0245437.

6. Yu, X.; Wang, Y.; He, C.; Kang, L.; Miao, L.; Wu, Y.; Yang, S.; Zhu, J.; Liang, J.; Li, Q.; et al. The Trend of Unintentional Injury-Related Mortality among Children Aged under-Five Years in China, 2010–2020: A Retrospective Analysis from a National Surveillance System. BMC Public Health 2023, 23 (1), 1–10. https://doi.org/10.1186/S12889-023-15546-6.

7. Ahmed, A.; AlJamal, A. N.; Mohamed Ibrahim, M. I.; Salameh, K.; AlYafei, K.; Zaineh, S. A.; Adheir, F. S. S. S. Poisoning Emergency Visits among Children: A 3-Year Retrospective Study in Qatar. BMC Pediatr. 2015, 15 (1). https://doi.org/10.1186/S12887-015-0423-7.

8. Khan, N. U.; Khan, U.; Khudadad, U.; Ali, A.; Raheem, A.; Waheed, S.; Razzak, J. A. Trends in Mortality Related to Unintentional Poisoning in the South Asian Region from 1990 to 2019: Analysis of Data from the Global Burden of Disease Study. BMJ Open 2023, 13 (2), 62744. https://doi.org/10.1136/BMJOPEN-2022-062744.

9. World Health Organization. World Health Statistics 2022. Available online: https://www.who.int/news/item/20-05-2022-world-health-statistics-2022 (accessed on Oct 7, 2023).

10. Mowry, J. B.; Spyker, D. A.; Brooks, D. E.; Zimmerman, A.; Schauben, J. L. 2015 Annual Report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 33rd Annual Report. Clin. Toxicol. (Phila.) 2016, 54 (10), 924–1109. https://doi.org/10.1080/15563650.2016.1245421.

11. Prasadi, G. A. M.; Mohamed, F.; Senarathna, L.; Cairns, R.; Pushpakumara, P. H. G. J.; Dawson, A. H. Paediatric Poisoning in Rural Sri Lanka: An Epidemiological Study. BMC Public Health 2018, 18 (1). https://doi.org/10.1186/S12889-018-6259-Y.

12. Oreh, A. C.; Uchemefuna, I.; Mmamelu, N.; Imagbenikaro, E. U.; Nafiu, M. A.; Moses, L. A. Accidental Kerosene Oil Ingestion in Under-Five Age Children in Nigeria – The Need for Vigilance in Primary Care Settings in Low- and Middle-Income Countries (LMICs). J. Family Med. Prim. Care 2023, 12 (4), 796. https://doi.org/10.4103/JFMPC.JFMPC_1840_22.

13. Maiyoh, G. K.; Njoroge, R. W.; Tuei, V. C. Effects and Mechanisms of Kerosene Use-Related Toxicity. Environ. Toxicol. Pharmacol. 2015, 40 (1), 57–70. https://doi.org/10.1016/J.ETAP.2015.05.010.

14. Arku, R. E.; Brauer, M.; Duong, M. L.; Wei, L.; Hu, B.; Tse, L. A.; Mony, P. K.; Lakshmi, P. V. M.; Pillai, R. K.; Mohan, V.; et al. Ad-verse Health Impacts of Cooking with Kerosene: A Multi-Country Analysis within the Prospective Urban and Rural Epidemiology Study. Environ. Res. 2020, 188, 109851. https://doi.org/10.1016/J.ENVRES.2020.109851.

15. Lam, N. L.; Smith, K. R.; Gauthier, A.; Bates, M. N. Kerosene: A Review of Household Uses and Their Hazards in Low- and Mid-dle-Income Countries. J. Toxicol. Environ. Health B Crit. Rev. 2012, 15 (6), 396. https://doi.org/10.1080/10937404.2012.710134.

16. Kumar, S.; Kavitha, T.; Angurana, S. K. Kerosene, Camphor, and Naphthalene Poisoning in Children. Indian J. Crit. Care Med. 2019, 23 (Suppl 4), S278. https://doi.org/10.5005/JP-JOURNALS-10071-23316.

17. Anwar, S.; Rahman, A.; Houqe, S. A.; Moshed, A.; Yasmin, L.; Saleh, A.; Mohsin, M. Clinical Profile of Kerosene Poisoning in a Tertiary Level Hospital in Bangladesh. Bangladesh J. Child Health 2014, 38 (1), 11–14. https://doi.org/10.3329/BJCH.V38I1.20021.

18. Choi, J. Y.; Baumgartner, J.; Harnden, S.; Alexander, B. H.; Town, R. J.; D'Souza, G.; Ramachandran, G. Increased Risk of Respiratory Illness Associated with Kerosene Fuel Use among Women and Children in Urban Bangalore, India. Occup. Environ. Med. 2015, 72 (2), 114–122. https://doi.org/10.1136/OEMED-2014-102472.

19. Sanju, S.; Tullu, M. S.; Mondkar, S.; Agrawal, M. Kerosene Poisoning Complicated by Acute Pancreatitis. J. Pediatr. Intensive Care 2020, 9 (4), 284. https://doi.org/10.1055/S-0040-1705183.

20. Makrygianni, E. A.; Palamidou, F.; Kaditis, A. G. Respiratory Complications Following Hydrocarbon Aspiration in Children. Pedi-atr. Pulmonol. 2016, 51 (6), 560–569. https://doi.org/10.1002/PPUL.23392.

21. Dayasiri, M. B. K. C.; Jayamanne, S. F.; Jayasinghe, C. Y. Kerosene Oil Poisoning among Children in Rural Sri Lanka. Int. J. Pediatr. 2017, 2017, 1–7. https://doi.org/10.1155/2017/8798610.

22. Tormoehlen, L. M.; Tekulve, K. J.; Nañagas, K. A. Hydrocarbon Toxicity: A Review. Clin. Toxicol. (Phila.) 2014, 52 (5), 479–489. https://doi.org/10.3109/15563650.2014.923904.

23. Balme, K. H.; Zar, H.; Swift, D. K.; Mann, M. D. The Efficacy of Prophylactic Antibiotics in the Management of Children with Ker-osene-Associated Pneumonitis: A Double-Blind Randomised Controlled Trial. Clin. Toxicol. (Phila.) 2015, 53 (8), 789–796. https://doi.org/10.3109/15563650.2015.1059943.

24. Parekh, U.; Gupta, S. Kerosene-a Toddler's Sin: A Five Years Study at Tertiary Care Hospital in Western India. J. Forensic Leg. Med. 2017, 47, 24–28. https://doi.org/10.1016/J.JFLM.2017.02.004.

25. IK, K.; Priyadarshini, D.; Nakka, S.; John, J.; Mahapatro, S.; Dwibedi, B.; Satapathy, A. K. Profile and Outcome of Childhood Hy-drocarbon Poisoning: An Observational Study. Cureus 2021, 13 (12). https://doi.org/10.7759/CUREUS.20144.

26. Oreh, A. C.; Uchemefuna, I.; Mmamelu, N.; Imagbenikaro, E. U.; Nafiu, M. A.; Moses, L. A. Accidental Kerosene Oil Ingestion in Under-Five Age Children in Nigeria – The Need for Vigilance in Primary Care Settings in Low- and Middle-Income Countries (LMICs). J. Family Med. Prim. Care 2023, 12 (4), 796. https://doi.org/10.4103/JFMPC.JFMPC_1840_22.

27. Ahmed, A.; Hasanul Banna, M.; Shojon, M.; Mahdi Hasan, M.; Raheem, E.; Hossain, M. S. Original Research: Accidental Poisoning in Children: A Single Centre Case Series Study in Bangladesh. BMJ Paediatr. Open 2022, 6 (1). https://doi.org/10.1136/BMJPO-2022-001541.

28. Edelu, B.; Odetunde, O.; Eke, C.; Uwaezuoke, N.; Oguonu, T. Accidental Childhood Poisoning in Enugu, South-East, Nigeria. Ann. Med. Health Sci. Res. 2016, 6 (3), 168. https://doi.org/10.4103/2141-9248.183944.

29. Alshahrani, M. M.; Albogami, H. A.; Asiri, A. A.; Al haydhah, K. S.; Aldeailej, I. M.; Aldehaim, M. A.; Lubbad, M. Y.; Alalyan, L. A.; Alasmari, A. F.; Al salem, I. Y.; et al. Epidemiological Trends of Acute Chemical Poisoning among Children over a Recent Three-Year Period in Saudi Arabia. Children 2023, 10 (2). https://doi.org/10.3390/CHILDREN10020295.

30. Alnasser, S. M. Drug and Chemical Poisoning Patterns in Makkah Region, Saudi Arabia. Drug Res. 2022, 72 (3), 148–155. https://doi.org/10.1055/A-1658-3036.

31. Alzahrani, S. H.; Ibrahim, N. K.; Elnour, M. A.; Alqahtani, A. H. Five-Year Epidemiological Trends for Chemical Poisoning in Jed-dah, Saudi Arabia. Ann. Saudi Med. 2017, 37 (4), 282. https://doi.org/10.5144/0256-4947.2017.282.

32. Alghadeer, S.; Alrohaimi, M.; Althiban, A.; Kalagi, N. A.; Balkhi, B.; Khan, A. A. The Patterns of Children Poisoning Cases in Community Teaching Hospital in Riyadh, Saudi Arabia. Saudi Pharm. J. 2018, 26 (1), 93–97. https://doi.org/10.1016/J.JSPS.2017.10.007.

33. Hakeem, F. F.; Alshahrani, S. M.; Ghobain, M. Al; Albabtain, I.; Aldibasi, O.; Alghnam, S. The Impact of COVID-19 Lockdown on Injuries in Saudi Arabia: Results From a Level-I Trauma Center. Front. Public Health 2021, 9, 704294. https://doi.org/10.3389/FPUBH.2021.704294.

34. Almutairi, S. A.; Alsaleem, J. H.; Alrashed, M. A.; Alsalim, M. J.; Al-Qadhi, A. A.; Menezes, R. G. Pediatric Poisoning Deaths in Saudi Arabia: A Systematic Review. Leg. Med. (Tokyo) 2023, 60. https://doi.org/10.1016/J.LEGALMED.2022.102173.

Figure 1

Number of kerosene poisoning cases reported in the national surveillance database across Saudi Arabia from 2019 to 2021.

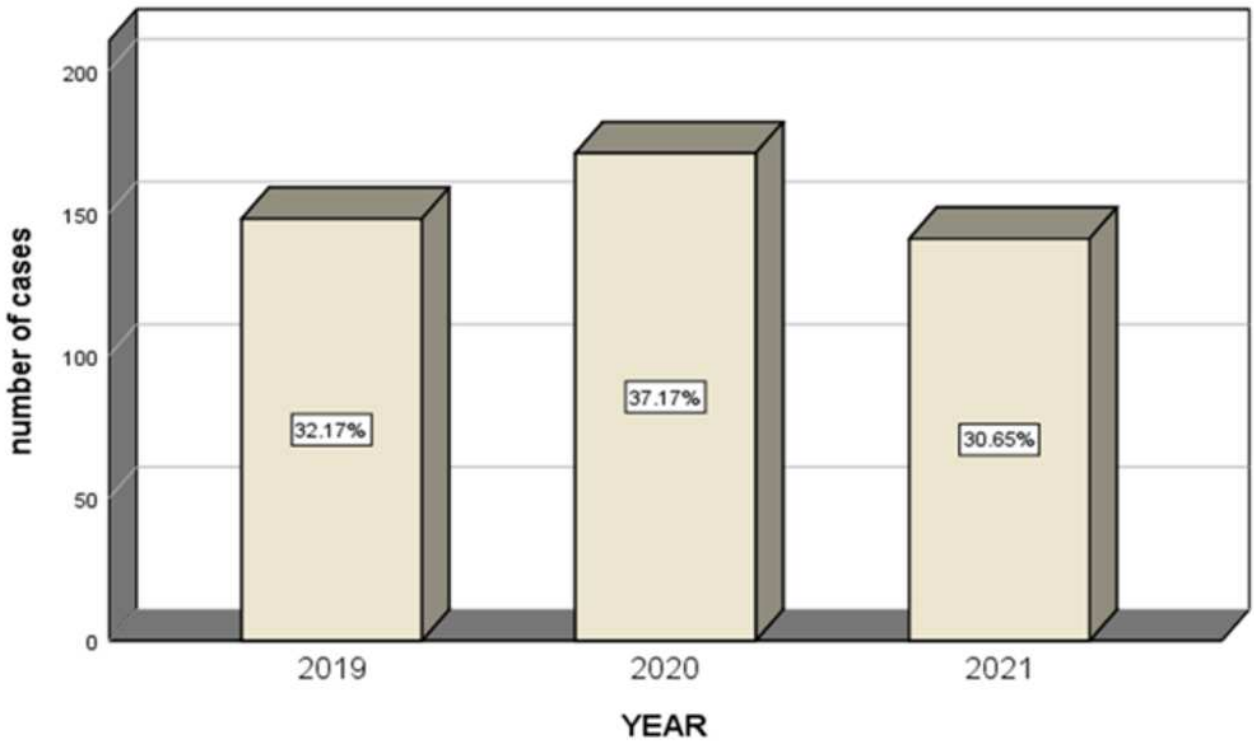

Figure 2

Gender distribution of kerosene poisoning cases reported in Saudi Arabia from 2019 to 2021.

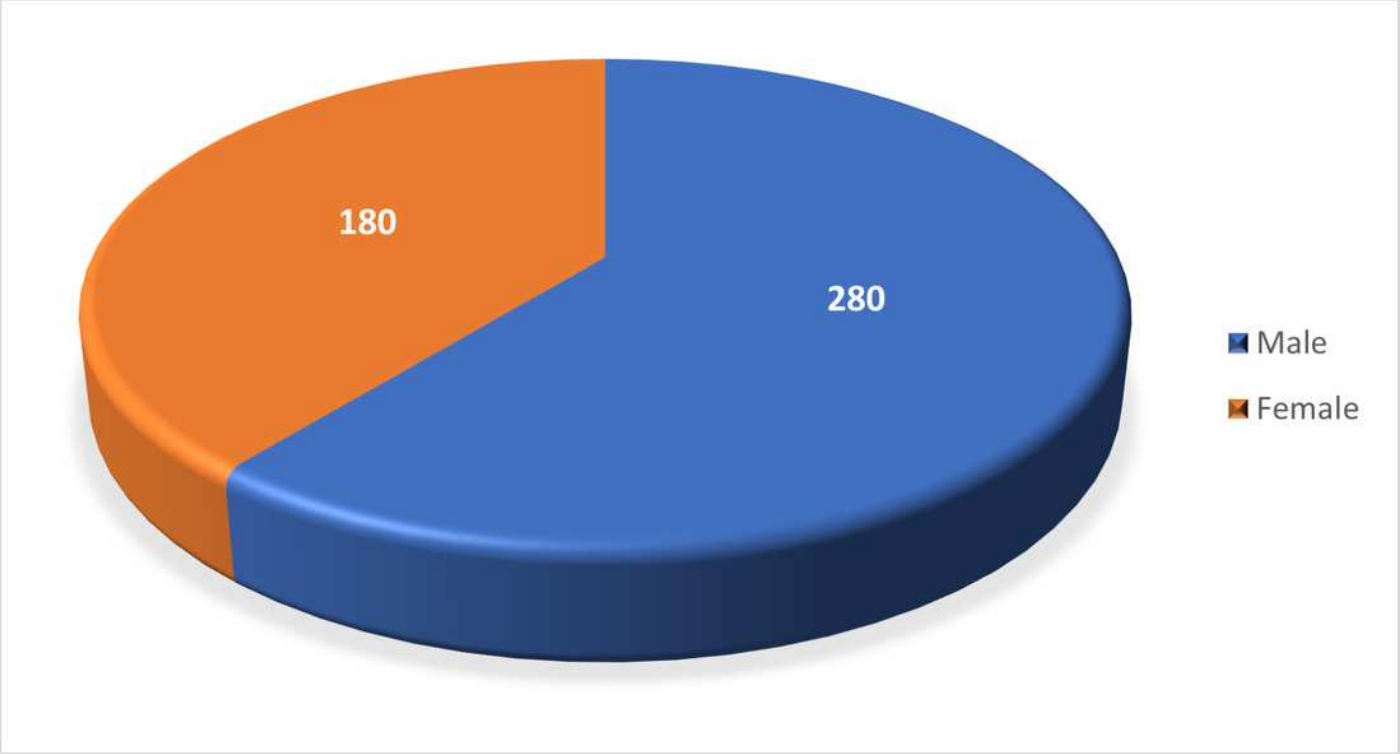

Figure 3

Gender distribution of kerosene poisoning cases reported in Saudi Arabia by year.

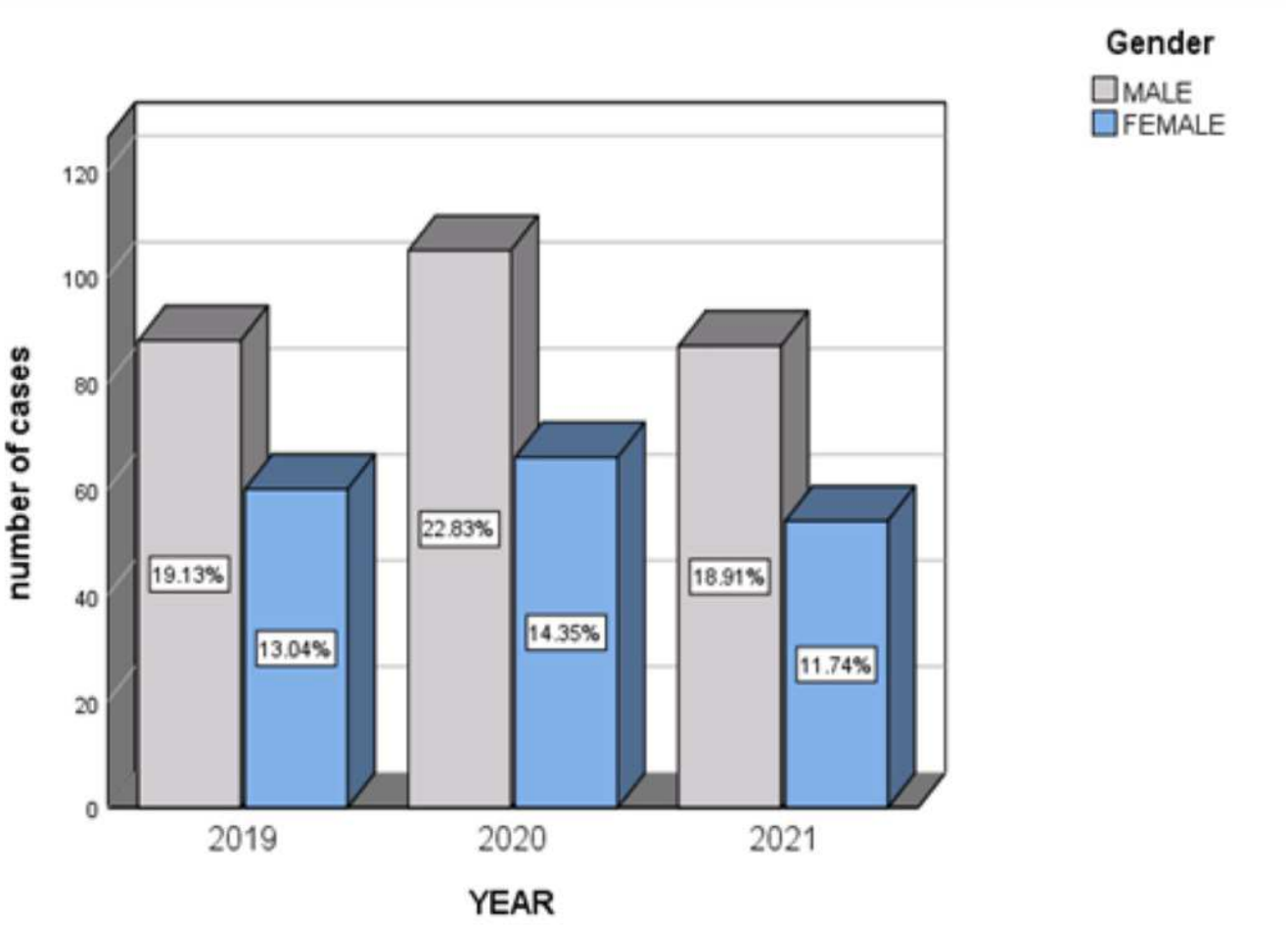

Figure 4

Age group distribution of kerosene poisoning cases reported in Saudi Arabia from 2019 to 2021.

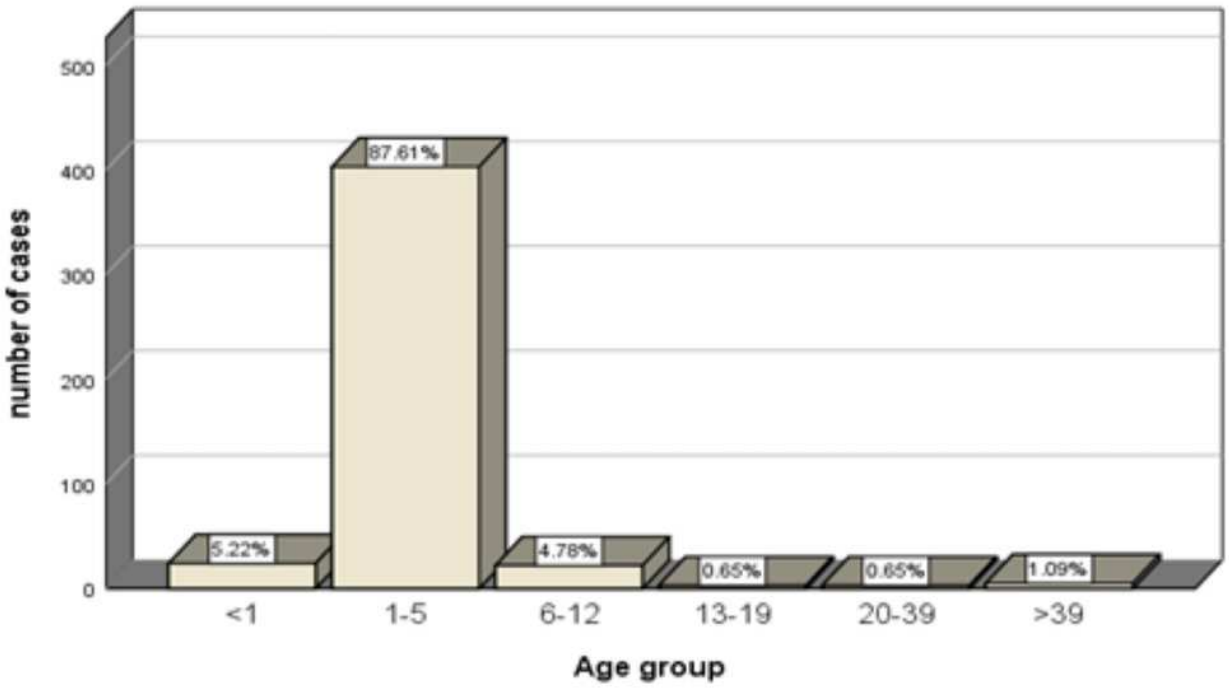

Figure 5

Regional distribution of kerosene poisoning cases reported in Saudi Arabia from 2019 to 2021.

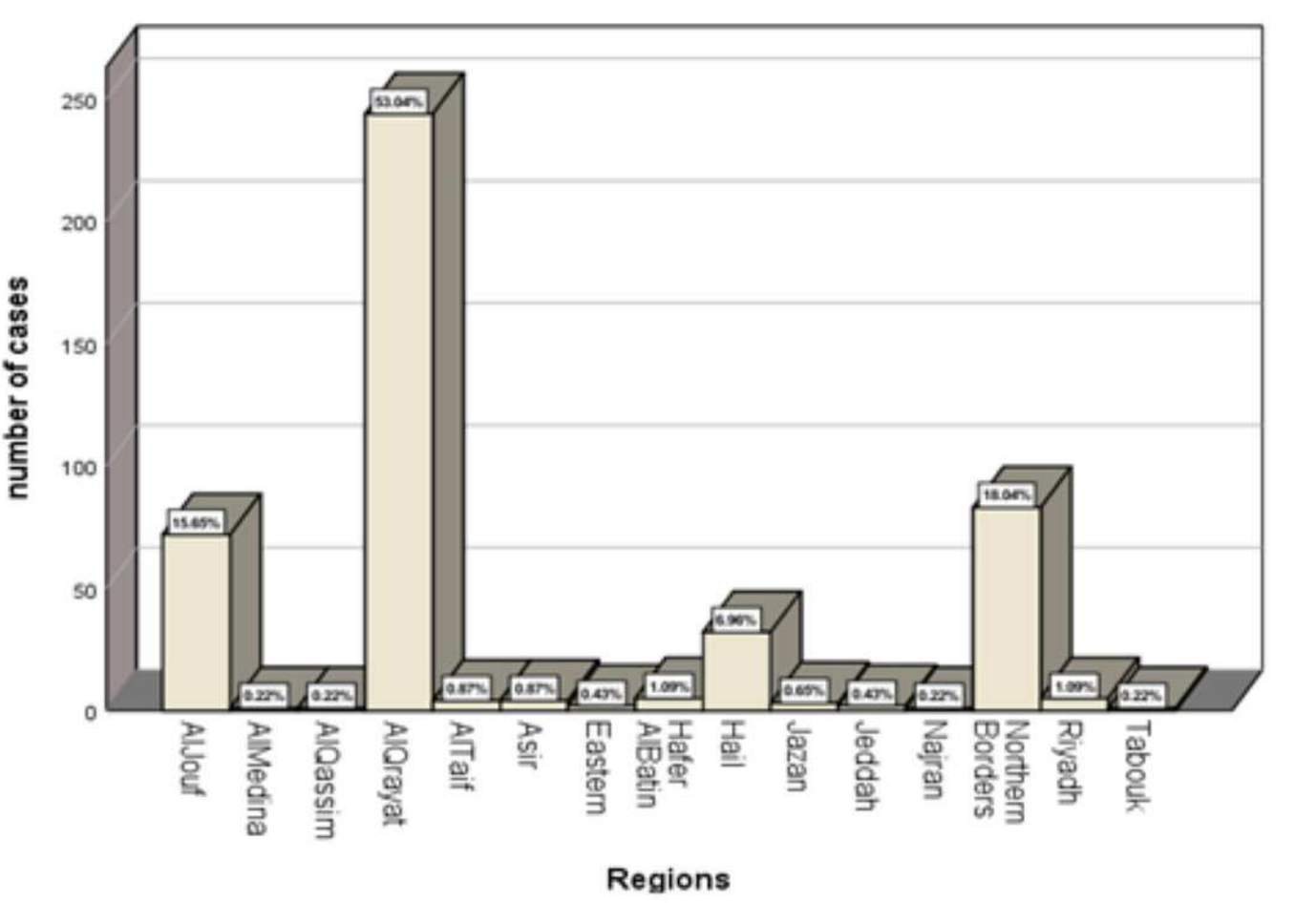

Figure 6

Monthly distribution of kerosene poisoning cases reported in Saudi Arabia from 2019 to 2021.

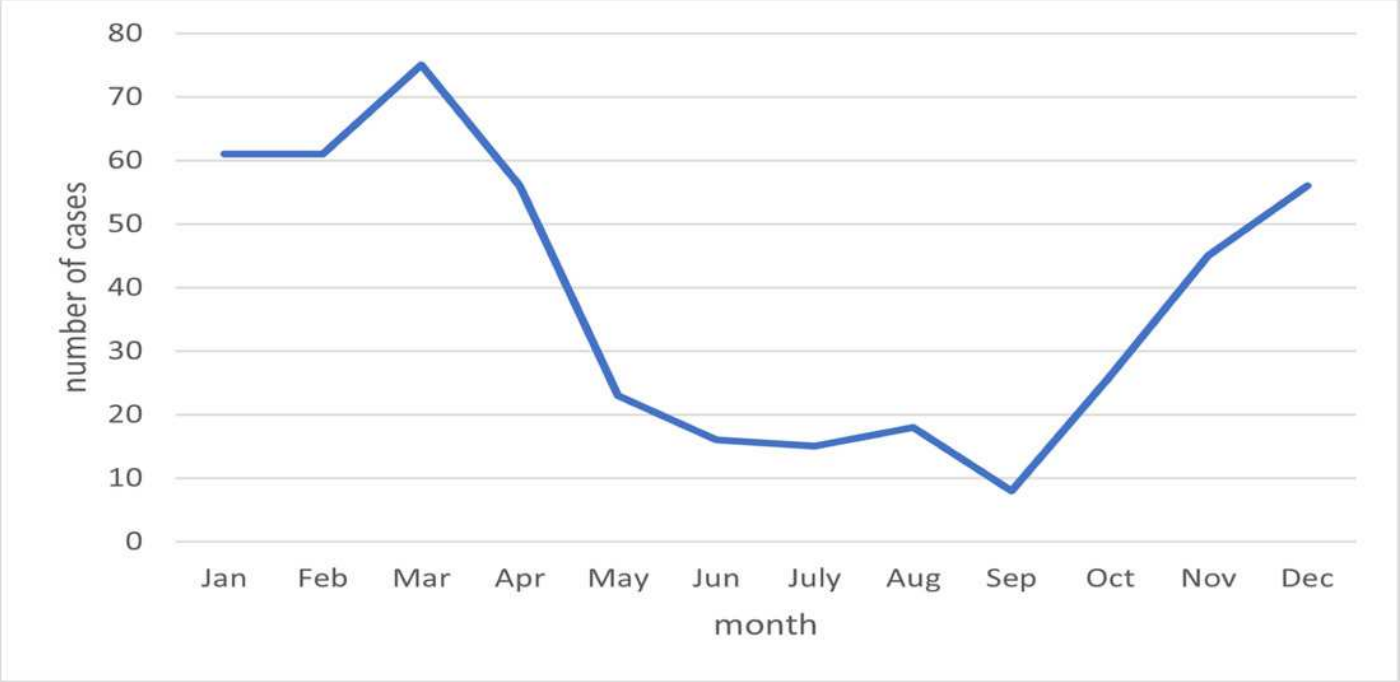

Figure 7

Number of kerosene poisoning cases reported in Saudi Arabia by month of occurrence each year from 2019 to 2021.

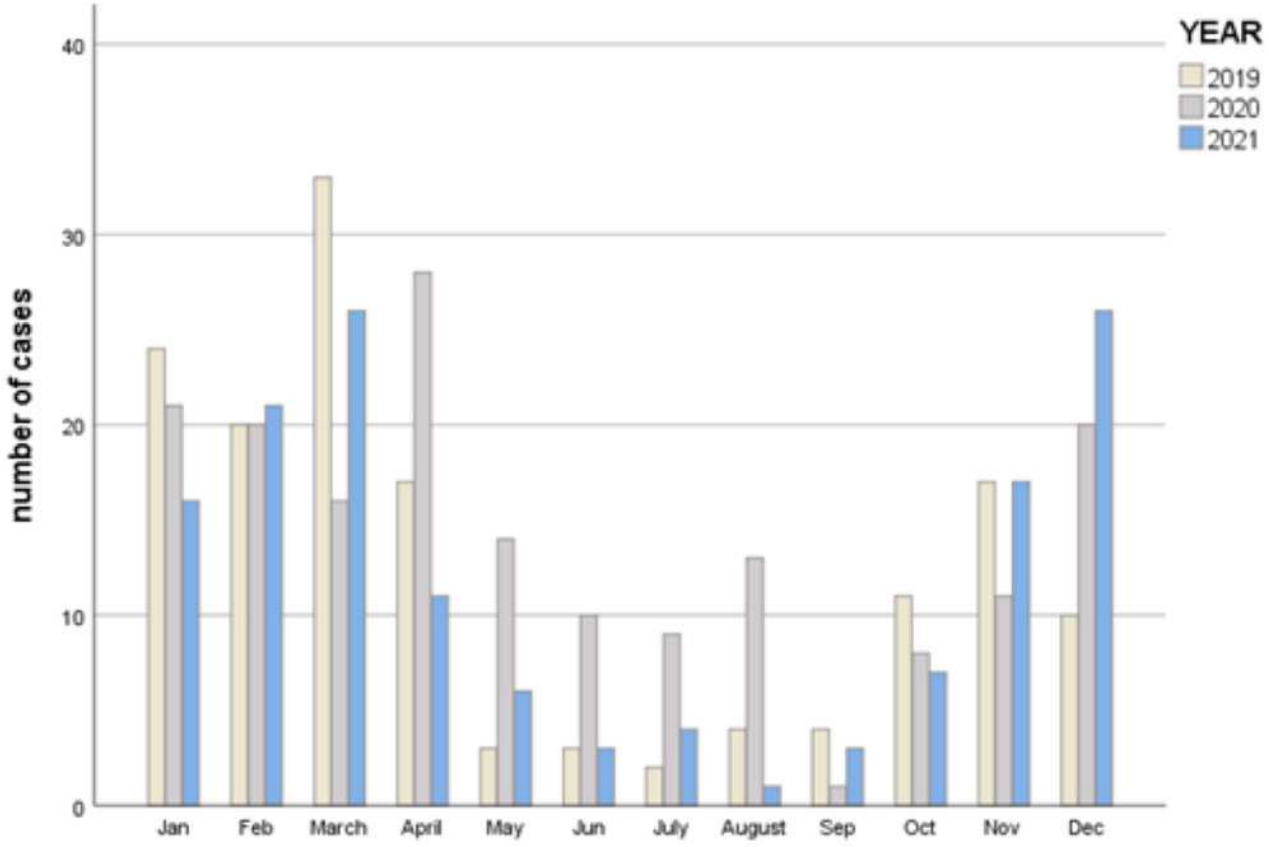

Table 1(on next page)

Age analysis of kerosene poisoning cases reported in Saudi Arabia from 2019 to 2021.

1

2

N	Minimum	Maximum	Mean	Std. Deviation
460	0	75	2.98	6.257

3

Table 2(on next page)

Age group distribution of kerosene poisoning cases reported in Saudi Arabia from 2019 to 2021.

1

2

Age group	frequency	Percent
<1	24	5.2
1-5	403	87.6
6-12	22	4.8
13-19	3	.7
20-39	3	.7
>39	5	1.1
total	460	100

3

Table 3(on next page)

Regional distribution of kerosene poisoning cases reported in Saudi Arabia from 2019 to 2021.

1

2

region	No. of cases	% of cases
AlQrayat	244	53
Northern Borders	83	18
AlJouf	72	15.7
Hail	32	7
Hafer AlBatin	5	1.1
Riyadh	5	1.1
AlTaif	4	0.9
Asir	4	0.9
Jazan	3	0.7
Eastern	2	0.4
Jeddah	2	0.4
AlMedina AlMonawarah	1	0.2
AlQassim	1	0.2
Najran	1	0.2
Tabouk	1	0.2

3

Table 4(on next page)

Monthly distribution of kerosene poisoning cases reported in Saudi Arabia from 2019 to 2021.

1

2

3

month	No. of cases	% of cases
Jan	61	13.3
Feb	61	13.3
Mar	75	16.3
Apr	56	12.2
May	23	5
Jun	16	3.5
July	15	3.3
Aug	18	3.9
Sep	8	1.7
Oct	26	5.5
Nov	45	9.8
Dec	56	12.2