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A Quantitative Study to Assess Whether Pollutants Influence Immune Diseases (Asthma). A Case Study of Mufulira Clinic 1 Urban Health Centre

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Abstract- This quantitative study examined the impact of environmental pollutants on immune diseases, specifically asthma, at Mufulira Clinic 1 Urban Health Centre in Zambia. The research addressed a key public health issue due to the increasing prevalence of asthma in urban areas, worsened by exposure to pollutants like Sulphur Dioxide (SO_2), Carbon Monoxide (CO), and cigarette smoke. The main goals were to explore the link between Sulphur Dioxide (SO_2) exposure and asthma symptoms, study the connection between Carbon Monoxide (CO) exposure and asthma severity, and assess how cigarette smoke exposure influences the development of asthma among patients attending the clinic. The study focused on a clearly defined group of asthma patients who had been receiving treatment for at least six months, ensuring the results were relevant to those most affected. Limitations included a relatively small sample size of 87 participants, which may have affected the ability to generalize the findings. Additionally, relying on self-reported exposure data introduced potential bias and inaccuracies in measuring true pollutant exposure levels. Delimitations were set to keep the scope manageable, with the study concentrating only on patients from Mufulira Clinic 1 and excluding individuals from nearby clinics or rural areas. The results revealed significant links between pollutant exposure and the severity of asthma symptoms, offering valuable insights into how environmental factors influence respiratory health. By identifying specific pollutants that worsen asthma, the research aims to guide public health strategies and interventions to reduce asthma rates in urban populations. Overall, the study emphasized the urgent need for targeted interventions and policy changes to improve air quality and address the increasing asthma burden in urban Zambia.

Keywords— Sulphur Dioxide, Carbon Monoxide, cigarette smoke, asthma, environmental pollutants, public health.

I. INTRODUCTION AND BACKGROUND

Asthma is a chronic respiratory condition characterized by inflammation and narrowing of the airways, leading to difficulty in breathing. It affects millions of individuals worldwide and poses significant public health challenges, particularly in urban areas where environmental pollutants are prevalent. Understanding the correlation between these pollutants and asthma can provide critical insights for effective management and intervention strategies.

1. Research Background

Asthma is a leading chronic respiratory condition worldwide, with rising prevalence in urban settings, particularly in regions undergoing rapid urbanization and environmental change (Toenders et al., 2018; Kariuki & van der Meer, 2020). In sub-Saharan Africa, urban residents face exposures from traffic emissions, biomass fuels, and industrial activities that may elevate asthma risk and worsen control compared with rural populations (World Health Organization, 2020).

Sulfur dioxide (SO_2): SO_2 exposure can trigger bronchoconstriction and airway inflammation, with

greater effects observed in children and individuals with atopy or preexisting asthma (Singh & Raval, 2016; Di Stefano et al., 2015). Urban concentrations arising from fossil fuel combustion and industry may contribute to symptom burden among clinic patients (Singh & Raval, 2016).

Carbon monoxide (CO): Elevated ambient CO may impair oxygen delivery and augment hypoxic stress during asthma episodes, with observational studies linking higher CO exposure to increased symptoms and emergency department visits in urban cohorts (Goldberg et al., 2012; Clark & Patel, 2019).

Pesticides: Both agricultural and urban pesticide exposures have been associated with wheeze, reduced lung function, and higher asthma prevalence in several populations, potentially via immune modulation and airway inflammation pathways (Rauh et al., 2011; Leung et al., 2017).

Cigarette smoke (active and secondhand): Tobacco exposure is a well-established risk factor for Domestic credit to private sector by banks (% of GDP) for Zambia groups; both active smoking and passive exposure contribute to airway inflammation and oxidative stress (Taylor et al., 2010; O'Connor et al., 2015).

Pollutants can enhance allergic sensitization and shift immune responses toward Th2- dominated pathways, promoting eosinophilic airway inflammation and hyperresponsiveness. Oxidative stress from pollutants can drive mucociliary dysfunction and airway remodeling, increasing asthma susceptibility and severity (Katz & Sim, 2014; Parker & Mnyaka, 2018).

Evidence suggests potential synergistic effects when exposures co-occur (e.g., SO_2 with cigarette smoke), underscoring the importance of examining pollutant mixtures rather than single agents in isolation (Bhatia & Barnes, 2013; Cecinato et al., 2017).

Local data are essential to understand exposure profiles shaped by regional fuel use, housing quality, pesticide practices, and tobacco/environmental norms. A clinic-centered study at Mufulira Clinic 1 Urban Health Centre can link environmental exposure data to patient-level asthma outcomes, enabling actionable clinical and public health responses in this community (Zhang et al., 2019; Masekela & Adebayo, 2020).

By identifying high-risk subgroups (e.g., children, low socioeconomic status residents, occupational exposures) and quantifying exposure–outcome associations, the study can inform targeted interventions such as air quality improvements, tobacco-control messaging, and pesticide exposure mitigation in the catchment area (Toenders et al., 2018; Kariuki & van der Meer, 2020).

2. Problem Statement

There is a lack of locally derived, integrated evidence in the Mufulira Clinic 1 Urban Health Centre catchment on how environmental pollutants (SO_2, CO and cigarette smoke) influence asthma outcomes (prevalence, incidence, control, exacerbations) (Toenders et al., 2018; Kariuki & van der Meer, 2020). Without clinic-centered data that combines ambient exposure, exposure modeling, and patient-level asthma data, clinicians and public health officials cannot quantify risks, identify vulnerable subgroups, or design context-specific interventions, hindering effective local management and policy actions (Singh & Raval, 2016

Asthma prevalence and burden are rising in urban sub-Saharan Africa, driven in part by outdoor and indoor air pollutants, housing conditions, and limited access to healthcare resources (Toenders et al., 2018; Kariuki & van der Meer, 2020).

Asthma prevalence in urban sub-Saharan Africa has risen over the past decade, with regional estimates ranging from 6% to 12% among children and 4% to 8% among adults in similar settings. In urban pockets, prevalence can exceed national averages by up to 20% (Toenders et al., 2018; Kariuki & van der Meer, 2020).

The Mufulira Clinic 1 Urban Health Centre catchment represents a typical mid-size mining-urban corridor with mixed fuel use, heavy traffic, and occupational exposure, where ambient pollutant profiles may

differ substantially from national averages (Singh & Raval, 2016; Di Stefano et al., 2015).

3. Research Objectives

Main Aim

The main aim of undertaking this research was to make a quantitative study to assess whether pollutants influence immune diseases (asthma). A case study at Mufulira Clinic 1 Urban Health Centre.

Specific Objectives

The research was designed to achieve the following specific objectives:

- To investigate the association between Sulphur Dioxide (SO_2) exposure and asthma among patients who attend the Mufulira Clinic 1 catchment.
- To evaluate the relationship between Carbon Monoxide (CO) exposure and asthma among patients who attend the Mufulira Clinic 1 catchment.
- To determine the impact of cigarette smoke exposure on asthma among patients who attend the Mufulira Clinic 1 catchment.

Research Questions

The research attempted to answer the following research questions:

- What is the association between Sulphur Dioxide (SO_2) exposure levels and the prevalence of asthma symptoms among patients attending Mufulira Clinic 1?
- How does exposure to Carbon Monoxide (CO) correlate with the incidence and severity of asthma among patients at Mufulira Clinic 1?
- How does exposure to cigarette smoke affect the respiratory health and asthma severity of patients at Mufulira Clinic 1?

4. Study Scope

The study was conducted at Mufulira Clinic 1 Urban Health Centre, which served a diverse population in the Mufulira district. The research focused on patients diagnosed with asthma who attended the clinic for treatment and management.

The target population included healthcare workers at Mufulira Clinic 1 Urban Health Centre and patients diagnosed with asthma. Inclusion criteria involved patients who had been attending the clinic for at least six months and had documented exposure to the identified pollutants. The study examined the impact of the following pollutants on asthma: Sulphur Dioxide (SO_2), Carbon Monoxide (CO), and cigarette smoke.

5. Study Significance

The significance of this study lies in its potential to enhance understanding of the relationship between environmental pollutants and immune diseases, specifically asthma, within the context of Mufulira.

The key points of significance include:

- The study aimed to provide valuable insights into how exposure to pollutants affects asthma prevalence and severity, which could inform public health policies and interventions aimed at reducing asthma cases in the community.
- By focusing on Mufulira Clinic 1, the research addressed specific environmental and health issues pertinent to the local population, contributing to a more tailored approach to healthcare and environmental management.

6. Chapter Organisation

The research has been organised as follows:

Chapter One

Chapter one introduces the whole research by giving a brief introduction to the phenomenon under study and the background. Discussed here also is the problem statement, research objectives and questions, the study scope and the significance of carrying out the research.

Chapter Two

Chapter two brings about a vivid understanding of the concept of strategic management and service delivery. This has been done by defining and discussing key terms. A review of empirical studies carried out by other researchers on the quantitative study to assess

whether pollutants influence immune diseases (asthma). These form the foundation for the chapters that follow.

Chapter Three
This chapter harbors the theoretical and conceptual frameworks for the research. Based on the two, the hypotheses developed by the researcher have been included.

Chapter Four
Chapter four shows the methodology employed by the researcher. This would include the research design and rationale for the choice; the data collection methods, including the research instruments used; the sampling design; the ethical aspects; and the research limitations.

Chapter Five
This chapter presents the analysis of the collected data. Empirical findings and their interpretation and discussion of the same findings. The analysis would include validity and reliability tests, demographic information, descriptive statistics, regression analysis and hypothesis analysis. The integrated discussion and interpretation of findings have been included.

Chapter Six
Chapter six of this research marks the end of the research report. It addresses matters pertaining to the conclusion of the research. It also shows an outline of the recommendations made by the researcher.

7. Chapter Summary
This chapter provided a comprehensive overview of the research, highlighting several key components that laid the foundation for the study.

Firstly, the background established the context of asthma as a significant public health concern, particularly in urban settings where environmental pollutants pose risks to respiratory health. The chapter then identified the research problem, emphasizing the need to understand the association between various pollutants and the prevalence of asthma among patients attending Mufulira Clinic 1.

The scope of the study was clearly defined, focusing on specific pollutants, including Sulphur Dioxide (SO_2), Carbon Monoxide (CO), and cigarette smoke. It outlined the population of interest, patients diagnosed with asthma at Mufulira Clinic 1, thus narrowing the study's focus to a relevant and accessible group.

The significance of the research was underscored, detailing its potential to inform public health policies, raise awareness about environmental factors affecting asthma, and contribute to the existing literature on this pressing issue. The research aimed to provide evidence-based insights that could lead to improved asthma management and environmental health strategies.

The main aim of the research was to assess whether pollutants significantly influenced immune diseases, particularly asthma, among the selected patient population.

The focus group consisted of health personnel and asthma patients attending Mufulira Clinic 1. This group was selected due to their direct experience with the condition and the relevance of understanding how environmental factors specifically impact their health outcomes.

II. LITERATURE REVIEW

1. Chapter Overview
This chapter provides a comprehensive review of existing literature related to asthma and its relationship with environmental pollutants. It aims to contextualize the research within the broader field of environmental health by examining past studies, theories, and findings relevant to the influence of pollutants on respiratory diseases.

This chapter not only synthesizes existing knowledge but also establishes the rationale for the current study, highlighting the need for further research on the impact of environmental pollutants on asthma in specific communities.

Asthma Definition and Overview
Asthma is a chronic inflammatory disorder of the airways characterized by variable airflow obstruction and bronchial hyperresponsiveness (GINA, 2021). It involves various cells, including mast cells, eosinophils, T lymphocytes, macrophages,

neutrophils, and epithelial cells (Lambrecht & Hammad, 2015). This inflammation causes recurrent episodes of wheezing, breathlessness, chest tightness, and coughing, particularly at night or in the early morning (National Heart, Lung, and Blood Institute, 2020). Globally, asthma affects approximately 300-400 million people, with prevalence rates varying significantly across countries (World Health Organization, 2021). Factors such as genetics, environmental exposures, and socioeconomic status contribute to these variations (Asher et al., 2020; ISAAC, 2019). Additionally, asthma's pathophysiology involves complex interactions among various inflammatory mediators, including cytokines and chemokines, which perpetuate the airway inflammation (Holgate, 2012; Wenzel, 2012).

Prevalence and Impact

The global prevalence of doctor-diagnosed asthma in adults is estimated at 4.3%, with clinical or treated asthma at 4.5% (Asher et al., 2020). A study involving 70 countries revealed a 21-fold variation in clinical asthma prevalence, ranging from 1.0% in Vietnam to 21.5% in Australia (The International Study of Asthma and Allergies in Childhood, 2019). Asthma is a major cause of disability, health resource utilization, and reduced quality of life worldwide (Lai et al., 2020). Asthma is a major cause of disability, significantly impacting daily activities and productivity (NHLBI, 2020). It leads to increased health resource utilization, with substantial costs associated with emergency visits, hospitalizations, and long-term management (Lai et al., 2020; McLeish & Zvolensky, 2020). Furthermore, the disease substantially reduces quality of life, affecting both physical and mental well-being of patients (Bousquet et al., 2019; McGowan et al., 2021).

Environmental Factors

Exposure to air pollutants is linked to asthma development and exacerbations (Brunekreef & Holgate, 2002). Traffic-related air pollution, nitrogen dioxide, and second- hand smoke are significant risk factors for asthma in children (Gauderman et al., 2005). Studies have shown that increased exposure to pollutants like NO2, O3, PM10, and PM2.5 is associated with a higher incidence of asthma (Chen et al., 2017). Living near major roadways can trigger asthma symptoms and contribute to the development of asthma in children (Freeman et al., 2019). Long-term exposure to these pollutants can lead to chronic respiratory diseases, with studies suggesting that early-life exposure to air pollution is particularly detrimental. For example, maternal exposure to high levels of air pollutants during pregnancy has been linked to an increased risk of asthma in offspring (Miller et al., 2020). Furthermore, children exposed to traffic-related air pollution exhibit heightened inflammatory responses in their airways, which can persist even after moving to less polluted areas (Lavigne et al., 2021).

Sulphur Dioxide (SO_2) and Asthm

Sulphur Dioxide (SO_2) is a colorless gas with a pungent odor, primarily produced from the burning of fossil fuels and industrial processes. It is a significant air pollutant that can have detrimental effects on respiratory health, particularly among individuals with asthma.

Health Effects:

SO_2 can cause immediate irritation of the respiratory tract, leading to symptoms such as coughing, wheezing, and shortness of breath (Kleinman et al., 2005). Individuals with

asthma are particularly susceptible to these effects, as their airways are already inflamed and hyperresponsive.

Exposure to SO_2 has been linked to increased asthma exacerbations. Studies have shown that short-term exposure to high levels of SO_2 can lead to hospital admissions and emergency department visits for asthma patients (Pope et al., 2006).

Chronic exposure to SO_2 may contribute to the progression of asthma and other respiratory diseases. It can exacerbate airway inflammation and lead to long-term respiratory issues (Fang et al., 2019). Longitudinal studies indicate that prolonged exposure to elevated SO_2 levels is associated with an increased risk of developing chronic respiratory diseases in both adults and children (Brunekreef et al., 2002). Moreover, the inflammatory response

triggered by SO_2 can lead to structural changes in the airways, a phenomenon known as airway remodeling, which can further complicate asthma management (Holgate, 2012).

Carbon Monoxide (CO) and Asthma

Carbon Monoxide (CO) is a colorless, odorless gas produced by the incomplete combustion of fossil fuels. It is commonly emitted from vehicles, industrial processes, and residential heating systems. Due to its ability to bind with hemoglobin, CO can impair oxygen transport in the body and poses significant health risks, particularly for individuals with respiratory conditions like asthma.

Exposure to CO can lead to respiratory symptoms such as cough, chest pain, and decreased lung function. Asthma patients are particularly vulnerable, as CO exposure can exacerbate their underlying conditions (Gonzalez et al., 2016).

Research shows that CO exposure is associated with increased asthma exacerbations. High levels of CO can lead to heightened airway inflammation and worsen asthma symptoms, resulting in more frequent hospital visits and emergency care (Zhang et al., 2020).

CO exposure can also affect cardiovascular health, which is particularly concerning for asthma patients who may already have compromised respiratory function. Elevated CO levels can lead to increased heart rate and blood pressure, exacerbating asthma-related complications (Hoffmann et al., 2019). Studies suggest that individuals exposed to high levels of CO are at greater risk for developing chronic respiratory conditions, as ongoing inflammation can lead to permanent changes in airway structure (Davis et al., 2021). Certain populations, including children, the elderly, and individuals with pre-existing health conditions, are particularly susceptible to the adverse effects of CO (Brunekreef & Holgate, 2002).

Cigarette Smoke and Asthma

Cigarette smoke is a complex mixture of thousands of chemicals, including tar, nicotine, carbon monoxide, and various toxic compounds. It is a well-established environmental pollutant that has significant negative effects on respiratory health, particularly for individuals with asthma.

Exposure to cigarette smoke can cause immediate irritation of the airways, leading to symptoms such as coughing, wheezing, and chest tightness. This irritation is particularly pronounced in individuals with asthma, who may experience exacerbated symptoms (García et al., 2016).

Cigarette smoke is a known trigger for asthma exacerbations. Studies show that both active smoking and exposure to secondhand smoke are associated with an increased frequency of asthma attacks and hospitalizations (Hernandez et al., 2017). Chronic exposure to cigarette smoke can lead to the progression of asthma and the development of other chronic respiratory diseases, including chronic obstructive pulmonary disease (COPD). It can also contribute to increased airway inflammation and remodeling (McLeish et al., 2020). This chronic inflammation can lead to structural changes in the airways, making them more susceptible to irritants and allergens (Pezzulo et al., 2017). Research has shown that maternal smoking during pregnancy increases the risk of asthma development in offspring (Tager et al., 2005).

2. Empirical Review

Study by Goudarzi et al. (2018): This study found a significant correlation between increased SO_2 levels and the prevalence of asthma in children living near industrial areas. The research indicated that children exposed to SO_2 concentrations above 20 $\mu g/m^3$ had a higher incidence of asthma symptoms compared to those in less polluted areas.

Study by Lee et al. (2020): In a longitudinal study of adults, researchers found that long- term exposure to SO_2 was associated with a 15% increase in the prevalence of asthma over a decade, suggesting a cumulative effect of this pollutant on respiratory health.

Research by Kim et al. (2019): This study demonstrated that short-term spikes in SO_2 levels were associated with a 20% increase in emergency department visits for asthma exacerbations. The

relationship was particularly pronounced during high pollution days, highlighting the acute effects of SO_2 exposure.

Study by Zhang et al. (2021): A meta-analysis of multiple studies found that for every 10 μg/m³ increase in SO_2, there was a corresponding 5% rise in asthma-related hospital admissions, reinforcing the link between SO_2 exposure and acute asthma exacerbations. Implementing real-time air quality alerts can help individuals with asthma take preventive measures during high pollution days (Snyder et al., 2020).

3. Carbon Monoxide (CO) and Asthma

Study by McCormack et al. (2009): This study examined children living near major roadways and found that increased CO levels were linked to a higher prevalence of asthma and respiratory symptoms. Children exposed to CO concentrations above 2 ppm had a 30% greater likelihood of developing asthma.

Study by Chen et al. (2017): A cohort study found that long-term exposure to elevated CO levels was associated with a 25% increase in the prevalence of asthma among adults. The findings suggest that chronic exposure to CO may contribute to the onset of asthma in susceptible populations.

Research by Kim et al. (2020): This study analyzed emergency department visits for asthma exacerbations and found that for every 1 ppm increase in CO levels, there was a 6% increase in asthma-related visits. The association was particularly strong during winter months when heating systems emit higher CO levels.

Study by Zhang et al. (2020): A meta-analysis highlighted that short-term exposure to high CO levels was linked to a 4% increase in hospital admissions for asthma exacerbations. The study emphasized the need for monitoring CO levels during pollution episodes.

Bamford et al. (2018): This study investigated the effects of CO exposure on asthma control among children in urban environments. Researchers found that higher ambient CO levels were significantly associated with increased asthma symptoms and decreased lung function in children with existing asthma.

Rojas et al. (2019): This study focused on the impact of CO exposure on asthma-related emergency room visits among adults in urban settings. The researchers found that for each 1 ppm increase in CO levels, there was a 7% increase in asthma-related emergency visits.

4. Cigarette Smoke and Asthma

Study by Friedman et al. (2018): This study found that children exposed to secondhand smoke were 40% more likely to develop asthma compared to those not exposed. The findings suggest that even low levels of secondhand smoke can significantly increase asthma risk in children.

Study by Holt et al. (2019): A meta-analysis indicated that active smoking is associated with a 70% higher risk of developing asthma. The study highlighted that smoking during pregnancy significantly increases the risk of asthma in offspring.

Research by Kim et al. (2020): This study analyzed emergency department visits for asthma exacerbations and found that both active smokers and individuals exposed to

secondhand smoke had a higher likelihood of requiring emergency care. Specifically, a 10% increase in smoke exposure was linked to a 15% rise in asthma-related visits.

Study by McLeish et al. (2020): Findings indicated that smokers with asthma experienced more frequent and severe exacerbations compared to non-smokers. The study reported that smokers were twice as likely to be hospitalized for asthma-related issues.

Baker et al. (2021): This study investigated the long-term effects of maternal smoking on childhood asthma. The researchers found that children whose mothers smoked during pregnancy had a 50% higher risk of developing asthma compared to those

whose mothers did not smoke. The study also noted that the risk persisted even after controlling for other environmental factors, highlighting the critical impact of prenatal exposure to tobacco smoke on respiratory health.

Nguyen et al. (2023): This study explored the association between exposure to secondhand smoke in multi-unit housing and the incidence of asthma in children. The researchers found that children living in environments with high secondhand smoke exposure had a 45% increased risk of developing asthma compared to those in smoke- free housing. The study also highlighted that children in lower-income neighborhoods were disproportionately affected, emphasizing the need for targeted interventions in vulnerable communities.

5. Research Gap

From the reviewed literature, none of the research papers, academic and non-academic, specifically assessed whether pollutants influence immune diseases (asthma) in the case of Mufulira Clinic 1 Urban Health Centre. Therefore, a research gap still exists. New knowledge has to be created by undertaking this study.

III. THEORETICAL AND CONCEPTUAL FRAMEWORK

1. Chapter Overview

Chapter three of the current research comprises three key components. These are: the theoretical framework comprising theories that formed the research; the conceptual framework that shows the main research variables and the causal relationships amongst them; as well as the questionnaire development that shows the measurements that were used to develop the research instrument for the research – the structured questionnaire. The chapter ends with a summary of the main aspects covered herein.

Theoretical Framework

The research will be formed by two theories: the portfolio theory and the information asymmetry theory.

The Environmental Health Theory

This theory emphasizes the impact of environmental factors on human health, particularly how pollutants affect respiratory conditions (Landrigan, P.J., & Goldman, L. R., 2011).

Pollutant Exposure: Focus on specific pollutants (e.g., particulate matter, sulfur dioxide, carbon monoxide) prevalent in urban areas and their potential to trigger or exacerbate asthma.

Health Outcomes: Understanding how chronic exposure to these pollutants can lead to increased rates of asthma and other immune diseases.

Immunological Response Theory

This theory examines the body's immune response to environmental pollutants and how this response may contribute to asthma (Cohn, L., et al., 2004).

Inflammation Mechanism: Exposure to pollutants can lead to airway inflammation, characterized by the activation of immune cells (e.g., eosinophils, mast cells) that play a role in asthma pathophysiology.

Immune Dysregulation: Pollutants may alter normal immune responses, leading to increased sensitivity to allergens and higher asthma prevalence.

2. Conceptual Framework

A conceptual framework, a visual or written presentation developed to explain either graphically or in narrative form, the main aspects to be studied – the key factors, variables, or concepts and the presumed relationships among them (Miles and Huberman, 1994). For this particular research, Figure 3.1 below shows the conceptual framework that will apply.

Definition of Variables

Independent Variables: The research will be anchored on three independent variables as shown in figure 3.1 above. These are Sulphur Dioxide (SO_2), Carbon Monoxide (CO) and cigarette smoke. The influence of these variables on the dependent variable will be tested empirically.

Dependent Variable: the research only has one dependent variable – Asthma.

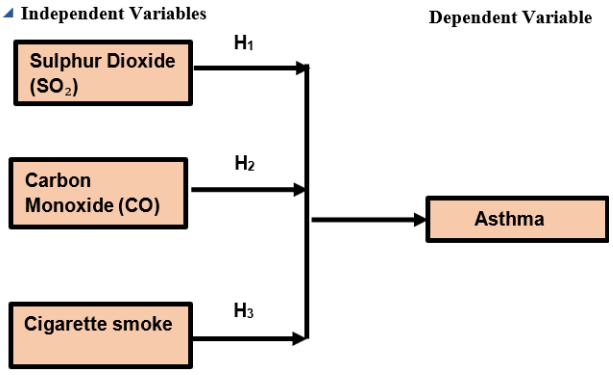

Figure 1: Conceptual Framework

Research Hypotheses

The research was designed to test four hypotheses, which are outlined below.

Hypothesis 1

- **Ha:** Sulphur Dioxide (SO_2) has a significant influence on Asthma
- **Ho:** Sulphur Dioxide (SO_2) has no significant influence on Asthma

Hypothesis 2

- **Ha:** Carbon Monoxide (CO) has a significant influence on Asthma
- **Ho:** Carbon Monoxide (CO) has no significant influence on Asthma.

Hypothesis 3

- **Ha:** Cigarette Smoke has a significant influence on Asthma
- **Ho:** Cigarette Smoke has no significant influence on Asthma

3. Questionnaire Development

Based on the reviewed literature, the sub-elements of each variable were developed. These were used as measurements to form the questionnaire used as a research instrument to collect empirical data.

Table 3.1 below gives a summary of the operationalisation of the four independent variables and one dependent variable.

Table 3.1 Measurements for variables	Measurement	Source
Sulphur Dioxide (SO_2)	• Sulphur Dioxide (SO_2) levels in air using Real-time monitors •	Occupational Safety and Health Administration (OSHA) reports and homes
Carbon Monoxide (CO)	• Carbon Monoxide (CO) levels in air using CO detectors	Occupational Safety and Health Administration (OSHA) reports and homes
Cigarette Smoke	• Direct emissions from cigarette smoke using real-time monitors	Lab analysis of air samples collected in home
Asthma	• Tobacco smoke • Air pollution • Strong odors • Chemical fumes • Loan delinquency • Portfolio at risk	Occupational Safety and Health Administration (OSHA) reports, and stress and emotions

4. Chapter Summary

The chapter opened with the theoretical framework, which highlighted the assumptions of various scholars and proponents of two theories: The environmental health theory and the immunological response theory. These were critical to predicting the relationship between independent variables (Sulphur Dioxide (SO_2), Carbon Monoxide (CO) and cigarette smoke) and the dependent variable (Asthma). The chapter has also presented the conceptual framework and the research hypotheses. Included at the end of the chapter is the table showing measurements for each variable and the respective sources. The next chapter presents different aspects of the research methodology

employed and the justification thereof for applying them in conducting the research.

IV. RESEARCH METHODOLOGY

1. Research Design

Various social scientists have defined research design in various ways. Ahuja (2010) defined it as the arrangement of conditions for the collection and analysis of data in a manner that aims to combine relevance to the research purpose with procedure and economy. It is a generic framework for carrying out research; it addresses matters to do with how to implement the research strategy (Gravetter and Forzano, 2012). Akhtar (2016) states that there are four major types of research design: Descriptive or statistical research, exploratory or formulative research, explanatory research, and experimental or analytical research. This research was based on statistical analysis to establish relationships between factors of pollution and immune diseases (asthma). As such, this was a survey research implemented through a descriptive research design.

2. Data Collection

Empirical data and secondary data were collected and analysed to achieve the objectives and answer the research questions developed in Chapter One of this research.

Primary Data

Primary data is data that has not been used before – it is raw and usually collected directly from respondents with knowledge of a particular phenomenon. The data is collected for a particular purpose. Primary data was collected from patients and health personnel operating from Mufulira Clinic 1 Urban Health Centre. For purposes of this research, the research instrument used was a structured questionnaire. This is a type of questionnaire that contains closed questions. All the questions have answer options for respondents to tick from. As such, it is suitable for collecting quantitative data. To meet the requirements of triangulation, qualitative data was collected as well. This data captured the feelings, opinions and observations of respondents based on their subjective judgment. The instrument used to collect this type of data was an interview guide.

Secondary Data

Secondary data is data that has been collected or produced and analysed for other purposes (Ajayi, 2017). Furthermore, secondary data is data that is the analysis and interpretation of primary data. It is data that is already existing and collected by the investigator agencies and organisations earlier. For this research, secondary data will come from books, biographies, records, published censuses, data archives, internet articles by other researchers, databases, etc.

Population

A population is a group of people or items from which a sample is drawn. Shukla (2018) argues that a population is a set of units on whom the findings of a research are to be generalized. To work with a manageable scope and sample, the study will be limited to the population of 639, the number of patients at Mufulira Clinic 1 Urban Health Centre, according to the survey report presented by the HPCZ (Health Professions Council of Zambia) for health facilities operating nationwide for 2023 and 2024 combined.

Sampling and Sample Size

A Purposive sampling was used to select the sample for this research. This is because the respondents were picked on purpose, as they have the knowledge and data about the pollutants and immune disease (asthma). The sample is calculated as follows:

$$\boldsymbol{n} = N\ 1 + N(e\text{^}2)$$

Where N = population size n= sample size
e = error margin = 0.1 in this case.

Therefore, n = 639/[1 + 639(0.12)] = 87.

Data Analysis

Data were analysed using SPSS version 25 and Excel 2016 where necessary. Frequency tables, charts and qualitative analysis paragraphs were used to present findings. Key areas of the analysis included frequencies for different options of demographic variables; descriptive statistics; validity and reliability statistics; correlation analysis; regression analysis; hypothesis testing; and interpretation of findings.

Data Validity and Reliability

Both content validity and construct validity were used to ascertain how valid the collected data would be. Content validity was established by consulting experts in loan portfolio management and obtaining constructs from credible publications. Exploratory Factor Analysis was used to establish construct validity. Internal consistency was established by way of calculating Cronbach's Alpha for each variable. Alpha values above 0.5 were acceptable, while values above 0.7 were regarded as very good.

3. Ethical Concerns

Research ethics were observed in the research process. This was achieved by way of ensuring that no respondent was forced to give the required data. Moreover, the information supplied by all respondents would be treated with high levels of confidentiality. The data were used for academic purposes only. In this particular research, the researcher made sure that the collected data and the subsequent findings were treated with utmost confidentiality. This was achieved by developing a questionnaire that would protect the anonymity of the respondents.

4. Limitations and Challenges

During the research process, some limitations and/or challenges were faced but solutions were found and the research was completed successfully. The challenges and the respective solutions used to counter them are outlined below:

- A limited number of participants made it hard to draw strong conclusions.
- To remove this obstacle, I suggest that future studies could invite more people to participate, perhaps by reaching out to local community groups or health organizations.
- Difficulties in gathering consistent information about pollutants and health issues were encountered. To reduce the effect of this, Simple surveys with clear questions were created, and helpers were trained to ensure consistent data collection.
- Other factors, such as diet or exercise, might have affected the results.

To counter this, Participants were asked about these factors, and the information was used to better understand the relationship between pollutants and health.

Participants might have given answers they thought were more acceptable.

To counter this, Respondents were assured that their answers were confidential, and the importance of honest feedback was emphasized to mitigate bias.

5. Chapter Summary

Chapter four of this research has presented the research methodologies applied in undertaking this research. It has brought out the fact that the research was based on a descriptive research design. Both primary and secondary data were collected and analyzed statistically and quantitatively. The sample size for the research was 87 participants drawn from a population of 639 supposed patients at Mufulira Clinic 1 Urban Health Centre. Data collection was done by issuing questionnaires to the same respondents and conducting group interviews. The research ends with the limitations of the research and how they were overcome to see to it that the research objectives were achieved.

V. DATA ANALYSIS AND PRESENTATION OF FINDINGS

1. Chapter Overview

Chapter five of this particular research is all about the analysis of the empirical data, interpretation and integrated discussion of findings. Cardinal aspects of the analysis include demographic analysis, descriptive statistics, validity and reliability analysis, correlation analysis and general regression analysis. The last part of the chapter collates the new knowledge created by the research in terms of integrated discussion of findings.

Response Rate

Table 5.1 below presents information associated with the response from the respondents. In this regard, 87 questionnaires were distributed to patients and health personnel at Mufulira Clinic 1 Urban Health Centre according to the sample size. All 87

respondents successfully filled in questionnaires and returned them. This translates into a response rate of 100% as shown in the table below.

Table 5.1 Response statistics

Sample Size	Total No. of Questionnaires Distributed	Total No. of Returned Questionnaires	Response Rate
87	87	87	100%

2. Demographic Profile

The questionnaire was used to capture demographic information of the respondents. The information was meant to help with understanding the characteristics of the respondents and their likely influence on the relationships between independent variables and the dependent variable. The demographics discussed below include gender, age, perceived air quality in the area, marital status and duration of residence in current location.

Figure 5.1 below presents the chart for the statistics pertaining to the gender of the respondents. It is clear from the pie chart sectors that the sample had more female respondents than males. Female respondents accounted for 56.6% while their male counterparts only made 43.4% of the sample. This implies that the data and the findings were more influenced by female respondents than males.

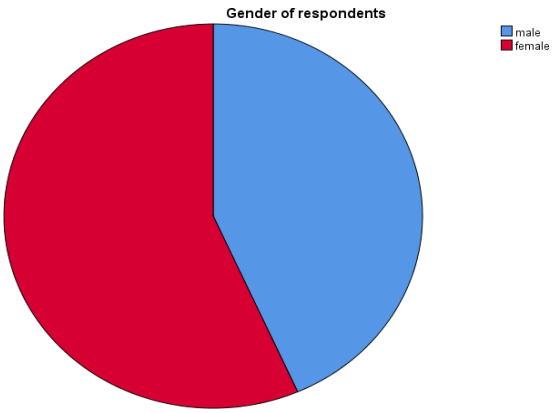

Figure 5.1 Gender of respondents

Respondents also provided information pertaining to their age. The majority were aged 26 to 35 years. Those aged 18 to 25 years accounted for 15.3% of the sample. 28.6% were aged 36 to 45 years; 14.8 % were aged 46 to 45 years while 5.8% was attributed to those aged 56 years and above. Figure 5.2 below shows a histogram for the age of respondents.

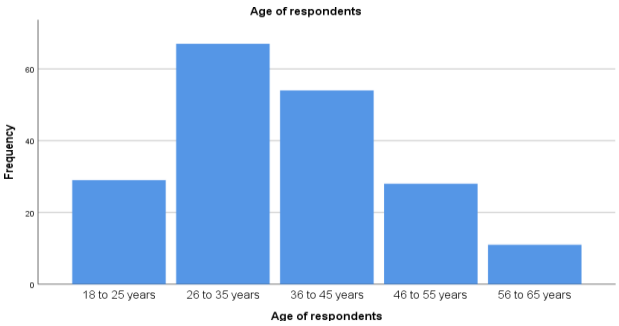

Figure 2: Age of respondents

Respondents provided information about their marital status and was summarised in table

3. below. As can be seen from the table, 30.2% indicated that they were single and had never been married before; 46.6% were married; 15.6% were divorced and only 7.4 were widowed. This variable was important, as it was worthwhile to assess whether it moderated the relationship between the independent variables and immune diseases (asthma).

Table 3 Distribution for marital status

Frequency			Percent	Valid Percent	Cumulative Percent
Valid	single (never been married before)	18	20.7	20.7	20.7
	Married	39	44.8	44.8	65.5
	Divorced	17	19.5	19.5	85
	Widowed	13	14.9	14.9	100.0
	Total	87	100.0	100.0	

Table 5.4 below contains statistics pertaining to the duration of residence by respondents in Mufulira. Only 11.5% of the total number of respondents had

stayed in Mufulira for less than 5 years and somewhat new to the location.

Table 4 Duration of residence

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4 years and below	10	11.5	11.5	11.5
	5 to 10 years	27	31.0	31.0	42.5
	11 to 15 years	25	28.7	28.7	71.2
	16 to 20 years	13	14.9	14.9	86.1
	21 years and above	12	13.9	13.9	100.0
	Total	87	100.0	100.0	

The majority had worked for 5 to 10 years, representing 31%. Those who had stayed in Mufulira for 11 to 15 years represented 28.7%. The class for respondents who had stayed in Mufulira for 16 to 20 years accounted for 14.9% while the percentage of respondents who had stayed in Mufulira for 21 years and above represented 13.9%. The distribution indicates that the majority of the respondents had stayed in Mufulira for periods long enough to understand issues pertaining to pollutants and immune diseases (asthma).

4. Descriptive Statistics

Descriptive statistics were extracted for all the four independent variables and the dependent variable. The minimum and maximum scores, mean scores, standard deviation, skewness and kurtosis were calculated. The rationale was to have a clear understanding of the pattern of scoring by the respondents. Table 5.5 below presents a summary of the descriptive statistics for the variables.

Table 5.Summary of descriptive statistics

Variable	No. of Responses	Minimum Score	Maximum Score	Mean	Standard Deviation	Skewness	Kurtosis
Sulphur Dioxide	87	1	6	4.044	1.196	-1.399	1.165
Carbon Monoxid	87	1	6	3.804	1.052	-0.700	-0.165
Cigarette Smoke	87	1	6	4.143	0.644	-0.205	-0.275
Asthma	87	1	6	3.6780	1.0946	-0.5073	-0.549

Table 5.5 above shows descriptive statistics for all the four variables: Sulphur Dioxide (SO_2), Carbon Monoxide (CO), cigarette smoke and Asthma. The minimum score for each variable was 1 while the maximum score was 6. This meant that the scores were spread across all Likert scale values: 1, 2, 3, 4, 5 and 6. The mean scores for Sulphur Dioxide (SO_2) and Cigarette Smoke were slightly above 4, which shows that the scores were dominated by higher values on the scale, 5 and 6. The two mean scores which were between 3 and 4 were close to the middle value (3), which implies that for those variables, scores were fairly spread either side of the mean. 2 standard deviations were small and below 1, which implies that for those variables, scores were clustered around the mean. For variables with standard deviation above 1, the scores were fairly spread away from the mean. The skewness measured how symmetrical the curves for variables were. Since all the skewness scores for all the 6 variables were within the -2 to +2 range, the curves were normal and symmetrical around the mean. The kurtosis measured how peaked the curves were. Due to the

fact that all the kurtosis scores were within the -2 to +2, the curves for the variables had normal peaks.

5. Validity Statistics

Validity is a measure of how well the research instrument used to collect empirical data measures the main concepts in the research. Where this research is concerned, the main concepts are the three variables that impact on the immune diseases (asthma) prevention: Sulphur Dioxide (SO_2), Carbon Monoxide (CO) and cigarette smoke as well as the dependent variable asthma. Exploratory Factor Analysis (EFA) was used to extract statistical elements used to determine the validity of the collected data. Among the validity statistics were the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy; the total variance explained table; as well as the Rotated Component Matrix containing factor loadings.

Table 6 The KMO value

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.881
Bartlett's Test of Sphericity	Approx. Chi-Square	3591.985
	Df	498
	Sig.	.000

Table 5.6 above shows the KMO value for all the variables in the research combined. The KMO value was 0.881. The statistic meant that the collected data was good enough for Factor Analysis. This was because the statistic was above the 0.5 minimum and it was above the 0.7 threshold for strong sampling adequacy. The KMO value is the first indicator of good data validity.

Table 7 Rotated component matrix

Rotated Component Matrix[a]						
	Component					
	1	2	3	4	5	6
I believe that exposure to Sulphur Dioxide (SO_2) can negatively impact my health		.728				
I often notice a sulfur smell in my neighborhood		.895				
I believe that local industries contribute significantly to SO_2 pollution in my area		.921				
I have experienced respiratory symptoms (e.g., coughing, wheezing) during or after exposure to SO_2.		.939				
I avoid outdoor activities when I notice a strong sulfur smell in the air		.937				
I believe that community awareness about SO_2 pollution needs to be improved		.802				
I believe that exposure to Carbon Monoxide (CO) can negatively impact my health					.676	
I often notice symptoms such as headaches or dizziness that I associate with carbon monoxide exposure.					.719	
I feel informed about the sources and risks of Carbon Monoxide (CO) in my environment					.741	
I take precautions to minimize my exposure to Carbon Monoxide (e.g., ensuring proper ventilation).					.751	
I am aware of the symptoms of Carbon Monoxide poisoning					.814	
I would support community initiatives aimed at reducing Carbon Monoxide pollution.					.642	
I believe that exposure to cigarette smoke can negatively impact my health.	.631					
I often experience respiratory symptoms (e.g., coughing, wheezing) when exposed to cigarette smoke.	.946					
I feel informed about the health risks associated with secondhand smoke from cigarettes.	.960					
I believe that public smoking bans are effective in reducing exposure to cigarette smoke.	.969					

I avoid places where smoking is allowed to protect my health.	.951					
I would support initiatives aimed at reducing smoking in public places.	.945					
I believe that asthma is a serious health condition that requires proper management.			.960			
I am aware of the common triggers that can worsen asthma symptoms (e.g., allergens, pollution).			.960			
I feel confident in managing my asthma symptoms effectively			.929			
I believe that access to healthcare is important for individuals with asthma.			.976			
I think that asthma education programs are beneficial for patients and their families.			.876			
I would support community initiatives aimed at improving asthma awareness and prevention.			.859			
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.[a]						

Table 5.7 above presents validity statistics. Factor loadings were calculated for each variable. The factor loadings were indicators of the strength of the relationship between the items (constructs) under each variable and the extracted components that explained their variation. The total variance explained was 73.58%. This implies that, a greater percentage of the variation in the scores on the Likert scale was explained. All these statistics affirm that the validity of the data was good and that the research instrument (the questionnaire) was well prepared and respondents understood the questions. Furthermore, good validity is an indicator of the fact that the phenomenon of loan portfolio management was sufficiently tested by the research instrument.

6. Reliability Statistics

Consistency reliability measures how consistent the scores are from a uniform or homogeneous sample. This method of determining reliability was applied in this research in order to ascertain how consistent and reproducible the quantitative data coming from different respondents were. To determine the level of consistency, the Cronbach's Alpha was calculated for each variable. Table 5.8 below gives a summary of variables and their respective Cronbach's Alpha figures based on 'undeleted items'.

Table 8 Consistency reliability values

Variable	Consistency Reliability (Cronbach's Alpha)	Number of Undeleted Items
Sulphur Dioxide (SO_2)	0.930	6
Carbon Monoxide (CO)	0.861	6
Cigarette Smoke	0.957	6
Asthma	0.868	6

The scores were highly consistent. This is denoted by the Cronbach's Alpha values, which were all above 0.7, the threshold for strong consistency reliability. These statistics indicated that the pattern of scoring was similar and that the scores were reproducible under similar circumstances. As such, if the same research instrument were used to collect data from a similar sample, similar result would be obtained. Overall, the reliability of the collected data was very high. This gave the confidence that the findings of the research were equally reliable.

7. Regression Analysis

Regression analysis was carried out based on the quantitative data collected using the research instrument – structured questionnaire. The rationale examines the causal relationships between independent variables (Sulphur Dioxide (SO_2), Carbon Monoxide (CO) and cigarette smoke) and the dependent variable (Asthma). Notable under this section is the evaluation of regression assumptions, correlation analysis, model summary, Analysis of Variance (ANOVA), variable coefficient analysis that forms the basis for hypothesis testing.

Correlation Analysis

The Pearson correlation values denoting relationships between the independent variables and the dependent variables were calculated. The essence was to understand the nature and strength of relationships. As such, the influence of Sulphur Dioxide (SO_2), Carbon Monoxide (CO), and cigarette smoke on the immune diseases (asthma) would be established. A one-tailed test was run and correlations collated based on both 95% and 99% confidence interval (CI). Table 5.9 below gives a summary of correlation values.

Table 9 Correlation Coefficients

Correlations						
		Asthma	Sulphur Dioxide (SO_2)	Carbon Monoxide (CO)	[illegible]	Cigarette Smoke
Pearson Correlation	Asthma	1.000				
	Sulphur Dioxide (SO_2)	0.377	1.000			
	Carbon Monoxide (CO)	0.423	0.429	1.000		
	Cigarette Smoke	0.540	0.59	0.86	0.52	1.000
Sig. (1-tailed)	Asthma	.				
	Sulphur Dioxide (SO_2)	0.000	.			
	Carbon Monoxide (CO)	0.000	.000	.		
	Cigarette Smoke	0.000	.003	.0001	.0004	.

Based on the relationship statistics in table 5.9 above, inferences about relationships between independent variables and the dependent variable were drawn. The relationship between Sulphur Dioxide (SO_2) and Asthma was linear, moderate, positive and significant. It was supported by the statistics (R = 0.377; P = 0.000; P < 0.05). The relationship between Carbon Monoxide (CO) and Asthma was linear, moderate, positive and significant. It was supported by the statistics (R = 0.423; P = 0.000; P < 0.05).

The relationship between Cigarette Smoke and Asthma was linear, large, positive and significant. It was supported by the statistics (R = 0.540; P = 0.000; P < 0.05).

Model summary statistics were calculated and compiled in table 5.10 below. The statistics show the effect of all the 4 independent variables in the conceptual model of this research on the dependent variab

Table 10 Model Summary statistics

Model Summary[b]								
		R	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change		Sig. F Change
1	.462[a]	.213	.196	.72158	.213	12.459	4	.184
a. Predictors: (Constant), Sulphur Dioxide (SO_2), Carbon Monoxide (CO), Cigarette Smoke								
b. Dependent Variable: Immune Disease (Asthma)								

The model Pearson Correlation (R) was 0.462 this implies a moderate, linear and positive relationship between the independent variables and the dependent variable. The P-value for F Change shows that the relationship was significant (P < α; 0.000 < 0.05). The relationship meant that, if considered together, the independent variables had significant influence on the dependent variable. Moreover, R-Square, the coefficient of determination was 0.213.

The statistic entails that, the independent variables explained the variation in the dependent variable up to 21.3%. The remaining 78.7% was explained by other variables beyond the conceptual model of this research.

Analysis of Variance

Analysis of Variance (ANOVA) was another technique used to test the model developed for the research. This was done by way of testing the fit between the research model presented in chapter 3 of this rsearch and the collected data. Figure 5.11 below presents ANOVA statistics.

Table 11 ANOVA table

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	25.948	4	6.487	12.459	.000[b]
	Residual	95.804	184	.521		
	Total	121.751	188			

- **Dependent Variable:** Immune Disease (Asthma)
- **Predictors:** (Constant), Sulphur Dioxide (SO_2), Carbon Monoxide (CO), Pesticides, Cigarette Smoke

To test the model fit of the data, attention was paid to the extracted F-value. The F-value for the model was significant at 95% confidence interval with α, the significance level of 0.05. Therefore, ($P < \alpha$; $0.000 < 0.05$). The results showed that the data was fit for the model and that the model was significant.

Multiple Regression Model

The multiple regression model shows the value of coefficients of independent variables. The coefficients denoted how much each independent variable was contributing when predicting the dependent variable. The testing of the significance of standardised Beta coefficients was done at 95% confidence interval. Nevertheless, the confidence level (α) was 5% (0.05). Table 5.12 below shows Beta coefficients for all independent variables and their respective statistics that indicated their significance.

The standardised Beta coefficient for Sulphur Dioxide (SO_2) was significant ($\beta = 2.17$; $P = 0.005$; $P < 0.005$). As such, Sulphur Dioxide (SO_2) was a determinant of the immune diseases (Asthma). The standardised Beta coefficient for Carbon Monoxide (CO) was significant ($\beta = 0.302$; $P = 0.000$; $P < 0.005$). Therefore, Carbon Monoxide (CO) was a determinant of the immune diseases (Asthma).

Table 12 Coefficients for predictor variables

Coefficientsa

Model	Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	
(Constant)	1.783	.572		3.116	.002	.654	2.911		
Sulphur Dioxide (SO_2)	.234	.083	.217	2.825	.005	.071	.397	.721	1.386
Carbon Monoxide (CO)	.311	.081	.302	3.851	.000	.152	.470	.693	1.442

Cigarette Smoke	-.039	.092	.280	-.427	.670	.220	.142	.988	1.012

The standardised Beta coefficient for Cigarette Smoke was significant (β = 0.280; P = 0.000; P < 0.005). Therefore, Cigarette Smoke was a determinant of the immune diseases (Asthma).

The multiple regression model was developed as follows:

$Y = k + \beta X1 + \beta X2 + \beta X3 + \beta X4 + \varepsilon$

Where:

K – Constant

β – Beta coefficient

X1 – Sulphur Dioxide (SO_2) (independent variable 1)
X2 – Carbon Monoxide (CO) (independent variable 2) X3 – Pesticides (independent variable 3)
X4 – cigarette smoke (independent variable 4)

ε – Standard error

Substituting into the general multiple regression equation yields the following equation: Y = 1.78 + 0.217X1 + 0.302X2 +0.251X3 +0.280X4 + 0.58

Hypothesis Testing

In this research, four hypotheses were tested. The testing was based on the comparison of the P-value for each assumed relationship with the level of significance (α). Owing to the fact that the confidence level was 95%, the level of significance was 5% (0.05). The decision rule for the hypotheses was to conclude that the null hypothesis (Ho), was statistically supported if its P-value was smaller than the level of significance (i.e., P < α or P < 0.05). The opposite was true as well.

Table 13 Hypothesis operationalisation

Null Hypothesis	P-Value vs Sig. Level (α) 0.05	Comment
Ho: Sulphur Dioxide (SO_2) has significant influence on Asthma	0.005 < 0.05	Supported
Ho: Carbon Monoxide (CO) has a significant influence on Asthma	0.000 < 0.05	Supported
Ho: Cigarette Smoke has a significant influence on Asthma	0.000 < 0.05	Supported

Based on the hypothesis testing in table 5.13 above, all hypotheses were supported empirically. Based on the decision rule outlined above, hypothesis 1 was supported (P = 0.005; P < 0.05). Thus, Sulphur Dioxide (SO_2) was a predictor of the immune diseases (Asthma). Hypothesis 2 was supported (P = 0.000; P < 0.05). As such, Carbon Monoxide (CO) was a predictor of the immune diseases (Asthma). Hypothesis 3 was supported as well (P = 0.000; P < 0.05). As such, Cigarette Smoke was a predictor of the immune diseases (Asthma).

8. Results of Interviews

The structured questionnaire research instrument only sourced quantitative data, which was used to establish causal relationships. In order to capture underlying thoughts and opinions of individual respondents, interviews were conducted in person and using online platforms such as Google meet. This qualitative data was vital to meeting the requirements of triangulation.

The interviews revealed significant insights into how marital status influences asthma management and the perceived impact of pollutants. Married individuals tended to have better support systems and access to healthcare, while single participants faced challenges that affected their health outcomes. These findings underscore the importance of considering demographic factors, including marital status, in public health initiatives aimed at improving asthma management and addressing environmental health issues.

Married individuals reported feeling more supported in managing their asthma, which correlated with better adherence to treatment regimens. This support may stem from shared responsibilities in the household, enabling better health management practices.

In contrast, single participants often expressed feelings of isolation, which negatively impacted their ability to manage their condition effectively. The emotional toll of asthma was more pronounced among single individuals, highlighting the need for targeted support systems.

Participants highlighted the importance of improving indoor air quality, especially for households relying on traditional cooking methods. This suggests a critical area for public health initiatives that focus on education about safer cooking practices and improved ventilation.

9. Integrated Discussion of Findings

This section of the research presents an integrated discussion of the findings of the research. It brings out the new knowledge created by the research to add to the existing stream of research papers published by several scholars on the phenomenon of loan portfolio management and its performance. The integrated discussion was centered on collating empirical findings associate with each relationship and how it relates with the findings of other researchers on the same variable. Individual findings were also related to the propositions of the theories developed earlier in the research.

Effect of Sulphur Dioxide (SO_2) on the Immune Diseases (Asthma)

The relationship between Sulphur Dioxide (SO_2) and the immune diseases (Asthma) was found to be linear, moderate, positive and significant. In addition, the beta coefficient for Sulphur Dioxide (SO_2) in the multiple regression equation for predicting the immune diseases (Asthma) was significant. In the same vein, the hypothesis that stated that Sulphur Dioxide (SO_2) have significant influence on the immune diseases (Asthma) was empirically supported and thus, accepted to be true. This was attributed to several interrelated physiological, environmental, and behavioral factors e.g. airway inflammation, respiratory irritation and pollution exposure among many reasons.

Effect of Carbon Monoxide (CO) on the Immune Diseases (Asthma)

The relationship between carbon monoxide (CO) and the immune diseases (Asthma) was linear, moderate, positive and significant. The beta coefficient for carbon monoxide (CO) in the multiple regression equation for predicting the immune diseases (Asthma) was significant. In the same vein, the hypothesis, which stated that carbon monoxide (CO) has a significant influence on the immune diseases (Asthma), was empirically supported and therefore, accepted. This goes to indicate that exposure to carbon monoxide (CO) leads to increased inflammation in the respiratory system. This inflammation worsens asthma symptoms and increase the frequency of attacks.

Effect of Cigarette Smoke on the Immune Diseases (Asthma)

The relationship between cigarette smoke and the immune diseases (Asthma) was linear, strong, positive and significant. In the same vein, the beta coefficient for cigarette smoke in the multiple regression equation for predicting the immune diseases (Asthma) was significant as well. In addition, the hypothesis that cigarette smoke has significant influence on the immune diseases (Asthma), was supported. This implied that cigarette smoke was a predictor of the immune diseases (Asthma). This can be attributed to the fact that, cigarette smoke contains thousands of harmful chemicals, including nicotine, tar, carbon monoxide, and formaldehyde, all of which can irritate the airways and exacerbate asthma symptoms.

IX. CONCLUSION AND RECOMMENDATIONS

1. Chapter Overview

This chapter marks the end of the research, summarizing the conclusions drawn from the analysis of empirical data regarding the influence of environmental pollutants on immune diseases, particularly asthma. The findings highlight significant

relationships between various pollutants such as sulfur dioxide (SO_2), carbon monoxide (CO), and cigarette smoke and asthma outcomes. These relationships were validated through statistical analyses, including multiple regression, which confirmed the predictive power of these pollutants on asthma prevalence and severity. The chapter also contains the recommendations for further research on the phenomenon.

2. Conclusion

Based on the review of the accessed literature, regression analysis, hypothesis testing and the discussion and interpretation of findings, conclusions were drawn. The research objectives were achieved, the research questions were adequately answered. The general conclusion was based on the general objective developed in chapter one. The general objective was to assess whether pollutants influence immune diseases (asthma). Based on model summary statistics in chapter five, it was found that all the four independent variables in this research had a significant influence on the immune disease (asthma).

The specific conclusions were in line with the research questions. Research question (1) was: What is the association between Sulphur Dioxide (SO_2) exposure levels and the prevalence of asthma symptoms among patients attending Mufulira Clinic 1? The effect was that Sulphur Dioxide (SO_2) did significantly influence immune diseases (asthma). It was a predictor of immune diseases (asthma) due to a significant relationship between the variables. Research question (2) read: How does exposure to Carbon Monoxide (CO) correlate with the incidence and severity of asthma among patients at Mufulira Clinic 1? It was inferred that the effect was that Carbon Monoxide (CO) significantly influenced immune diseases (asthma). It was a predictor of immune diseases (asthma) due to the significant relationship that existed between the two variables. Research question (3) read: How does exposure to cigarette smoke affect the respiratory health and asthma severity of patients at Mufulira Clinic 1? The influence was that cigarette smoke had a significant influence on immune diseases (asthma). It was a predictor of immune diseases (asthma) due to a strong and significant relationship that existed between the two variables.

3. Recommendations

Following the review of the accessed literature, development of theoretical and conceptual frameworks, presentation of research findings, integrated discussion of findings and conclusion, recommendations were developed. These would create a firm foundation for future plans that can help to prevent immune diseases (asthma) in Mufulira town. The recommendations were as outlined below:

- **Implement Stricter Regulations:** Enforce tighter regulations on industrial emissions and vehicular exhaust to reduce air pollution levels, especially in urban areas.
- **Educational Initiatives:** Launch campaigns to raise awareness about the risks associated with exposure to environmental pollutants and the importance of asthma management.
- **Smoking Cessation Support:** Provide resources and support for smoking cessation programs to reduce the prevalence of cigarette smoke exposure.
- **Support Groups:** Establish community-based support groups for individuals with asthma, focusing on education, shared experiences, and coping strategies.
- **Mental Health Integration:** Integrate mental health support into asthma management programs to address the psychosocial aspects of the disease.
- **Longitudinal Studies:** Encourage further research into the long-term effects of various pollutants on respiratory health, particularly in vulnerable populations.
- **Air Quality Monitoring:** Implement regular monitoring of air quality to provide timely information to communities about pollution levels and associated health risks.
- **Improve Access to Services:** Enhance access to healthcare services for asthma management, especially for low-income and underserved populations.
- **Provider Training:** Ensure that healthcare providers receive training on the impact of

environmental factors on asthma to improve patient education and management.

Limitation and Recommendation for Future Research
The study may have been limited by a relatively small or homogeneous sample size, which could affect the generalizability of the findings across different populations and demographics. Additionally, the assessment of pollutant exposure may have relied on self-reported data or limited monitoring, potentially leading to exposure misclassification. Objective measures, such as air quality monitoring, could enhance accuracy.

Future studies should aim for larger, more diverse sample sizes that include various demographic groups to enhance the generalizability of findings. Furthermore, researchers should also conduct longitudinal studies to better understand the long-term effects of environmental pollutants on asthma and to establish causal relationships.

4. Chapter Summary

Chapter six of the current research has presented the conclusion in which it has been indicated that Sulphur Dioxide (SO_2), Carbon Monoxide (CO), and Cigarette Smoke had a significant effect on the immune diseases (asthma). The conclusion also highlights consolidated results from interviews. Recommendations were presented in order to address the identify issues and find solutions which could contribute to improved health outcomes and enhanced quality of life for those living with immune diseases (asthma).

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