Analyzing the Impact of Smog on Human Health in District Lahore, Pakistan

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Smog is a term used to describe pollution suspended in humid air, consisting of dust particles of various sizes, non-metal oxides, organic compounds, and heavy metals. Exposure to these toxic compounds, in addition to cigarette smoking, is a significant factor in the development of respiratory diseases. Smog is a visible form of air pollution that results from excessive emissions of primary pollutants such as volatile organic compounds (VOCs), hydrocarbons, sulfur dioxide (SO_2), nitrogen oxides (NO_x), and nitrogen dioxide (NO_2). These pollutants react in the atmosphere to form harmful and carcinogenic secondary smog components. Airborne chemicals that adversely impact public health include ozone and particulate matter (PM) of various sizes—PM2.5, PM2.5–10, and PM10—as well as nitrogen oxides. Special attention is given to lead, carbon dioxide (CO_2), sulfur dioxide (SO_2), and carbon monoxide (CO), with a focus on smaller dust particles (PM10 and PM2.5) because they can penetrate the lower respiratory tract. This page explores the effects of atmospheric pollutants on the onset and exacerbation of respiratory diseases, including asthma, chronic obstructive pulmonary disease (COPD), and lung cancer. It also discusses legislative measures implemented in various countries to mitigate exposure to harmful air pollution. Based on the survey responses, it appears that the individual may be experiencing symptoms related to respiratory, skin, and cardiac conditions, such as coughing, wheezing, and shortness of breath. They have been diagnosed with several health issues, including asthma, chronic bronchitis, pneumonia, and ischemic heart disease. Diagnostic tests such as chest X-rays and arterial blood gas (ABG) tests are likely to have been performed during their hospital stay. The individual has reported experiencing symptoms and health effects associated with air pollution or smog during their hospitalization.

Keywords: Impact, Smog, Human, Health, Air Pollution, Public Health.

Introduction:

Smog is a type of air pollution commonly described as a mixture of smoke and fog. The term "smog" was first used in London in the early 1950s to denote severe atmospheric pollution suspended in humid air. Smog results from a combination of human activities and climatic conditions. Primary sources include the burning of coal in industries, vehicular emissions, crop burning, construction activities, fireworks, and smoke from brick kilns. The global release of pollutants from factories and vehicles significantly contributes to smog formation, leading to severe pollution [1]. Fog is essentially a cloud-like formation at ground level, consisting of water droplets, vapors, and ice particles suspended in the air, creating a damp and cloudy mixture. When fog combines with smoke, it forms "smog." The term "smog" often refers to "photochemical smog," which results from complex photochemical reactions between nitrogen dioxide (NO_2), nitrogen monoxide (NO), sulfur dioxide (SO_2), and volatile organic compounds. These reactions release ground-level (tropospheric) ozone and fine particles into the environment [2].

Smog has historically been categorized into two types, named after the cities where they were first observed: London and Los Angeles. London smog, also known as reducing or sulfurous smog, is characterized by high concentrations of sulfur dioxide (SO_2) and particulate matter. This type of smog is primarily composed of "primary pollutants" emitted directly from combustion processes. The most severe episodes of London smog occur in urban areas with low winds and a shallow boundary layer, which trap pollutants in a relatively small air volume. These meteorological conditions typically arise during the winter months and early morning hours. London-type smog, marked by high aerosol loadings and elevated sulfur dioxide levels, is still present in many cities that burn coal today. Examples include Beijing and Shanghai in China, Cairo in Egypt, Belgrade in Serbia, and Kolkata in India [3].

Smog is commonly classified into two types based on their origin: London and Los Angeles. London smog, also known as reducing or sulfurous smog, is characterized by high concentrations of sulfur dioxide (SO_2) and particulate matter. This type of smog consists primarily of "primary pollutants" emitted directly from combustion processes. Severe episodes of London smog typically occur in urban areas with low winds and a shallow boundary layer, which trap pollutants in a confined air volume. These conditions are most common during winter months and early morning hours. London-type smog, which features high aerosol loadings and elevated sulfur dioxide levels, persists in cities that burn coal, such as Beijing and Shanghai in China, Cairo in Egypt, Belgrade in Serbia, and Kolkata in India [3].

In Europe, including Poland, severe atmospheric pollution during the autumn-winter period is historically described as London-type smog. This smog is composed of dust particles, non-metal oxides, organic compounds, and heavy metals. In contrast, the warmer seasons experience a different type of smog known as photochemical or Los Angeles smog, which is characterized by high levels of ozone, a harmful substance for human health. Exposure to these airborne pollutants is a modifiable risk factor for respiratory diseases [4].

Exposure to air pollution, particularly particulate matter (PM), poses significant health risks, primarily affecting the airways and cardiovascular system. Both PM10 and PM2.5 can cause eye irritation, allergies, and rhinitis. Globally, air pollution is a major contributor to deaths from chronic obstructive pulmonary disease (COPD), lung cancer, ischaemic heart disease, stroke, and other cardiovascular diseases [5]. Recent studies have shown a correlation between PM10 and hospital admissions for respiratory issues [6]. PM2.5, which can penetrate deeper into lung tissue than larger particles, is linked to increased risks of chronic diseases, including COPD and lung cancer. Cardiovascular conditions associated with PM2.5 include ischaemic heart disease and stroke [7]. Among affected individuals, 27% die from pneumonia, 20% from COPD, 8% from lung cancer, and 45% from cardiovascular diseases [8]. In Western countries, exposure to

PM2.5 is estimated to reduce life expectancy by an average of 8.3 months [9].

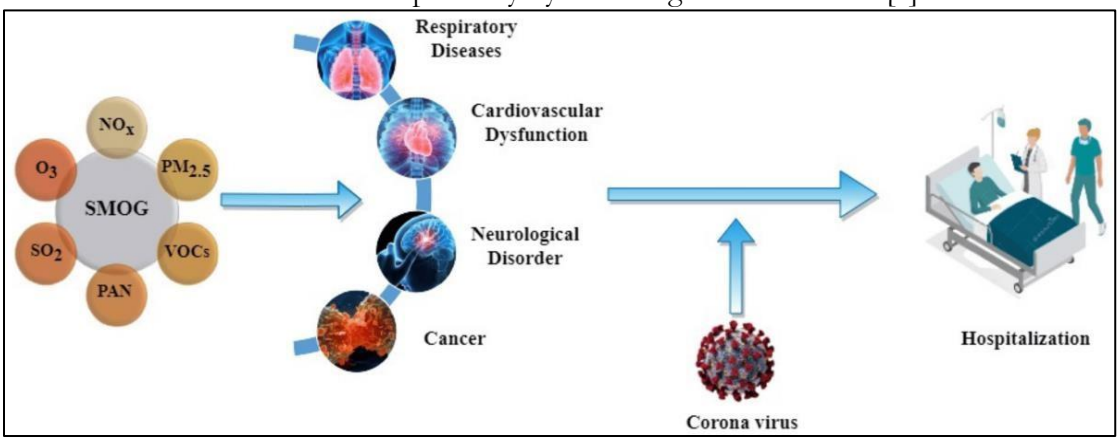

Figure 1: Relationship between COVID-19 and smog [10].

Study Area:

Lahore, the capital of Punjab province in Pakistan, is the focal point of this case study, "Analyzing the Impact of Smog on Human Health in District Lahore, Pakistan." Situated in the northeastern part of the country, Lahore is a densely populated city and a major urban center in South Asia. With a rich history spanning over a thousand years, Lahore is renowned for its cultural heritage, significant landmarks, and vibrant street life. However, rapid urbanization, industrialization, and a growing number of vehicles have significantly contributed to its environmental challenges.

Major traffic signal areas in Lahore, such as Kalma Chowk, Liberty Roundabout, Thokar Niaz Baig, and Yateem Khana Chowk, experience severe traffic congestion. These intersections, characterized by prolonged vehicle idling, see emissions from cars, motorcycles, buses, and rickshaws, resulting in elevated levels of pollutants like nitrogen oxides (NOx), carbon monoxide (CO), and particulate matter (PM2.5 and PM10). Additionally, industrial zones such as Kot Lakhpat Industrial Estate, Sundar Industrial Estate, and Sheikhupura Road Industrial Area contribute significantly to air pollution. Factories in these areas, involved in steel production, textiles, and brick kilns, release substantial amounts of smoke and particulate matter from fossil fuel combustion and other processes, aggravating respiratory and cardiovascular issues among residents.

The growing number of buses and motorcycles further exacerbates Lahore's smog problem. While public transportation is crucial for reducing individual car use, many buses are outdated and poorly maintained, emitting high levels of pollutants. Motorcycles, favored for their affordability and maneuverability, also contribute significantly to emissions of hydrocarbons (HC) and CO, largely due to lax emission standards and insufficient maintenance. The cumulative effect of these factors has led to severe smog episodes, especially in winter, highlighting the urgent need for intervention.

Questions:

- How does long-term exposure to smog impact respiratory health across different age groups?
- Are there discernible patterns of respiratory diseases associated with varying levels of smog pollution? If so, which diagnostic tests can identify these patterns?
- What role do specific air pollutants within smog play in the development of respiratory conditions?
- Does the combination of coronavirus and smog exacerbate health risks?
- How can technology contribute to combating environmental pollution?

Hypothesis:

Prolonged exposure to smog is positively correlated with an increased incidence of respiratory diseases and reduced lung function among urban residents.

Objective:

To determine the specific health effects of smog exposure in a targeted population.

Problem Statement:

Smog, a harmful mixture of pollutants such as smoke and fog, poses a serious threat to human health. It envelops cities and urban areas, exposing individuals to toxic compounds like particulate matter, ozone, carbon monoxide, and sulfur dioxide.

Methodology:

Study Design:

The study employs a cross-sectional design.

Study Duration:

The study utilizes data collected over a 6-month period: September 2023 to February 2024.

Study Setting:

This research will be conducted in the Department of Medicine and the Pulmonology Department at Gulab Devi and Ghurki Trust & Teaching Hospitals, Lahore, Pakistan.

Sample Size:

The study includes samples from 50 patients diagnosed with chronic obstructive pulmonary disease (COPD), stroke, ischemic heart disease, pneumonia, lung cancer, and cardiovascular diseases.

We use the Cochran formula: $n = \frac{Z^2 \frac{\alpha}{2} pq}{\rho^2}$ Eq (1)

Sampling Technique: Non-probability sampling (purposive sampling).

Inclusion Criteria:

Patients of either gender aged between 15 and 70 years diagnosed with chronic obstructive pulmonary disease (COPD), ischemic heart disease, stroke, pneumonia, lung cancer, or cardiovascular diseases.

Exclusion Criteria:

- Patients with any acute or chronic viral hepatitis, including HBV, HCV (acute or chronic), or HIV.
- Individuals with other acute or chronic liver diseases, such as alcoholic hepatitis.
- Cases of drug-resistant tuberculosis (TB).

Study Variables:

Age, Gender, Chronic obstructive pulmonary disease (COPD), Stroke, Ischemic heart disease, Pneumonia, Lung cancer, Cardiovascular diseases.

Data Collection Tools/Procedure:

A semi-structured questionnaire was developed to gather necessary information (Annex I). All patients diagnosed with COPD, stroke, ischemic heart disease, pneumonia, lung cancer, and cardiovascular diseases at Gulab Devi and Ghurki Trust & Teaching Hospitals, Lahore, Pakistan, were included. Data collection involved ABG tests and CT scans.

Data Analysis:

- Data will be analyzed using SPSS version 26.0 (SPSS Inc., Chicago, USA).
- Quantitative data will be summarized using mean, median, mode, and standard deviation. Appropriate statistical analyses will be conducted.
- Categorical data will be presented as frequencies and percentages. Bar charts and pie charts will be used to visualize the data. Suitable statistical tools will be applied for data analysis.

Result and Analysis:

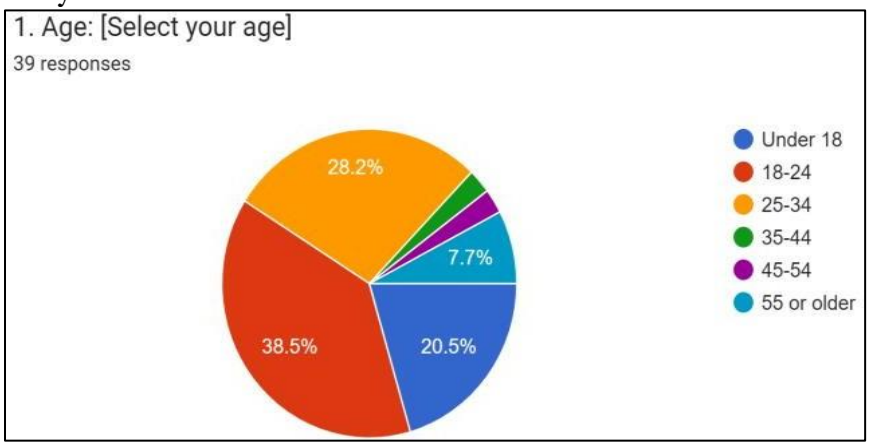

Figure 2: Percentage Distribution of Age:

Figure 2 illustrates the age distribution of participants in this study. The responses are as follows: 21% of subjects are under 18 years old, 39% are between 18 and 24 years old, 28% are between 25 and 34 years old, 8% are between 35 and 44 years old, and a small percentage falls into other age groups.

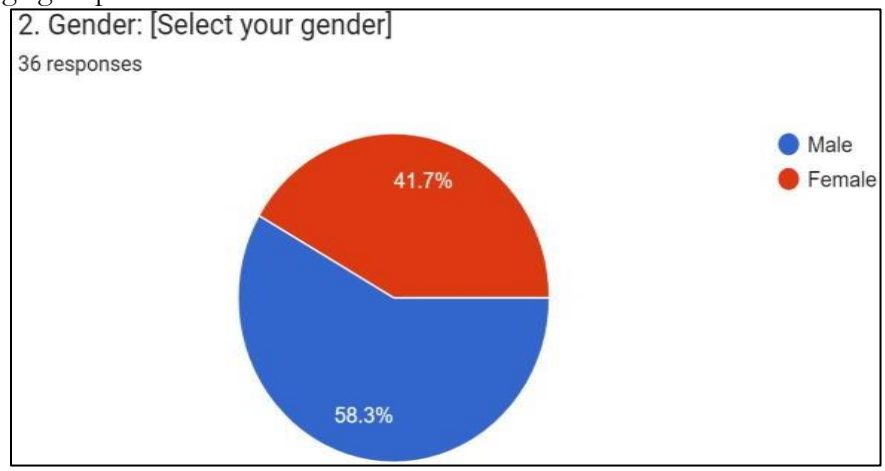

Figure 3: Percentage Distribution of Gender:

Figure 3 shows that, out of 40 patients, 59% were female and 41% were male. Thus, the pie chart clearly indicates that the majority of participants in this study were female.

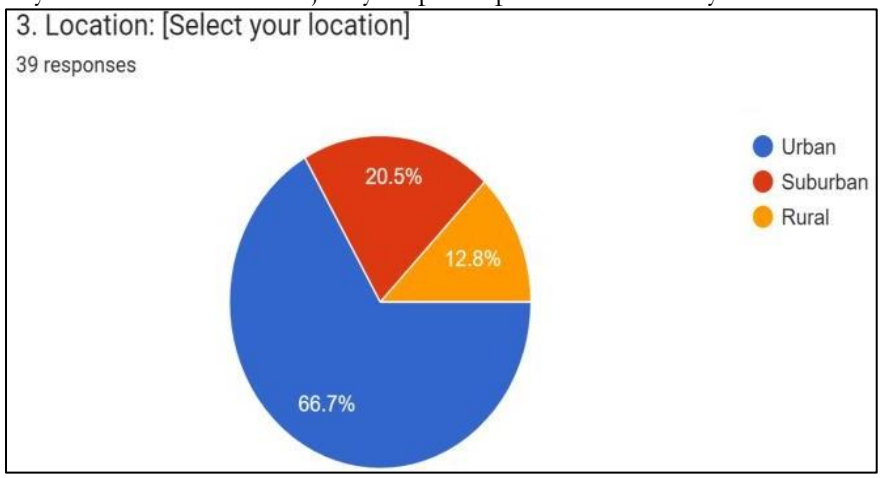

Figure 4: Percentage Distribution of Location:

Figure 4 shows that, out of 40 patients, 66% were from urban areas, 20% from suburban areas, and 13% from rural areas.

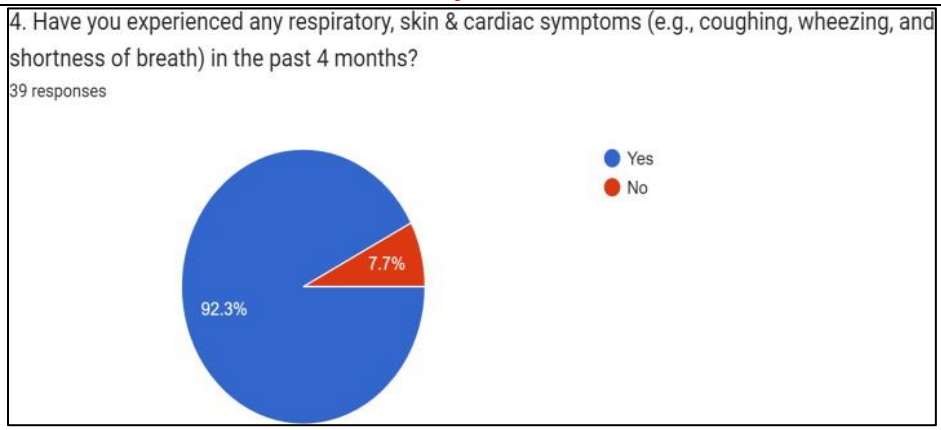

Figure 5: Percentage Distribution of Respiratory, Skin & Cardiac Diseases:

Figure 5 shows that, out of 40 patients, 92% had been suffering from the disease in the past four months, while 8% had not experienced the disease during this period. The pie chart clearly indicates that the majority of patients in this study have been affected by the disease.

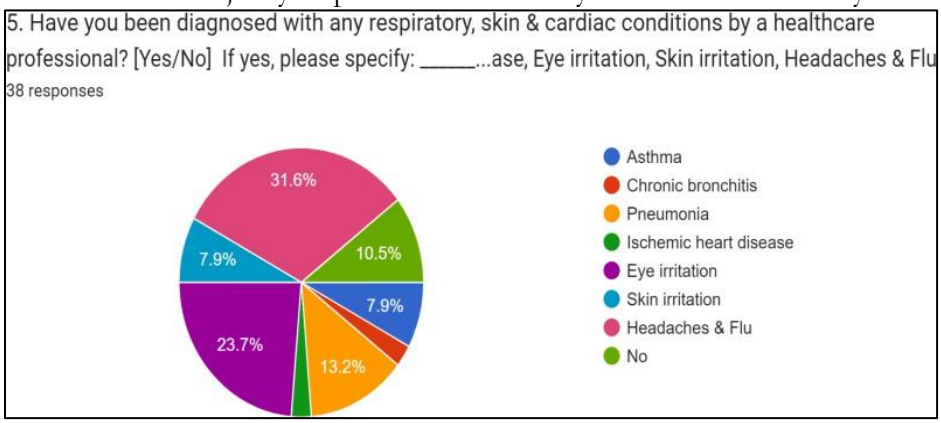

Figure 6: Percentage Distribution of Respiratory, Skin & Cardiac Diseases Diagnosed:

Figure 6 illustrates the distribution of diagnoses among 40 patients: 31% had headaches and flu, 11% had ischemic heart disease, 8% had asthma, 14% had pneumonia, 24% experienced eye irritation, and 10% had skin irritation. A small percentage suffered from other diseases. The pie chart clearly shows that the majority of patients in this study were affected by these conditions.

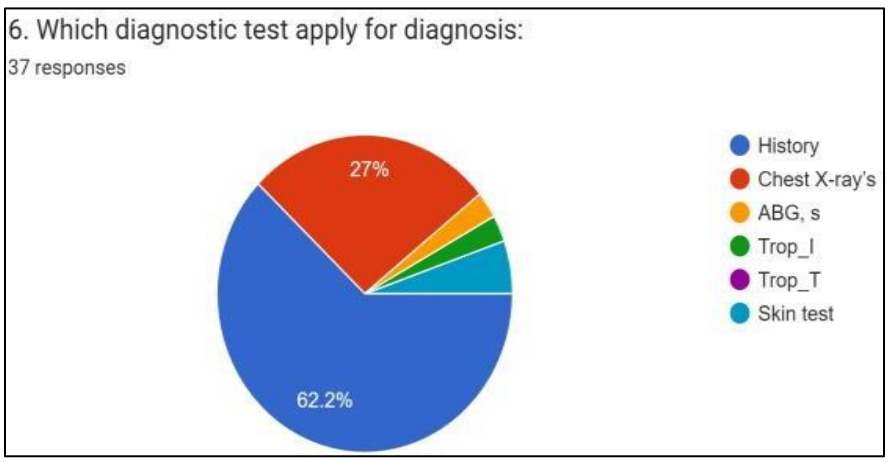

Figure 7: Percentage Distribution of Diagnostic Test:

Figure 7 shows that out of 40 patients, 62% were diagnosed based on their medical history, 27% were diagnosed through chest X-rays, and a small percentage were diagnosed using other methods. The pie chart clearly indicates that most patients in this study were diagnosed

through their medical history.

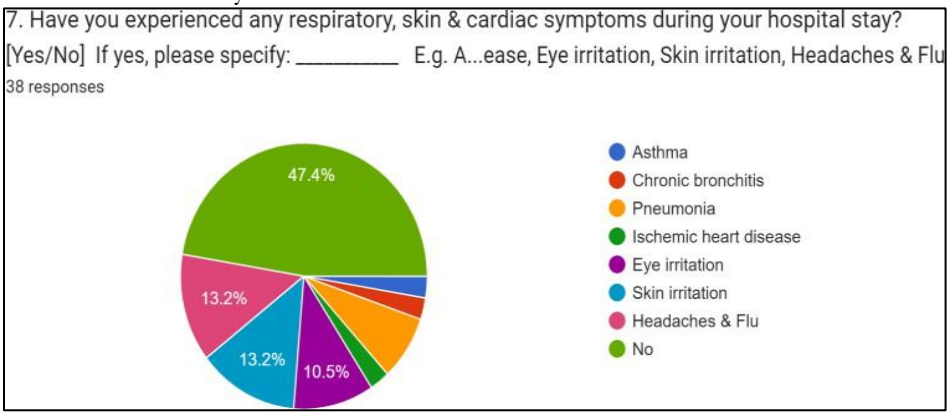

Figure 8: Percentage Distribution of Respiratory, Skin & Cardiac Diseases During Hospital Stay:

Figure 8 shows that out of 40 diagnosed patients, 14% had headaches and flu, 3% had asthma, 10% had pneumonia, 11% experienced eye irritation, and 13% suffered from skin irritation. The remaining patients reported other minor ailments. The pie chart indicates that 48% of the patients did not experience these symptoms during their hospital stay.

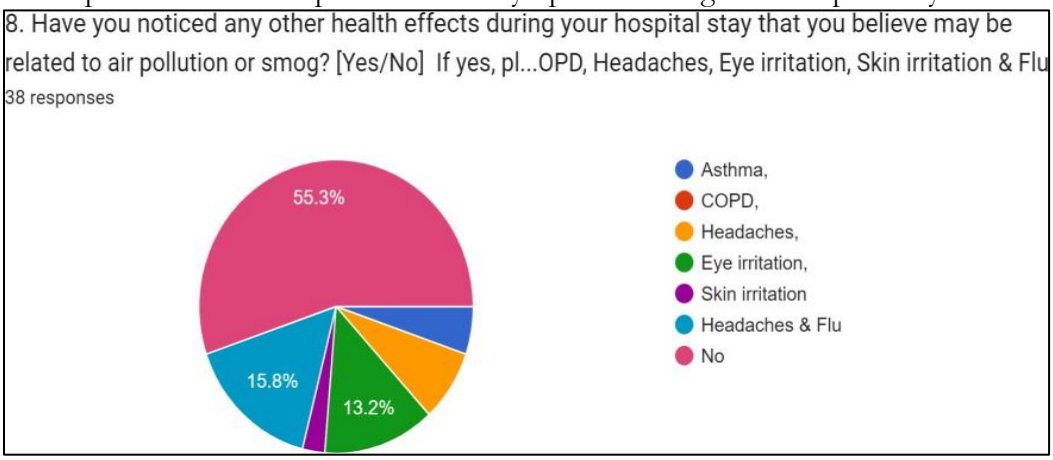

Figure 9: Percentage Distribution of Respiratory, Skin & Cardiac Diseases Related to Smog During Hospital Stay:

Figure 9 shows that out of 40 diagnosed patients, 16% had headaches and flu, 3% had asthma, 1% had pneumonia, 13% experienced eye irritation, and 2% had skin irritation. The remaining patients had other minor conditions. The pie chart indicates that 55% of the patients did not experience health effects related to air pollution during their hospital stay.

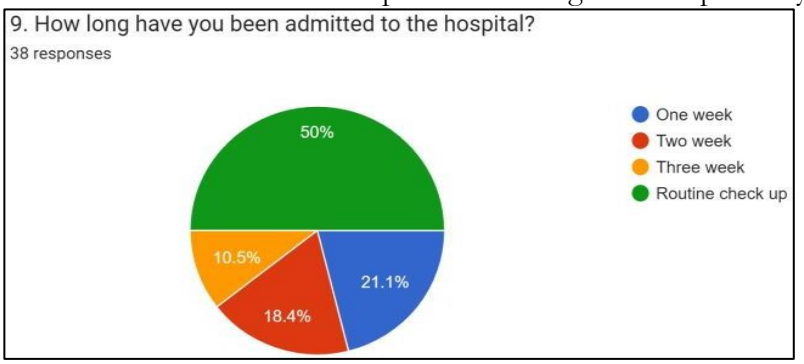

Figure 10: Percentage Distribution of Patient Admitted to Hospital:

Figure 10 shows that out of 40 patients, 50% were diagnosed during routine checkups. Additionally, 22% were admitted to the hospital for one week, 19% for two weeks, and 11% for

three weeks due to smog-related diseases.

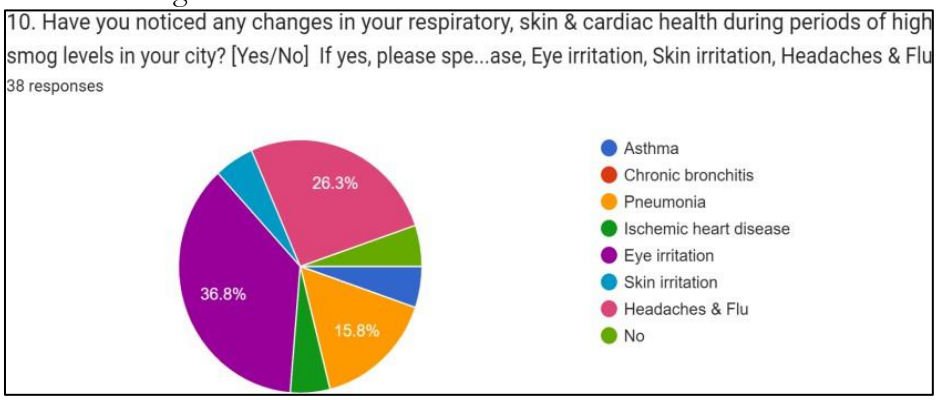

Figure 11: Percentage Distribution of Respiratory, Skin & Cardiac Diseases During Hospital Periods of High Smog Level:

Figure 11 shows that, out of 40 diagnosed patients, 26% experienced headaches and flu, 3% had asthma, 17% suffered from pneumonia, 37% reported eye irritation, and 10% experienced skin irritation. Other patients had minor ailments related to high smog levels in the city.

Additionally, 100% of the patients surveyed indicated that smog exposure affects their daily activities and quality of life. The pie chart also demonstrates that 100% of the respondents believe there is a need for increased awareness and action regarding air pollution and its impact on human health.

Discussion:

The research aims to rank suggested measures for preventing and reducing smog. According to a World Bank report, Pakistan ranks 4th in air pollution. However, controlling this issue is challenging for several reasons. Firstly, inadequate legislation and policies regarding industrial waste allow industries to release pollutants freely into the air. Additionally, many industrialists are affiliated with the government, complicating the passage of effective legislation. The strong influence of political mafias and industrialists who are major donors to political parties further hampers legislative and enforcement efforts. Even with robust legislation, enforcing regulations remains a significant challenge. Moreover, there is widespread denial of the issue's severity and a lack of understanding of its long-term consequences [11].

Vehicular emissions, crop burning, and solid waste combustion are major sources of smog in Pakistan. Smog negatively impacts human health, animals, tourism, and the economy. Lahore, Pakistan's second-largest city, is severely affected by winter smog. This study outlines the sources of smog, its hazards, and potential preventive measures to mitigate its effects in Pakistan. Few studies specifically address the economic impact of smog in Pakistan [12].

Human activities such as burning fossil fuels, coal combustion, and automobile exhausts release toxic gases that contribute to smog formation [13]. Air pollution, particularly smog, is a critical global issue affecting public health, ecosystems, and quality of life [14]. Smog has severe health impacts, inducing respiratory diseases and contributing to high morbidity and mortality, especially in developing countries like Pakistan. Effective air pollution control should be a top government priority [15].

Given the link between environmental pollution and respiratory disorders, it is crucial to address this issue comprehensively. Both primary and secondary prevention of lung disorders must be considered [16][17]. Smog, with its harmful mix of pollutants such as particulate matter, ozone, and nitrogen oxides, significantly impacts human health. It exacerbates respiratory diseases like asthma and chronic obstructive pulmonary disease (COPD) and increases susceptibility to respiratory infections. Smog also poses cardiovascular risks, with prolonged exposure linked to heart attacks and strokes due to inflammation and oxidative stress.

Vulnerable groups, including children, the elderly, and socioeconomically disadvantaged communities, face higher risks, exacerbating existing health disparities.

Conclusion and Recommendations:

Based on the survey responses, the individual appears to be experiencing respiratory, skin, and cardiac symptoms, including coughing, wheezing, and shortness of breath. They have been diagnosed with several conditions, such as asthma, chronic bronchitis, pneumonia, and ischemic heart disease. Diagnostic tests, including chest X-rays and ABG tests, were likely performed during their hospital stay. The individual reported experiencing these symptoms while in the hospital and noted a correlation with air pollution or smog.

Additionally, they observed changes in their health during periods of high smog levels in their city. These observations suggest a significant link between air pollution exposure and adverse health effects, underscoring the need for increased awareness and action to address air pollution. Implementing measures to reduce pollution levels is crucial for protecting public health, as prolonged exposure can severely affect daily activities and quality of life. Advocating for policies to improve air quality and raise awareness about the health risks associated with air pollution is essential for safeguarding public health and well-being.

Recommendations:

To mitigate the impact of smog on human health, several measures are recommended:

- Implement comprehensive air quality monitoring systems to accurately measure pollutant levels and identify areas with high smog concentrations.
- Launch educational campaigns to raise awareness about the health risks associated with smog exposure and inform the public about ways to reduce their exposure, such as avoiding outdoor activities during peak smog hours.
- Encourage the adoption of electric vehicles, promote carpooling and public transportation, and enforce stricter emissions standards for automobiles to reduce the number of pollutants released into the atmosphere.
- Design urban areas with an emphasis on green spaces and urban forestry to absorb pollutants and improve air quality. Additionally, prioritize pedestrian-friendly infrastructure to decrease reliance on motor vehicles.
- Enact and enforce strict environmental regulations aimed at reducing smog emissions and hold polluting industries accountable for their contributions to air pollution.

References:

1. Naureen I, Saleem A, Aslam S, Zakir L, Mukhtar A, Nazir R, Zulqarnain S. Potential Impact of Smog on Human Health. Haya Saudi J Life Sci. 2022;7(3):78-84.
2. Gaffney JS, Marley NA, Frederick JE. Formation and effects of smog. Environmental and Ecological Chemistry; Sabljic, A., Ed.; Eolss Publishers Co., Ltd.: Oxford, UK. 2009 Feb 4;2:25-51.
3. Ali Y, Razi M, De Felice F, Sabir M, Petrillo A. A VIKOR based approach for assessing the social, environmental and economic effects of "smog" on human health. Science of the Total Environment. 2019 Feb 10;650:2897-905.
4. Grzywa-Celińska A, Krusiński A, Milanowski J. 'Smoging kills'-effects of air pollution on human respiratory system. Annals of Agricultural and Environmental Medicine. 2020;27(1):1-5.
5. Moelling K, Broecker F. Air microbiome and pollution: composition and potential effects on human health, including SARS coronavirus infection. Journal of environmental and public health. 2020 May 28;2020.
6. S. Geravandi, P. Sicard, Y. O. Khaniabadi et al., "A comparative study of hospital admissions for respiratory diseases during normal and dusty days in Iran," Environmental Science and Pollution Research, vol. 24, no. 22, pp. 18152–18159, 2017.

7. R. B. Hayes, C. Lim, Y. Zhang et al., "PM2.5 air pollution and cause-specific cardiovascular disease mortality," International Journal of Epidemiology, vol. 49, no. 1, pp. 25–35, 2020.
8. P. J. Landrigan, R. Fuller, N. J. R. Acosta et al., "The Lancet Commission on pollution and health," Lancet (London, England), vol. 391, no. 391, pp. 462–512, 2018.
9. International Institute for Applied Systems Analysis (IIASA), 2011, http://www.unece.org/fileadmin/DAM/env/documents/2011/eb/wg5/WGSR48/Informal%20docs
10. /Info.doc.8_CIAM_report_on_Cost_effective_emission_reductions_to_improve_air_quality_in_ Europe_in_2010.pdf.
11. Javed A, Aamir F, Gohar UF, Mukhtar H, Zia-Ui-Haq M, Alotaibi MO, Bin-Jumah MN, Marc RA, Pop OL. The potential impact of smog spell on humans' health amid COVID-19 rages. International Journal of Environmental Research and Public Health. 2021 Oct 29;18(21):11408.
12. Ali Y, Razi M, De Felice F, Sabir M, Petrillo A. A VIKOR based approach for assessing the social, environmental and economic effects of "smog" on human health. Science of the Total Environment. 2019 Feb 10;650:2897-905.
13. Raza W, Saeed S, Saulat H, Gul H, Sarfraz M, Sonne C, Sohn ZH, Brown RJ, Kim KH. A review on the deteriorating situation of smog and its preventive measures in Pakistan. Journal of Cleaner Production. 2021 Jan 10;279:123676.
14. Javed A, Aamir F, Gohar UF, Mukhtar H, Zia-Ui-Haq M, Alotaibi MO, Bin-Jumah MN, Marc RA, Pop OL. The potential impact of smog spell on humans' health amid COVID-19 rages. International journal of environmental research and public health. 2021 Oct 29;18(21):11408.
15. Usman M, Amjad S, Khan A. Clearing the Air: Legal Strategies for Combating Smog and Pollution. Journal of Strategic Policy and Global Affairs. 2023 Dec 3;4(01).
16. Ghorani-Azam A, Riahi-Zanjani B, Balali-Mood M. Effects of air pollution on human health and practical measures for prevention in Iran. Journal of research in medical sciences: the official journal of Isfahan University of Medical Sciences. 2016;21.
17. Naureen I, Saleem A, Aslam S, Zakir L, Mukhtar A, Nazir R, Zulqarnain S. Potential Impact of Smog on Human Health. Haya Saudi J Life Sci. 2022 Mar;7(3):78-84.
18. Grzywa-Celińska A, Krusiński A, Milanowski J. 'Smoging kills'-effects of air pollution on human respiratory system. Annals of Agricultural and Environmental Medicine. 2020;27(1):1-5

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Questionnaire:

1. Age: [Select your age] Under 18
- 18-24
- 25-34
- 35-44
- 45-54
- 55 or older

2. Gender: [Select your gender]
- Male
- Female

3. Location: [Select your location]
- Urban
- Suburban
- Rural

4. Have you experienced any respiratory, skin & cardiac symptoms (e.g., coughing, wheezing, and shortness of breath) in the past 4 months?

- Yes
- No

5. Have you been diagnosed with any respiratory, skin & cardiac conditions by a healthcare professional? [Yes/No]
If yes, please specify: _____

- Asthma, Chronic bronchitis, Pneumonia, Ischemic heart disease, Eye irritation, Skin irritation, Headaches & Flu
- Asthma
- Chronic bronchitis Pneumonia
- Ischemic heart disease
- Eye irritation Skin irritation Headaches & Flu No

6. Which diagnostic test apply for diagnosis:

- History
- Chest X-ray's ABG, s
- Trop_I Trop_T Skin test

7. Have you experienced any respiratory, skin & cardiac symptoms during your hospital stay? [Yes/No]
If yes, please specify: _____

- E.g. Asthma, Chronic bronchitis, Pneumonia, Ischemic heart disease, Eye irritation, Skin irritation, Headaches & Flu
- Asthma
- Chronic bronchitis Pneumonia
- Ischemic heart disease Eye irritation
- Skin irritation Headaches & Flu No

8. Have you noticed any other health effects during your hospital stay that you believe may be related to air pollution or smog? [Yes/No]
If yes, please specify: _____

- E.g. Asthma, COPD, Headaches, Eye irritation, Skin irritation & Flu Asthma,
- COPD,
- Headaches,
- Eye irritation, Skin irritation Headaches & Flu No

9. How long have you been admitted to the hospital? One week

- Two-week Three week
- Routine checks up

10. Have you noticed any changes in your respiratory, skin & cardiac health during periods of high smog levels in your city? [Yes/No]
If yes, please specify: _____

- E.g. Asthma, Chronic bronchitis, Pneumonia, Ischemic heart disease, Eye irritation, Skin irritation, Headaches & Flu
- Asthma
- Chronic bronchitis Pneumonia
- Ischemic heart disease Eye irritation
- Skin irritation Headaches & Flu

11. Smog exposure can affect your daily activities and quality of life? [Yes/No]

- Yes
- No

12. Do you believe there is a need for increased awareness and action regarding air pollution and its impact on human health? [Yes/No]

- Yes
- No