

**RELATIONSHIP BETWEEN CLIMATIC FACTORS AND RESPIRATORY
DISEASES IN INFORMAL SETTLEMENT IN WINDHOEK, NAMIBIA**

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Abstract

This study focuses on the correlation between climatic factors and health in informal settlements in Windhoek, Namibia, to investigate if climatic factors have a role to play in respiratory disease occurrences. The objectives are to identify climate-related disease trends in Windhoek informal settlements and explore the association between respiratory diseases and changes in temperature, humidity, and rainfall patterns in these settlements. A quantitative retrospective methodology was employed as the study design. Amongst the diseases, Nose/Throat constituted 36.39% of all the respiratory disease, Other Respiratory System Disease accounted for 32.29%, Common Cold accounted for 28.74%, Pneumonia with 1.69%, Asthma/Bronchial Spasm 0.82%, and Tuberculosis 0.11%. Forty-five percent of patients were in the age category older than eighteen years, 38% in the age category 0-5 years, and 17% in the age category 5-17 years. Females accounted for the majority of cases with 52% in comparison to males that accounted for 48%. The study found that there is a significant ($p < 0.01$) variation in the morbidity pattern of respiratory diseases among age groups. A negative correlation at the 0.01 probability level between respiratory diseases (Asthma/bronchial spasms, Common Cold, Nose/Throat Disease/Disorder, Other Respiratory System Disease, Pneumonia) and maximum and minimum temperature was established. Only Nose and throat disease had a significant correlation with rainfall and humidity at the probability level 0.05. There was No association established between tuberculosis and the climatic factors. The study highlights the existence of a relationship between respiratory diseases and changes in temperature, humidity, and rainfall patterns in Windhoek's informal settlement. Even though these relationships were weak, it was evident that climatic factors do play a role in the occurrences of respiratory diseases. It is recommended that measures to prevent or mitigate the occurrence and prevention of respiratory infections be included in the preparation and handling of harmful human health effects of climate change.

Key words: Adaptation, Climatic indicators, Health, informal settlements, Respiratory diseases, Vulnerability, Weather Variability.

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Abbreviations

1.	ANOVA	Analysis Of Variance
2.	BA	Bronchial Asthma
3.	BP	Broncho Pneumonia
4.	CVD	Cardio Vascular Disease
5.	GP	General practitioner
6.	IHME	Institute for Health Metrics and Evaluation
7.	LRTI	Lower respiratory tract infections
8.	MA	Moving Average
9.	MOHSS	Ministry Of Health and Social Services
10.	NICE	National Institute for Health and Clinical Excellence.
11.	OPD	Out-Patient Department
12.	PTB	Pulmonary Tuberculosis
13.	RTI	Respiratory Tract Infection
14.	SSA	Sub-Saharan Africa
15.	TSL	Tonsillitis
16.	UN	United Nation
17.	URTI	Upper Respiratory Tract Infection
18.	WHO	World Health Organisation

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(UNAM)

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Dedication

I would like to dedicate this thesis to my late grandmother, Ms. Jacobina Soondaha Namboga. Ms. Jacobina has been my source of inspiration throughout my life. She was a hardworking woman and persevered throughout her lifetime to care for her children and grandchildren in despite her disability. May her soul rest in eternal peace.

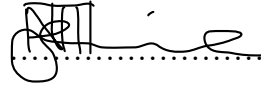
Declaration

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30/10/2019

Name of Student

Signature

Date

CHAPTER I

1. Introduction

1.1 Background of the Study

Namibia has seen a sharp increase in urbanisation since independence. Increased urbanisation in Namibia is not an isolated trend as it is observed across many countries in Southern Africa (1). Several challenges that are associated with rapid urbanisation, including unemployment, poverty, poor health care services, poor sanitation, urban slums, and environmental degradation. Informal settlements house a significant proportion of the world's urban population and pose grave threats to the health of their inhabitants, stemming from poor quality housing, lack of infrastructure, and minimal access to health care and other essential services (2).

Another result of urbanization in Namibia is the rapid growth and spread of informal settlements around major urban towns in the country. In addition to the increased area covered by informal settlements, the settlements are increasing in population due to rural-urban migration. According to Sverdlik (3), living in these settlements often poses significant health risks associated with lack of proper sanitation, poor drinking water quality, excessive exposures to indoor pollution, stress, violence, overcrowding, increased problems of drugs and other social problems, and increased exposure to harsh weather conditions (high and low temperatures, humidity and rainfall).

Adelekan (2) points out that urban health inequalities begin at birth, reproduced throughout a lifetime and may be recreated through vulnerability to climate change with a double burden on communicable and non-communicable diseases.

The changes in the global average temperature have a wide variety of effects at global, regional, and local levels. These effects include changes in average and extreme temperature, sea levels, precipitation patterns, and river runoff, drought occurrence, wind patterns, food production, ecosystem health, species distributions and phenology, and human health (4). The changing weather patterns expose human beings to more intense and increasingly frequent extreme events. It has been widely reported in the news of heatwaves across European countries resulting in health problems and ,in extreme cases, death. Although Namibia as a country has encountered heat waves as reported in the Namibian of 11 November 2017, no evidential health problems were recorded because of these heat waves. Additionally, changing weather patterns are reported to have an indirect impact on the availability of water, leading to reduced agricultural productivity - the quality and quantity of food all of which indirectly influence human health (4). The ecosystem's ability to provide essential goods and services, including cleaning the air and purifying the water, essential for human wellbeing are said to be affected by climate change. While several researchers have focussed on studying and understanding the effects of weather conditions (high and low temperatures, humidity, and rainfall) on health, little empirical research is done in this regard in the Namibian context. For this reason, the researcher felt the need to fill this gap knowledge on the association between the climatic factor and respiratory related illnesses in informal settlement in Windhoek, Namibia.

1.2 Statement of the problem

Worldwide, there is an increasing concern about climate change, and this has prompted an urgent research agenda including developing evidence based that will help prevent future health burdens through informed adaptation. A study conducted by Egondi *et*

al., (5) showed an increase in mortality associated with both hot and cold weather as well as rainfall in Nairobi. Mortality among people aged 50 and children aged below 5 years appeared most susceptible to cold compared to other age groups. Rainfall was found to increase all-cause mortality in general but was found to be strongly related to mortality amongst females. While low temperatures were associated with deaths due to acute infections, rainfall was associated with all-cause pneumonia and non-communicable diseases(5).

Namibia is considered to be one of the most vulnerable countries to the effects of climate change in Sub-Saharan Africa (SSA) (7). Vulnerability to changes in weather conditions not only depends on a change in frequency or duration of weather conditions but also on the capacity to respond adequately to those changes. Since Namibia is home to several different eco regions (e.g. tropical, semiarid, desert), the particular challenges posed by climatic changes will vary by region, and the responses are best formulated at the regional and the local levels.

The climate in Namibia is inherently highly variable. Based on data from selected meteorological stations, recent historical trends of climate in Namibia reveal that there has been a consistent increase in daily maximum temperatures (8). Namibia's various climatic zones make it difficult to detect and predict climate trends. Thus, the predicted climate change risk and associated impacts for Namibia's future are expected to exacerbate the already challenging situation. These challenges must be tackled with highly adaptive responses suitable for Namibia. However, very little information is available on how climatic factors affect the health of the Namibian population, especially the poor and disadvantaged groups throughout the country who are most vulnerable to the negative impacts of climate change and its health effects. It is

therefore important to investigate this association in the Namibian context to understand who is most at risk and to what extent.

The information on the associations among climatic factors (temperature, humidity, and rainfall) and health in these populations is lacking in our country. Subsequently, the delivery and planning of public health related interventions are hindered by this lack of information.

According to Omonitjo *et al.*, (9), all climate and weather variables have an influence on health. Due to the low standards of living in the Namibian informal settlements, compounded by overcrowding, poor housing, lack of basic infrastructure, and poverty, all weather related extreme events are likely to impact human health.

There is evidence that changes in climatic factors may be related to the onset of some diseases. These include aggravation of asthma and other upper respiratory tract infections due to mould exposure and common colds. They also include cardiovascular diseases such as stroke and lower respiratory tract infections like pneumonia (9). According to the World Health Organisation (WHO) and the United Nations (UN) partners (10), these diseases are amongst the common cause of death in Namibia and hence their selection for this study.

There is a substantial need to guide adaptation policies in these areas in order to minimize the negative impacts of changes in climatic factors. This dearth of literature generated the following question: *What is the statistical relationship (association) between the temperature, humidity, rainfall patterns, and the diseases (respiratory*

diseases namely upper respiratory tract infection, Flu, bronchopneumonia (BP), tonsillitis (TSL), pulmonary tuberculosis (PTB), and bronchial Asthma (BA)), faced by informal settlement dwellers in Windhoek? Hence, this study seeks to narrow the literature gap by answering the above question.

1.3 Purpose of the study

The study investigates the relationship between the climatic factors (temperatures, humidity, rainfall patterns) and the respiratory disease occurrences in the selected informal settlement dwellers in Windhoek, Namibia.

1.4 Objectives of the study

The following objectives were formulated to guide the study in answering the research question:

1. To establish climate related disease trends in the informal settlements in Windhoek.
2. To explore the relationship between respiratory diseases and changes in climatic factor (temperature, humidity, and rainfall) patterns in Windhoek, informal settlement.

1.5 Significance of the Study

This study will contribute by supplementing the public health literature. It will provide the Namibian nation with education on the relationship between temperature, rainfall, humidity, and its determinants on health in Namibia. The possible strategies on how to deal with harsh climatic factors produced by the study will assist individuals in the community to cope during harsh climatic factors and eventually reduce mortality and

morbidity cases. The findings of the study will also assist public health official's advocate for better planning, better allocation of resources, and improved infrastructures in the informal settlements. It is for this reason set to be of importance to public health and environmental policy-makers and managers. The general research framework formulated in this regard will guide future research, re-appraise current practices, and provide basic guidelines for new policies.

1.6 Limitations of the Study

Characteristically, the study design has some limitations. Firstly, the study only focused on settlement dwellers in Windhoek and it would therefore be incorrect to generalize the outcomes in this regard to all other regions in and/or outside Windhoek. Secondly, not everybody goes to the hospital for treatment, due to financial constraints and some patients use other methods such as traditional herbal medicine and spiritual means for their ailments. Thus, patients in this study do not cover patients in those categories. Lastly, People (informal settlement dwellers) that do not go to clinics and hospitals located in the informal settlements would be excluded from the study.

1.7 Delimitation of the Study

This study will only include health data obtained from clinics based in the informal settlements in Windhoek.

CHAPTER II

2. Literature review

2.1 Introduction

After providing a background of the study and the purpose as well as the aim of the study, this chapter continues to examine the different variables that will be underscored in this study and are discussed in line with prior studies and theories. This was achieved by paying keen attention to theoretical arguments on the association of climatic conditions and the health of those most at risk. It also pays attention to challenges encountered during variable episodes of climatic factors and seasonal adaptation strategies adopted during these episodes.

This section provides an in-depth review of the main literature. The review is divided into five main sections. The first section looks at the broad literature with specific emphasis on the key definitions that form the basis of the study and include informal settlements, climatic factors, and the respiratory diseases associated with these factors. The second section gives an in-depth review of Africa's vulnerability to climatic factors in general, describing the risk factors associated with this vulnerability. The subsequent section focuses on the leading causes of death in Namibia and gives an overview of the link between disease and exposure climate conditions. The final section provides specific effects of climatic factors on the health of humans and gives a detailed description of how respiratory diseases are influenced by the climatic factors.

2.2 Operational definitions

2.2.1 Informal settlements

The definition of informal settlements is context specific. Based on the United Nation habitat programme (11), these are defined as residential areas where a group of housing units has been constructed on land to which the occupants have no legal claim or which they occupy illegally and areas where housing is not in compliance with current planning and building regulations.

2.2.2 Climatic factors definitions

According to the national policy on climate change for Namibia (12), Climate is the long term-average weather condition of a large area of the earth's surface considered over a relatively long period of time whereas Weather is the state of the atmosphere at a given time. Temperature, rainfall, humidity, cloud coverage, sunshine, air pressure, and wind are components that constitute weather. Climate may vary (climate variability) in time and space beyond that of individual weather events (13) and may be caused by natural processes within a given climate system. Climate change as defined in the national policy on climate change for Namibia (12), refers to any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer). Climate change may result from natural factors; such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun.

Climate variability on the other hand refers to changes in patterns (such as precipitation patterns) in the weather and climate (12). The study focuses on the three main factors of the climate described below:

Temperature: Temperature is the measure of how cold or hot a place is. Temperature is usually higher during the day than at night. Rural areas are often cooler than cities because of the more buildings and factories in cities, which absorb heat during the day and release it slowly at night warming the surrounding air (14).

Humidity: Humidity refers to the amount of water vapour in the atmosphere. Humidity must be high for the formation of fog or clouds (14). Humidity has an influence on air temperature; the higher the relative humidity, the higher the temperature actually feels. The higher the humidity, coupled with a high temperature, makes the area feel so much hotter than it usually is.

Rainfall: Rainfall is defined as water that condensed from the aqueous vapour in the atmosphere and falls to earth in drops more than 1/50 inch in diameter. Rainfall is a common type of weather and it starts as small droplets of water in the clouds join together to get big and heavy and eventually fall from the clouds.

The three climatic factors selected for this study are measured regularly in Windhoek and the records are readily available. They are the independent variable in the study.

2.2.3. Health definitions

The World Health Organisation (15) defines health as the state of complete physical, mental, and emotional wellbeing and not merely the absence of disease. This study focuses, however, on the diseases that are amongst the top ten leading causes of death in Namibia as indicated by the WHO and UN partners (10); namely respiratory diseases (e.g. upper respiratory tract infection, common cold/flu, bronchopneumonia

(BP), tonsillitis (TSL), pulmonary tuberculosis (PTB), sinusitis and bronchial Asthma (BA). The researcher focused on the following health indicators as described below.

Respiratory tract infection (RTI): According to the national institute for health and clinical guidelines (NICE) (16), Respiratory tract infection (RTI) is defined as any infectious disease of the upper or lower respiratory tract. The Upper respiratory tract infections are defined as the infection of the upper part of the respiratory system above the lungs and can be due to viral or bacterial infection. Upper respiratory tract infections (URTIs) include the common cold, laryngitis, pharyngitis/tonsillitis, acute rhinitis, acute rhinosinusitis, and acute otitis media.

Influenza (Flu)/common cold: As stated by Fuhrman (17), Influenza, commonly referred to as the ‘flu’, is a respiratory virus that causes significant mortality and morbidity during annual epidemics, and is capable of affecting nearly half of the global population during severe pandemics (e.g., the 1918–1920 ‘Spanish Flu’). To date, the leading epidemiological hypothesis for the seasonality of influenza involves the crowding of sick and healthy individuals indoors in response to the winter season and a decrease in outdoor temperatures. Research has shown that ambient humidity and temperature are important in the transmission of influenza as it affects the size of the respiratory particle (17). When the air is dry, large drops partially evaporate, creating smaller, lighter drops that are more likely to remain airborne for extended periods.

Bronchopneumonia (BP): Pneumonia is an infection of the lungs and viruses or bacteria can cause it. It causes coughs, fever, and problems with breathing. It often affects only part of the lungs (18).

Pulmonary tuberculosis (PTB): As defined by Ait-Khaled et.al, (19), Tuberculosis is a bacterial disease caused by *Mycobacterium tuberculosis* (the tubercle bacillus) and spread from one person to another principally by airborne transmission. Tuberculosis can affect any organ in the body. Pulmonary tuberculosis is the most frequent site of involvement; extrapulmonary tuberculosis is less frequent. Only pulmonary tuberculosis is infectious.

Bronchial asthma Asthma is a disease characterized by recurrent attacks of breathlessness and wheezing, which vary in severity and frequency from person to person. This condition is due to inflammation of the air passages in the lungs and affects the sensitivity of the nerve endings in the airways so they become easily irritated (20). The strongest risk factors for developing asthma are exposure, especially in infancy, to indoor allergens (such as domestic mites in bedding, carpets and stuffed furniture, cats, and cockroaches) and a family history of asthma or allergy (20).

2.3 Africa's Vulnerability to Climatic factors

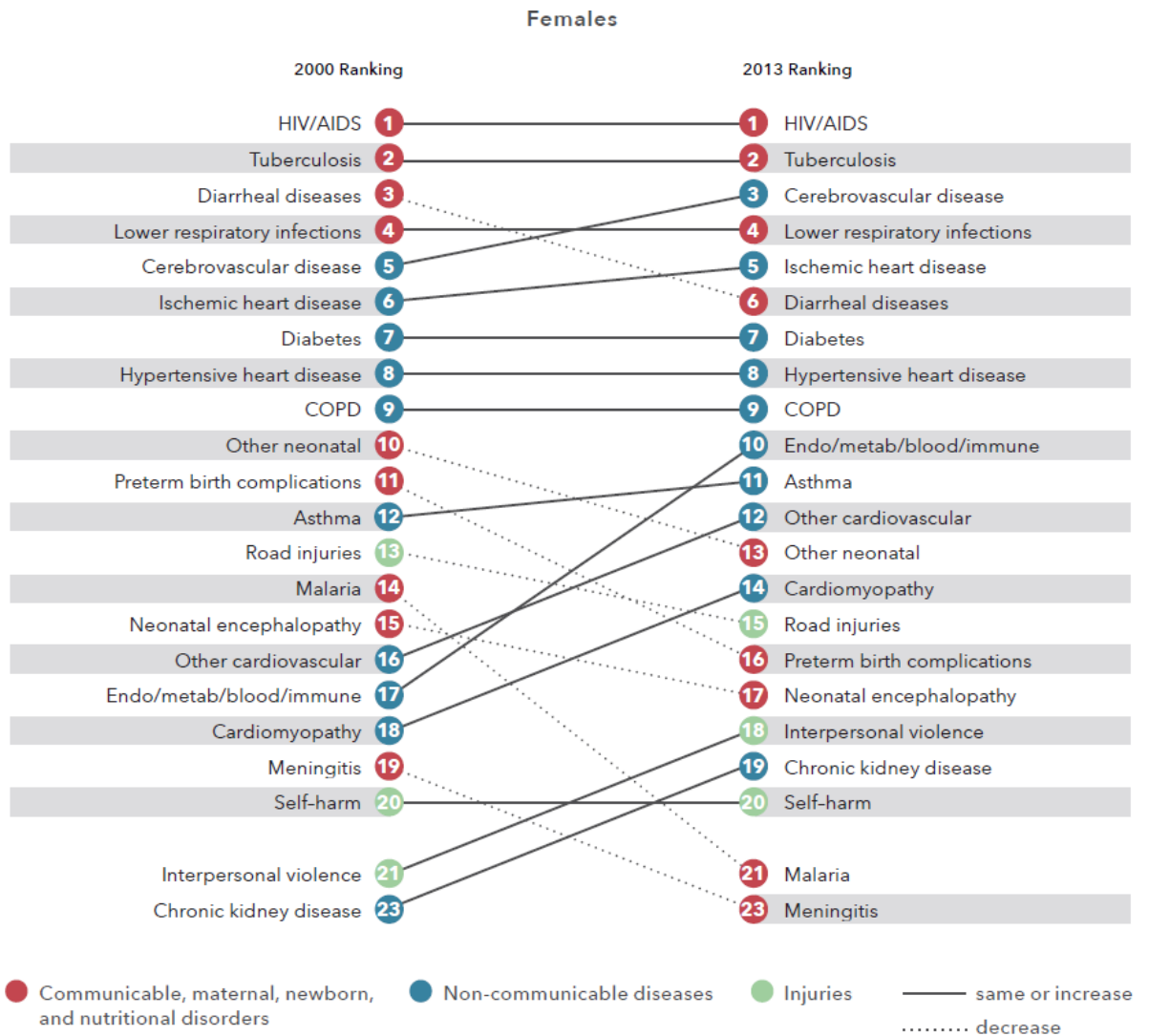
Risk factors contributing to vulnerability in Africa are low-income and geographical location. According to Guillaumont *et al.*, (21), the primary reason why some poor countries are vulnerable to climate change is that they lie in the low latitudes and therefore experience very high temperatures, such that further warming pushes them even further away from optimal temperatures. The rapid economic development and urbanization of poorer countries mean that Africa will be vulnerable to health hazards, and it is already vulnerable to several climate-sensitive diseases (22).

Vulnerability to changes in climatic factors [temperature, humidity, and rainfall] is a function of exposure, sensitivity, and the adaptive capacity of the population. According to Hosu *et al.*, (23) populations that are most at risk are women, children, the elderly, and the chronically ill, as well as the poor. The level of exposure to climatic factors is based on (a) the projections of changes in mean temperature and precipitation, extreme events, and climate variability, and (b) people's account of how the climate has changed over time. Sensitivity is defined in relation to (a) the relative risks and effects — biophysical effects and hazards, and (b) who will be affected by impacts of climatic conditions (temperature, humidity, and rainfall), who are the vulnerable groups, and where do they live? Adaptive capacity is discussed in terms of (a) adaptation constraints — social and physical, and (b) the current capacities in the identified hotspots, in general, that could facilitate adaptation to climate change (24). Exposure and sensitivity to climate impacts affect populations across the divide. The most hard-hit groups are those who dwell in informal settlements, the majority of who live in remote and rural areas, as well as coastal dwellers and peri-urban and urban areas. Informal settlements and rural areas have characteristics of high and dense populations per square kilometer, have poor shelter, and, due to lack of proper planning, exist in vulnerable zones such as flood lines. These populations have weak adaptive capacity due to their reliance on natural resources and low income (23).

2.4 Leading cause of death in Namibia

There is a constant increase in hospitalizations and mortality during winter months due to cardiovascular diseases as well as respiratory infections (25). Exposure to cold has often been associated with increased incidence and severity of respiratory tract infections. According to Mourtzoukou (25), low temperatures are associated with increased morbidity, especially in the vulnerable population groups— children and the

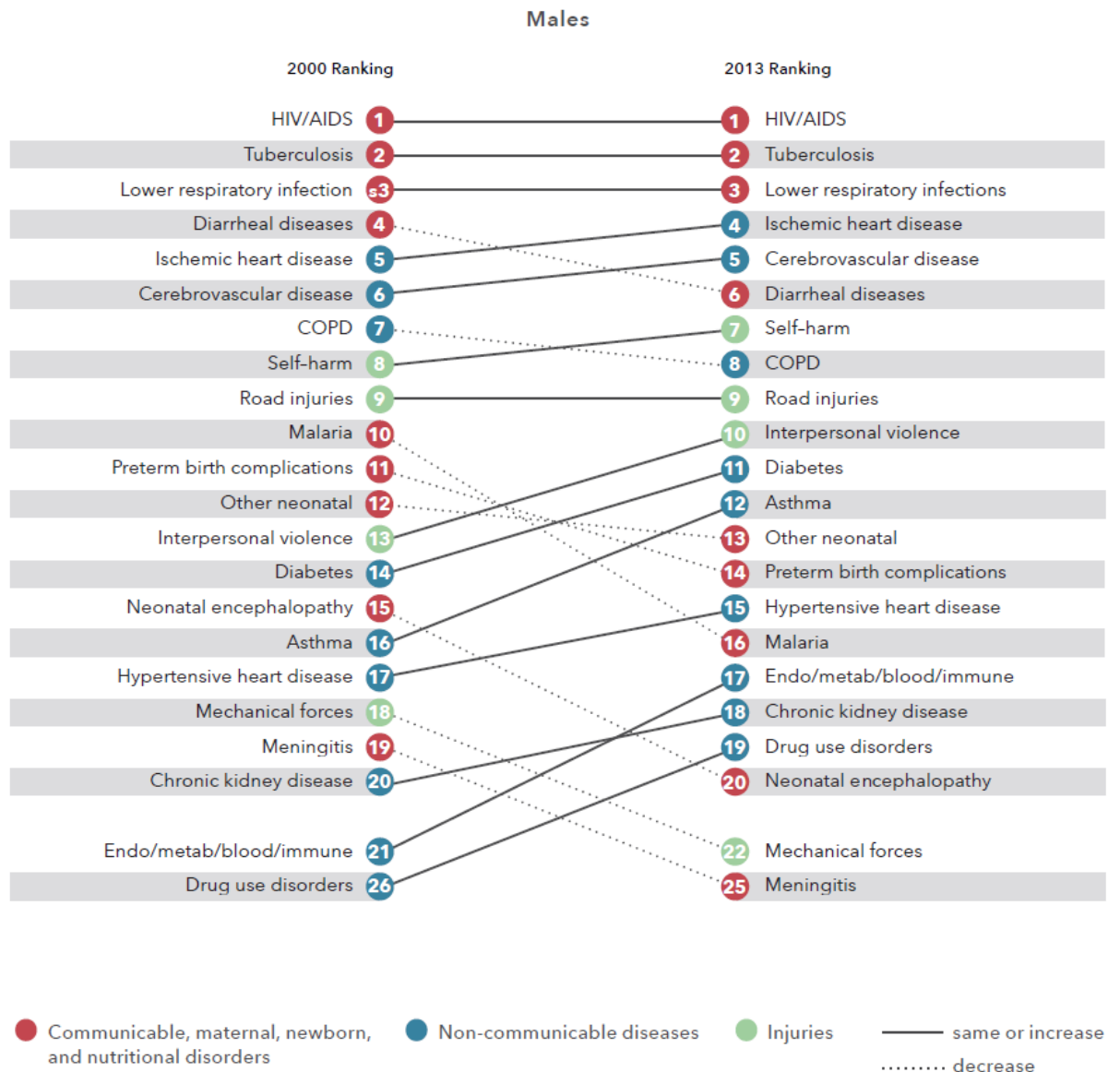
elderly—and with excess winter mortality due to cardiovascular and respiratory disease. The two figures below illustrate the major causes of death in Namibia.



Source: IHME (2016) (49)

Figure 1. Leading cause of death for females in Namibia 2000-2013.

As illustrated in figure 1 above, cardiovascular disease and respiratory tract infections are amongst the top five causes of death for females in Namibia.



Source: IHME (2016) (49)

Figure 2. The leading cause of death for males in Namibia 2000-2013.

Figures 1 and 2 above indicate that tuberculosis remained the second leading cause of death in both males and females in Namibia, while lower respiratory tract infection remained the third leading cause of death for males and the fourth cause of death for females over the same period. This highlights the importance of focusing on these diseases, as they are the leading causes of death in the country.

2.5 Effects of climatic factors on health

Over the last few decades, the direct and indirect consequences of climate on population health have been enormous. The IPCC (4) concludes that human health, already compromised by a range of factors, could be negatively impacted further by climate change and climate variability. Several empirical studies in various regions under diverse climatic conditions reveal that climatic factor variations have a significant influence on the transmission of some vector-borne diseases. Climate-induced effects are consistent with the observed changes and are linked to increasing vector-borne diseases, such as malaria, in some regions of Africa and South America (26). The IPCC (4) concludes that the climate is changing; humans are contributing to this change; weather patterns have become more extreme, and biological systems on all continents are responding to warming. In essence, the aggregate human impact on the environment has exceeded the limits of natural absorption or regeneration, resulting in an altered atmospheric composition, widespread land degradation, and depletion of fisheries, freshwater shortages, and biodiversity losses (27).

Climate change, because of the scale, magnitude, and breadth of its multiplier effects, poses a challenge to already-struggling economies. Warmer temperatures and ample rainfall, positively and significantly provide the necessary conditions for the multiplication and spread of vector-borne pathogens that are responsible for transmitting diseases such as malaria and Rift Valley Fever. This further burdens the health sector, especially in developing and middle-income countries. Change in Climatic conditions (temperature, humidity, and rainfall) directly increases the pathogen population by shortening its life cycle. Details about how these changes are affecting the health of human populations are spelled out by the IPCC (4).

The health effects that can be attributed to climate change are heat-related morbidity and mortality; asthma, respiratory allergies, and airway diseases; vector-borne and zoonotic diseases; cardiovascular disease and stroke; weather-related morbidity and mortality; food-borne diseases and nutrition; water-borne diseases; human developmental effects; mental health and stress-related disorders; neurological diseases and disorders; and cancer to mention a few (28).

Temperature, moisture and dehydration, and UV light greatly influence the pathogen cycle and survival in the environment and act on the transmission of airborne aerosols (29). The immune system is also under influence of adrenocortical hormones known to be expressed more during the winter season than summer, and increased secretion of steroids is associated with immunodeficiency. The changing pattern in vector and pathogen infectivity, the low exposure to sunlight during the rainy seasons, people spending more time indoors in a crowded environment, with subsequent seasonal variations in vitamin D levels could explain the seasonality of infectious diseases. The deficiency in vitamin D linked to the reduced exposure of skin surface to sunlight has harmful effects on human immunity and could increase the vulnerability to infections, mainly in people at extreme ages (29).

Heat, air pollution, change in quantity and quality of aeroallergens, and shift in infectious diseases linked to changing ecology of the pathogens have been previously reported as strong risk factors affecting respiratory health.

Change in climatic factors (temperature, humidity, and rainfall) is therefore disrupting or otherwise altering a large range of natural ecological and physical systems that are an integral part of Earth's life support system. The resultant climate impacts are both

positive and negative but predominantly negative (30), whether direct or indirect. The overall balance of health effects is likely to be negative (31) and populations in low-income countries are likely to be particularly vulnerable to the adverse effects.

The direct impacts include very cold, moderate to extremely high temperatures, and very low and very heavy rainfall (32). The direct impacts are felt immediately as a result of the mortality and morbidity associated with extreme weather events such as heat waves, floods, and drought. The collapse of infrastructure and sudden death or injury provides some of the evidence and, depending on the magnitude and the number of people exposed, the impact can range from minimal to catastrophic. Aside from droughts and extreme precipitation which results in flooding, Gerard *et al.*, (33) also argues that climate warming and changes in rainfall patterns may have significant and wide-ranging impacts on health, including changes in thermal stress and the distribution and seasonality of vector-borne, (34) and other infectious diseases (32).

The role of climatic factors in disease ecology and epidemiology are illustrated in a variety of ways and with varying levels of complexity. The most comprehensive conceptual models include environmental, social, economic, and health care system conditions and the direct and indirect effects they have on human health

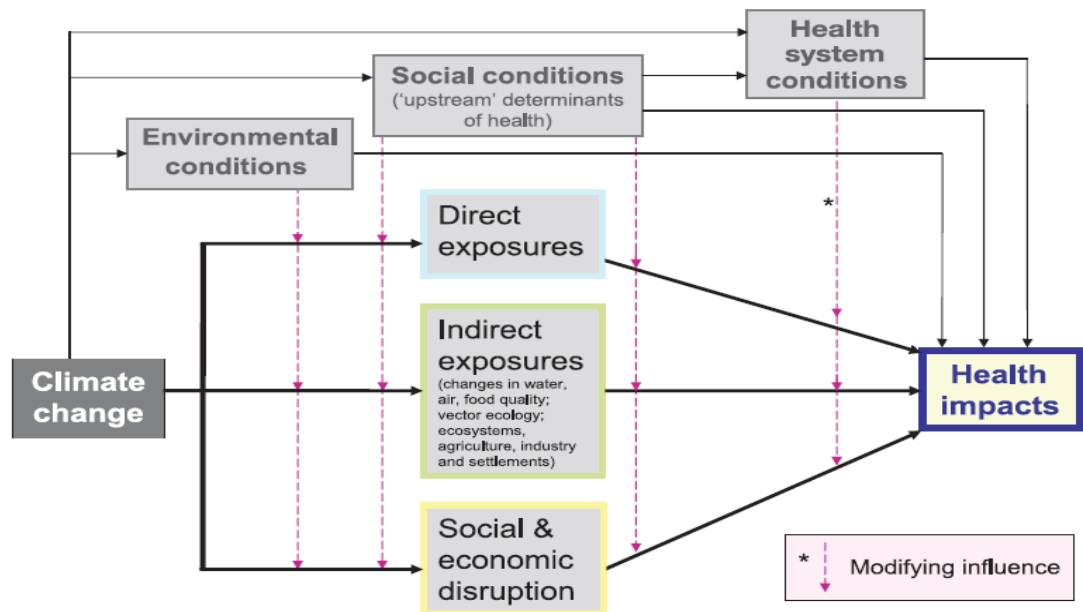


Figure 3. Schematic diagram of pathways by which climate change affects health, and concurrent direct-acting and modifying (conditioning) influences of environmental, social and health-system factors. Adopted from IPCC

2.5.1 Effects of temperature and humidity on health

Temperature refers to the measure of how cold or hot a place is and is measured with the use of a thermometer (14). The changes in the global average temperature have a wide variety of effects on global, regional, and local levels, such as changes (average and extremes) in temperature, sea levels, precipitation, and river runoff, drought, wind patterns, food production, ecosystem health, species distributions and phenology, and human health (4). It is predicted with a high degree of certainty that Namibia will become hotter throughout the years (with a predicted increase in temperatures of between 1°C and 3,5°C in summer and 1°C to 4°C in winter, with increased variability in rainfall trends (8). According to Makinen (35), cold weather may increase the incidence of disease by several mechanisms. When the weather is cold outside, people tend to spend more time indoors, which results in indoor population density that eventually promotes the person-to-person disease transfer. Cold dry air is also associated with the drying of the respiratory mucosa whereas the dry moist weather

affects the presence of particles such as dust, mold, spores, which in increased amounts worsen the chronic lung disease and susceptibility to other diseases.

There are several proposed mechanisms for the increased occurrence of RTIs during the winter months. Indoor crowding promotes the transmission of diseases and likely affect the number of observed RTIs. Informal settlers are particularly high risk of infection epidemics due to crowded living conditions and harsh environmental conditions.

Johnson and Eccles (36) suggest that acute cooling of the body surface could elicit reflex vasoconstriction in the nose and upper airways, which may inhibit the respiratory defense and convert an asymptomatic subclinical viral infection into an asymptomatic clinical infection. This study examined the effects of acute cooling of the feet and has shown common cold symptoms in 45 days in 10 % of the participants, suggesting that chilling is associated with the onset of common cold. Panter *et al.*, (37) indicated that the tropical and subtropical areas of Asia and Africa has a high prevalence and mortality from Pneumonia during the rainy season, this again shows the association of temperature and precipitation with pneumonia patterns

Polderman (38) argues that the drop in the core body temperature causes leukocytopenia, suppression of chemotactic migration of leukocytes, suppression of phagocytosis, reduction of the release of cytokines, insulin resistance, and hyperglycaemia, factors that increase susceptibility to infections.

A study conducted by Eccles (39) proved that exposure of the upper airways to cold air compromises local defense, and therefore increases the incidence of upper respiratory tract infections. The author suggests that the inspiration of cold air causes

a decrease in the temperature of the respiratory epithelium causing a decrease of mucociliary clearance and the local immune responses of the airway; i.e. it compromises the phagocytic activity leading to increased susceptibility to infection.

It is also evident that the duration of exposure to cold is associated with greater susceptibility to infection. The effect of extreme cold environmental temperature might be more severe if the period of extreme cold is longer

According to Maud (40), heat places stress on the thermoregulatory system. Exposure to high temperatures causes an increase in blood viscosity and blood cholesterol levels

The heat-related risk of mortality for respiratory diseases needs to be addressed for relevant environmental measures focusing on the one health concept. Evidence of associations between outdoor heat and respiratory hospitalizations has been reported in previous studies in developed countries however, data are lacking on the harmful effects of climate change on health in developing regions. This is where global warming and progressive population aging are expected with the improved accessibility to ARVs and anti-tuberculosis treatments resulting in the reduction of the mortality linked to both killers.

2.5.2 Effects of rainfall on health

As defined in Tabi (41) by Miller, rainfall is “a form of liquid precipitation that occurs as a result of the condensation of atmospheric water vapour into drops of water, heavy enough to fall on the earth’s surface”. It is measured using a rain gauge in mm and weather radars can estimate it. Rainfall patterns generally vary with seasons and geographic locations on the globe with decreasing intensity from the equator. Rainfall

in Namibia is highly seasonal in occurrence, with the major part of the country receiving its rain during the summer months. According to the report by Namibia resource consultant cc, ninety percent and more of all annual rains are received between October and April over most of Namibia.

Namibia's geographic position on the continent and subcontinent renders it prone to erratic, variable, and unreliable rainfall. The average rainfall is not harmful to population health but extreme rainfall, in combination with temperature can be catastrophic through flooding and associated diseases. Heavy rains still constitute a major challenge especially in informal settlements in Windhoek, as they are highly vulnerable to floods and cold weather conditions during winter mainly due to the nature of their dwellings. Heavy rainfall and drought are becoming common occurrences globally. According to the Namibian statistics agency (42), the rainfall in Namibia is extremely variable. The highest total rainfall of more than 600 millimeters per year is usually observed in the northeast, while the south and far west normally receives less than 50 millimeters.

CHAPTER III

3. Research Methodology

3.1 Introduction

This chapter provides an in-depth overview of the data collection process and the methods of analysis during the research inquiry. A discussion regarding the study design utilised to gain access to all relevant information needed is laid down. This chapter also provides a detailed description of the research instruments used including the research tools employed during data collection procedures. Lastly, it describes the respective techniques adopted during data analysis, the research limitations and challenges encountered throughout the research process.

3.2 Research Design

According to Creswell (43), quantitative research is an approach for testing objective theories by examining the relationship between variables. For this study, a quantitative retrospective, the correlational approach was conducted as the researcher intended to find a relationship between the variables, namely the climatic factors (temperature, humidity, and rainfall) and respiratory diseases (Flu/common cold, bronchopneumonia (BP), pulmonary tuberculosis (PTB) and bronchial asthma (BA), Nose throat disease and other respiratory tract infections). The study involved the collection of numerical data for the meteorological variables with temperature in degree Celsius, humidity in percentages (%), and rainfall in mm) over the past 5 years (2013-2017).

Ihaka (44) indicates that time series arise as recordings of processes that vary over time. This study utilised an analytical method and intends to establish the association between weather patterns and diseases amongst the informal settlements in Windhoek.

Disease morbidity and mortality cases for the clinics utilised mainly by informal settlements: Hakahana clinic, Okuryangava clinic, Otjomuise clinic, Khomasdal clinic, and Wanaheda clinic were collected from the regional office in Windhoek Namibia.

3.3 Data collection

3.3.1 Sampling method and sample size

Ary (45) describes a population as all the organisms that both belong to the same group or species and live in the same geographical area, and a sample as being part of the population. The population for this study comprised of informal settlement dwellers in Windhoek Namibia. According to the Namibia Inter-Censal Demographic survey (NIDS) report of 2016, the Khomas region, which is home to the country's capital city Windhoek, is amongst the regions with the highest number of informal settlement (42.3), which is home to the country's capital city Windhoek. According to the 2011 Namibian population census, the total population of the informal settlement dwellers in Windhoek stood at 102,643 people. The sample size was 213,258 respiratory related cases as it included the total number of respiratory disease cases recorded from the five selected clinics over the study period (2013-2017). Only first-time patient cases were recorded. The climatic factors data were obtained from the Windhoek Meteorological Office.

3.3.2. Data collection tools and procedure

Disease/case data

The data collection process involved the use of secondary sources.

Only morbidity and mortality cases due to respiratory tract infections (such as Flu/common cold, bronchopneumonia (BP), pulmonary tuberculosis (PTB) and bronchial asthma (BA), Nose throat disease, and other respiratory tract infections) were collected. These diseases are amongst the top ten leading causes of death in Namibia (43) and their prevalence is known to be associated with climatic conditions and hence their selection. Disease morbidity and mortality data for the informal settlements collected included data from the following clinics: Hakahana clinic, Okuryangava clinic, Otjomuise clinic, Khomasdal clinic, and Wanaheda clinic. These data were obtained electronically from the regional office in Windhoek Namibia. The five clinics were selected, as they are located in the informal settlement constituencies under study. The morbidity and mortality data collected was for five years from 2013 to 2017.

The case data collected included age categories for the diseased patients, the gender of each case, as well as the month and year the cases were recorded.

All morbidity and mortality cases (due to respiratory tract infections,) recorded in the period between January 2013 to December 2017 were collected. The researcher was fortunate enough that all data collected was computerised hence retrieved all the secondary data/ records electronically. The cases recorded were the first time occurrences and not follow up cases.

Meteorological data

The meteorological office in Windhoek was approached to provide the records on the minimum and maximum temperature in ($^{\circ}\text{C}$), relative humidity in (%) as well as the

monthly rainfall in (mm) for the year's 2013- 2017. All the meteorological data were recorded from the weather station [0740154 X] - Windhoek Met, Measured at 08:00. The meteorological office is the official organization charged with the responsibilities to observe and understand weather and climate and provide meteorological services in support of national needs and international obligations. The mean monthly temperatures were derived from the daily minimum and maximum temperatures recorded from the station [0740154 X] - Windhoek Met, measured at 08:00. This station collects data for the Khomas region and the informal settlements in the study fall under this region. To identify the trend of change, the annual mean was obtained by dividing the sum of the monthly means by the number of months for each year. Daily relative humidity and daily rainfall data were assembled to come up with average monthly relative humidity and average monthly rainfall respectively. Meteorological data were also collected as secondary data from the Met office electronically.

3.3.3 Challenges encountered during data collection.

The researcher was faced with several challenges during data collection and these are listed below.

- a) The clinics did not record dates of onset of diseases. For this reason, the total cases per month of disease were used as total counts without lag days.
- b) The clinics did not record the residential area where the patients were coming from. Making this difficult to single out only those from informal settlements.

3.4 Data Analysis

3.4.1 Statistical analysis

To identify the specific factors or parameters that explain the temporal patterns of the listed diseases; a stepwise multiple logistic regression analysis was conducted using the SPSS application, version 25. Stephenson (46) illustrates how Multiple regression

is used in the case that the response variable may depend on more than one explanatory variable. The multiple regression equation having more than two explanatory factors is given below:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + \dots + b_nX_n$$

The dependent variable, Y (monthly value of different categories of diseases) and independent variables X₁, X₂, X₃, ... X_n, (meteorological parameters) was regressed using the above equation; b₀ is the interception coefficient; b₁, b₂, b₃, b₄, ... are linear effect parameters or coefficients (46). A regression model is considered statistically significant if the calculated F value is larger than the F distribution value at a probability of α . The analysis of variance (ANOVA) including F test, the p-value of the models, and determination coefficient R² that measures the goodness of fit of the regression model at a confidence limit of 95% was performed. The larger the magnitude of t values and the smaller the magnitude of p-values, the more significant is the corresponding coefficient. The p-value utilised was P= 0.01 and 0.05. This regression model was adopted to describe how the independent variable is numerically related to the dependent variable.

The correlational analysis incorporated in the statistical software package is used to understand the nature of the relationship between two variables. Pearson's r correlation is widely used to measure the relationship between linearly related variables. It is for this reason that Pearson's r correlation was selected for this study to examine the linear relationship between rainfall, relative humidity, maximum and minimum temperature, and specific respiratory diseases to address the second objective of the study.

CHAPTER IV

4. Results Presentation

4.1 Introduction

This chapter presents the findings of the quantitative data gathered during the study. It paid Emphasis to the trends in climatic factor patterns and the associations between the climatic factors variability and disease occurrence in the informal settlements in Windhoek. The unusual weather conditions that summer and winter brings pose a threat to the Windhoek informal settlements, considering their nature of dwellings that renders them most vulnerable to climatic catastrophes.

This presentation of the results focused on parameters such as:

1. The demographic characteristic, to illustrate the age category that is affected the most by weather variability as well as the gender with the most diseases prevalence;
2. The statistical analysis results to show the associations/correlations between climate change factors and health that were obtained
3. Finally presenting the seasonal characteristics to indicate the season with most disease cases, climatic factors trends, as well as disease trends, presented graphically.

4.2 Demographic characteristics of the sample population

Disease Cases reported from the five clinics from 2013 to 2017 were 213,258. The 212,142 cases were respiratory diseases, while 1,116 are cardiovascular diseases. Amongst these cases within the study period, Nose/Throat Disease/Disorder accounted for 36.39%, followed by Other Respiratory System Disease with 32.29%, then OPD

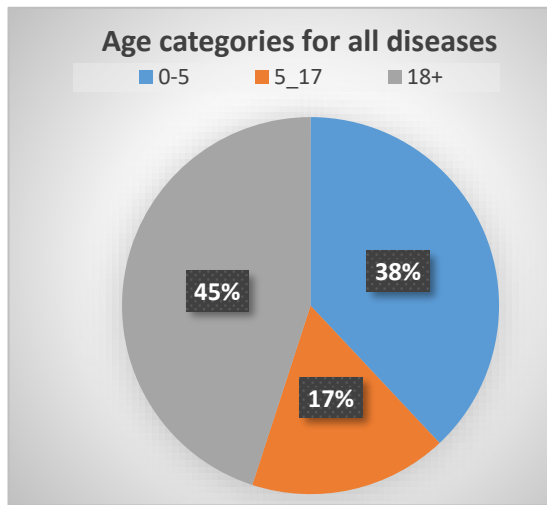
Common Cold with 28.74%, Pneumonia with 1.69%, OPD Asthma/Bronchial Spasm with 0.82% and lastly Tuberculosis with 0.11%. All respiratory diseases jointly accounted for 99.48% of all diseases, while cardiovascular diseases were unspecified and accounted for less than 1%.

Table 1. Age characteristics of respiratory and cardiovascular disease patients in Windhoek's informal settlements.

TOTAL CASES (2013-2017)	0-5 years	5-17 years	18+ years	TOTALS
Total OPD Asthma/Bronchial Spasm	432 (25%)	204 (12%)	1096(63%)	1732 (0.82%)
Totals OPD Common Cold	22750	9278	28941	60969 (28.74%)
OPD Nose/Throat Disease/Disorder	32749	16089	28371	77209 (36.39%)
Totals OPD Other Respiratory System Disease	23212	9656	35628	68496 (32.29%)
Totals OPD Pneumonia	2229	329	939	3497 (1.69%)
TOTALS OPD Tuberculosis	5	9	225	239 (0.11%)
Totals : All respiratory	81377	35565	95200	212142

The pie chart below shows that the highest cases of diseases were observed in the age category of 18 years and older with 45% followed by the age group 0-5 with 38% and lastly by the 5-17 age group with only 17% cases.

a)



b)

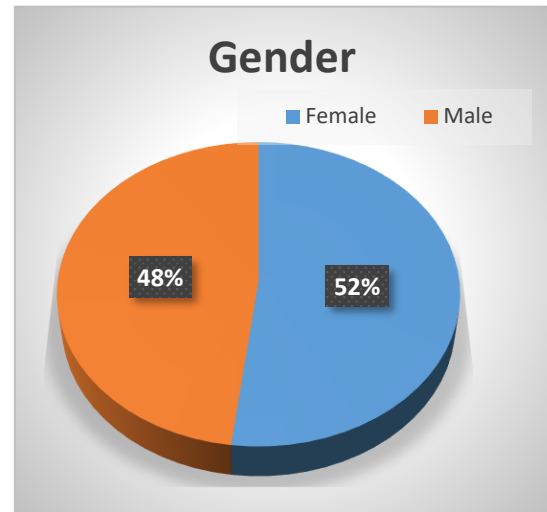


Figure 4. Demographic profile of the sample represented in age categories (a) and gender

(b)

These results indicate that the elderly above the age of 18 and the young below the ages of 5 are the most affected age groups. Generally, it is known that the young and the elderly are most susceptible to diseases as their immune systems are weaker or immune compromised. The very active age group between 5 and 17 years have high immunity, as they are most active.

4.3 Results obtained after the application of Statistical software. (SPSS and Correlational analysis results).

As indicated under methodology, the statistical software package called the SPSS version 25 was used in this study and the following results were obtained.

Table 6 below shows the coefficient of correlation between respiratory diseases and weather parameters in Windhoek's informal settlements. All metrological variables that are significantly correlated with the respiratory diseases are shown in table 5 below. Table 5 also indicates that there exists a negative correlation between Asthma/bronchial spasms, Common Cold, Nose/Throat Disease/Disorder, Other Respiratory System Disease, Pneumonia, and maximum temperature and minimum

temperature all at the 0.01 probability level. Nose and throat diseases also show a negative correlation with Humidity and rainfall at 0.05 probability level while Asthma/bronchial spasms, Common Cold, Other Respiratory System Disease, Pneumonia are not significantly correlated with humidity and rainfall. Furthermore, tuberculosis was not significantly correlated with any of the weather parameters.

Table 2: Coefficient of correlation between selected respiratory disease and weather parameter/climatic indicators in the Windhoek’s informal settlements.

<i>Respiratory disease</i>	<i>Maximum Temperature</i>	<i>Minimum Temperature</i>	<i>Humidity</i>	<i>Rainfall</i>
OPD Asthma/ Bronchial Spasm	-0.332**	-0.373**	0.039	-0.045
OPD Common Cold	-0.563**	-0.573**	-0.136	-0.256
OPD Nose/Throat Disease/Disorder	-0.442**	-0.491**	-0.285*	-0.319*
OPD Other Respiratory Disease	-0.478**	-0.568**	-0.236	-0.277
OPD Pneumonia	-0.444**	-0.443**	-0.109	-0.111
OPD Tuberculosis	-0.028	-0.047	0.047	-0.134

** - Correlation is significant at 0.01 probability level (2-tailed).

* - Correlation is significant at 0.05 probability level (2-tailed).

Table 7 below presents the regression model between respiratory diseases and climatic indicators (temperature, humidity, and rainfall) in Windhoek’s informal settlements.

The results of the analysis show that maximum temperature and minimum temperature

accounted for 24.9 % of the temporal pattern of Asthma/bronchial spasms occurrences. Specifically, maximum temperature accounted for 11% ($R^2 = 0.11$) and minimum temperature, 13.9% ($R^2 = 0.139$). Maximum temperature accounted for 31.7% ($R^2 = 0.317$) whereas minimum temperature accounted for 32.8% ($R^2 = 0.328$) of the temporal pattern of OPD Common cold at the 0.01 probability level.

The regression model of OPD nose /throat disease on maximum and minimum temperature is significant at the 0.01 probability level, while on rainfall and relative humidity, it was significant at 0.05 probability level. Maximum temperature contributed 19.5% ($R^2 = 0.195$), minimum temperature 24.1% ($R^2 = 0.241$) at 0.01 probability level. Relative humidity and rainfall contributed 8.1% ($R^2 = 0.081$) and 10.2% ($R^2 = 0.102$) respectively at the 0.05 probability level. Furthermore, maximum temperature and minimum temperature were the temporal contributors to pneumonia and other respiratory diseases unlisted. For pneumonia, Maximum temperature accounted for 19.7% ($R^2 = 0.197$) and minimum temperature accounted for 19.6 % ($R^2 = 0.196$), whereas for the other respiratory diseases unlisted, maximum temperature accounted for 22.9% ($R^2 = 0.229$) and minimum temperature 32.3% ($R^2 = 0.323$) both at the 0.01 probability diseases.

From the results above, maximum temperature, minimum temperature, relative humidity, and rainfall are the climatic factors that played significant roles in the occurrences of respiratory diseases in Windhoek's informal settlements however, relative humidity and rainfall only played a significant role in the nose/throat disease.

Table 3: Summary of Regression between respiratory diseases and weather parameters in Windhoek's informal settlements

<i>Depended variable</i>	<i>Independent variable</i>	<i>R</i>	<i>R²</i>	<i>Adjusted R²</i>	<i>Std Error</i>	<i>R² Change</i>	<i>F</i>	<i>Significant F² Change</i>
Asthma/Bronchial Spasm	Maximum Temp	0.332	0.110	0.095	12.844	0.110	7.179	0.010
	Minimum Temp	0.373	0.139	0.124	12.633	0.139	9.374	0.003
OPD Common Cold	Maximum Temp	0.563	0.317	0.306	367.931	0.317	26.975	0.000
	Minimum Temp	0.573	0.328	0.316	365.105	0.328	28.296	0.000
Nose/Throat Disease	Maximum Temp	0.442	0.195	0.181	377.429	0.195	14.077	0.000
	Minimum Temp	0.491	0.241	0.228	366.442	0.241	18.464	0.000
	Humidity	0.285	0.081	0.066	403.240	0.081	5.146	0.027
	Rainfall	0.319	0.102	0.079	328.355	0.102	4.537	0.039
Other Respiratory Disease	Maximum Temp	0.478	0.229	0.215	351.114	0.229	17.203	0.000
	Minimum Temp	0.568	0.323	0.311	329.018	0.323	27.643	0.000

OPD	Maximum	0.444	0.197	0.184	29.935	0.197	14.271	0.000
Pneumonia	Temp							
	Minimum	0.443	0.196	0.182	29.959	0.196	14.153	0.000
	Temp							

4.4. Graphic presentation of results to show case monthly patterns of the selected respiratory diseases with climatic factors across the years of 2013-2017.

Figures 5a and 5b below show the monthly pattern of the selected respiratory diseases with the trend of minimum temperature across the years of 2013-2017. The high occurrence of pneumonia is associated with a minimum temperature range of 5.4 °C - 10.7 °C and a maximum temperature range between 22.2 and 25.7 °C. Common cold and OPD nose and throat disease is commonly associated with cold temperatures between 5-10 °C as illustrated in figure 5b below.

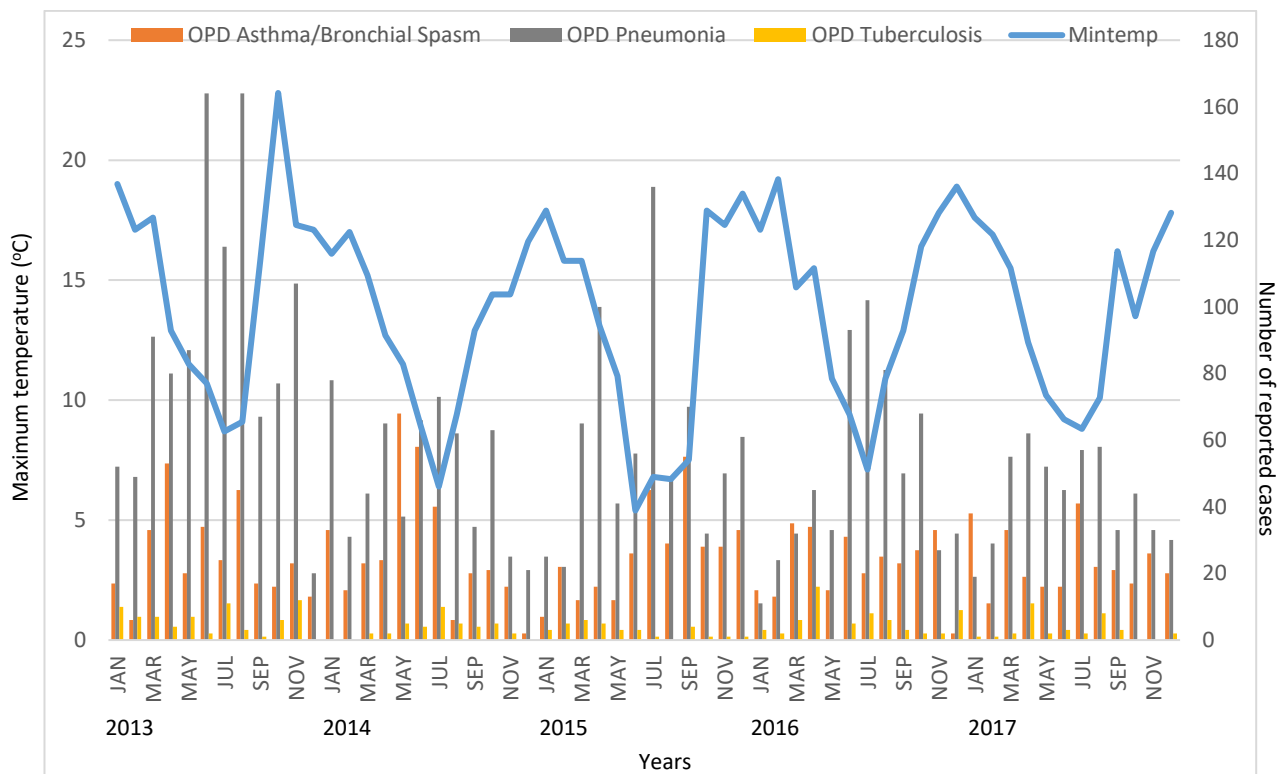


Figure 5a: Monthly pattern of OPD Asthma/Bronchial, OPD Pneumonia, and OPD Tuberculosis with the trend of minimum temperature across the years of 2013-2017

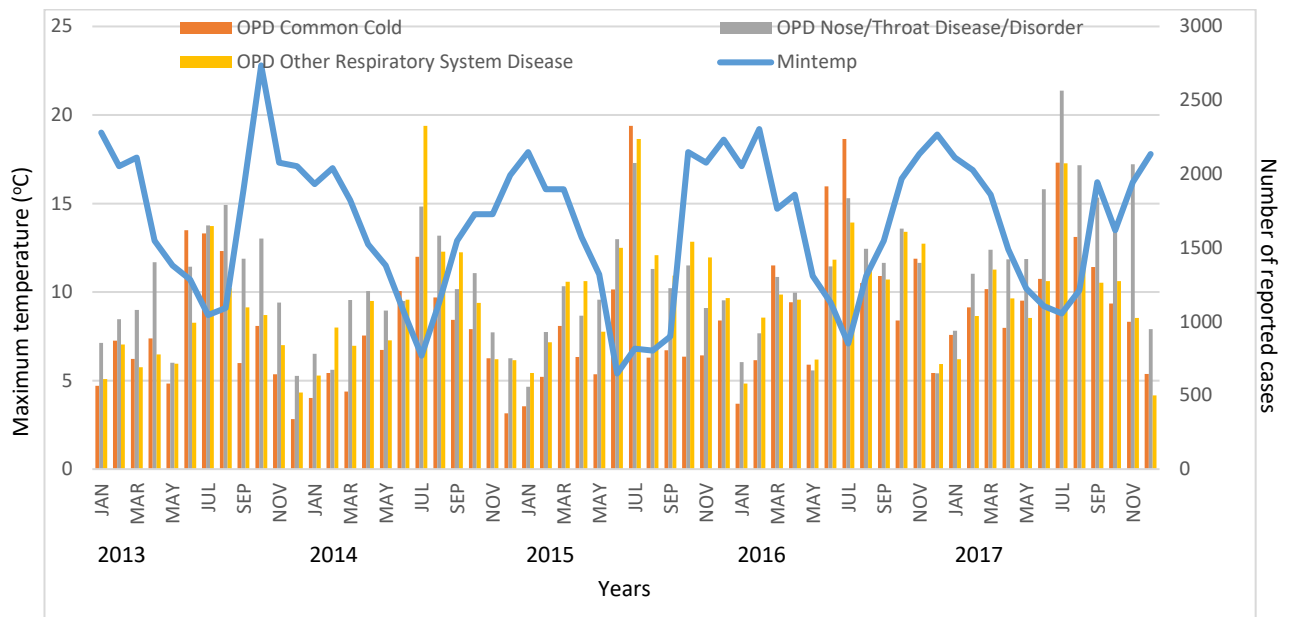


Figure 5b: Monthly pattern of OPD Common Cold, OPD Other Respiratory Disease and OPD Nose/Throat Diseases/Disorder with the trend of minimum temperature across the years of 2013-2017.

Figures 6a and 6b below shows an association between disease cases and maximum temperature. A negative association is observed, as temperature decreases the disease cases increase. This pattern is observed across the years under study (2013 to 2017). The winter months are observed to have higher disease cases over the summer months when the temperatures are higher.

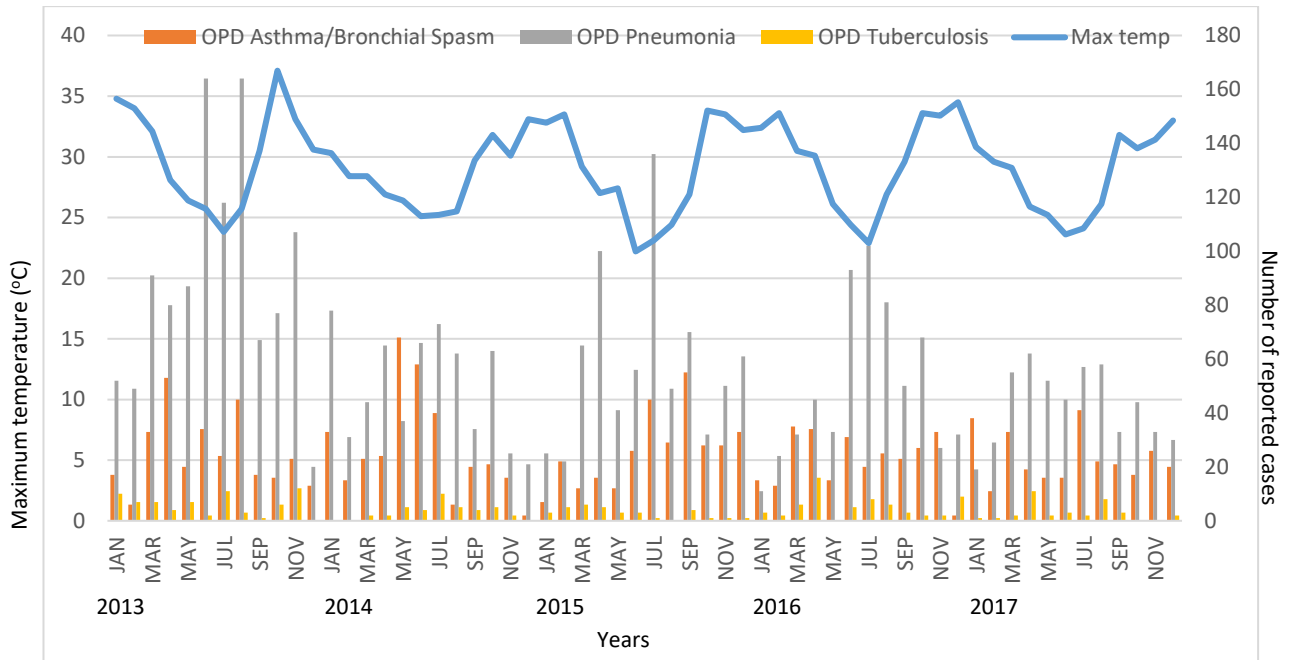


Figure 6a: Monthly pattern of OPD Asthma/Bronchial, OPD Pneumonia and OPD Tuberculosis with the trend of maximum temperature across the years of 2013-2017.

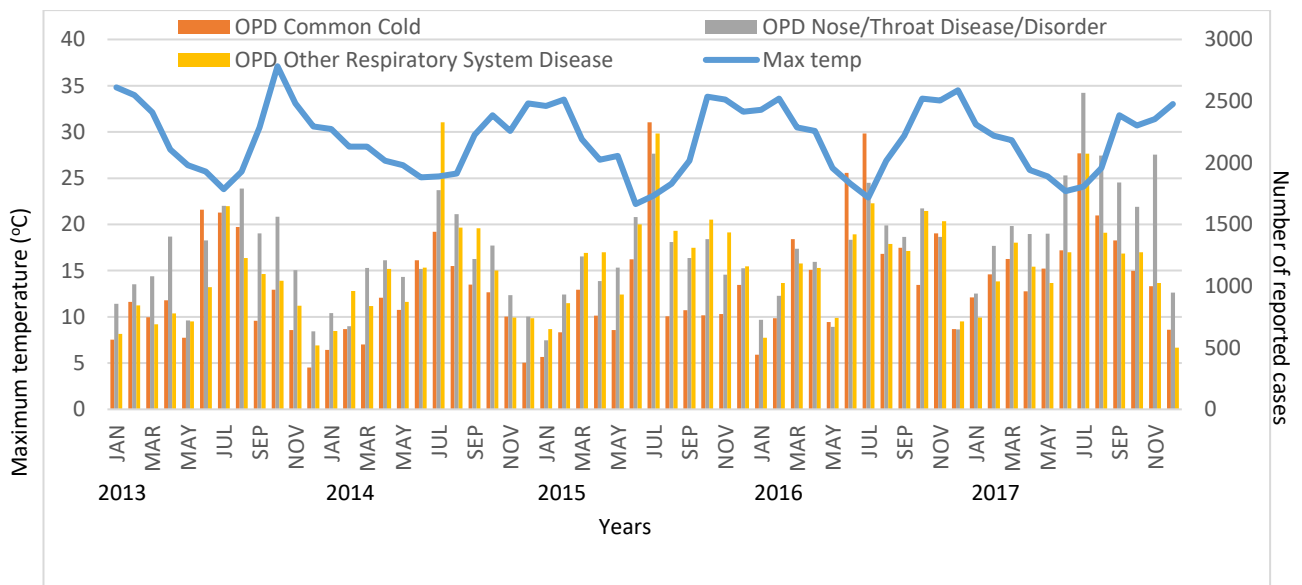


Figure 6b: Monthly pattern of OPD Common Cold, OPD Other Respiratory Disease, and OPN Nose/Throat Diseases/Disorder with the trend of maximum temperature across the years of 2013-2017.

Figures 7a and 7b below illustrates a monthly pattern of the selected respiratory disease with humidity. The figures show that there is no association between humidity and the selected diseases except for nose and throat disease that shows a negative association.

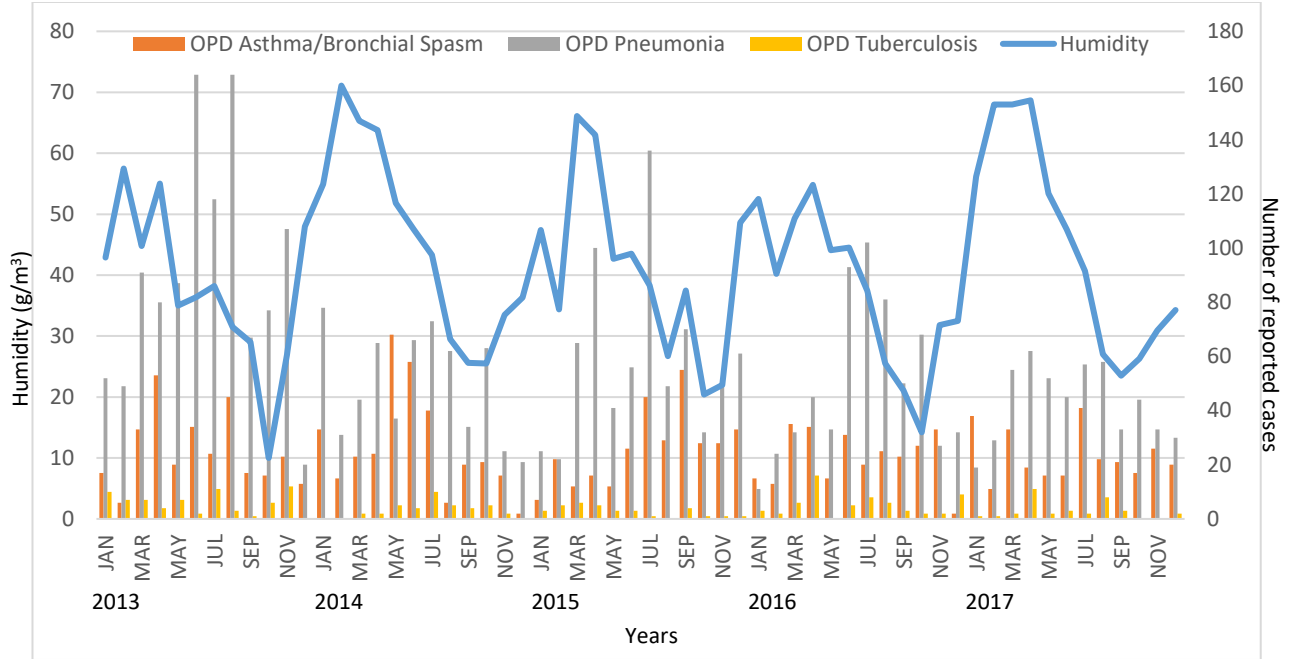


Figure 7a: Monthly pattern of OPD Asthma/Bronchial, OPD Pneumonia, and OPD Tuberculosis with the trend of humidity across the years of 2013-2017

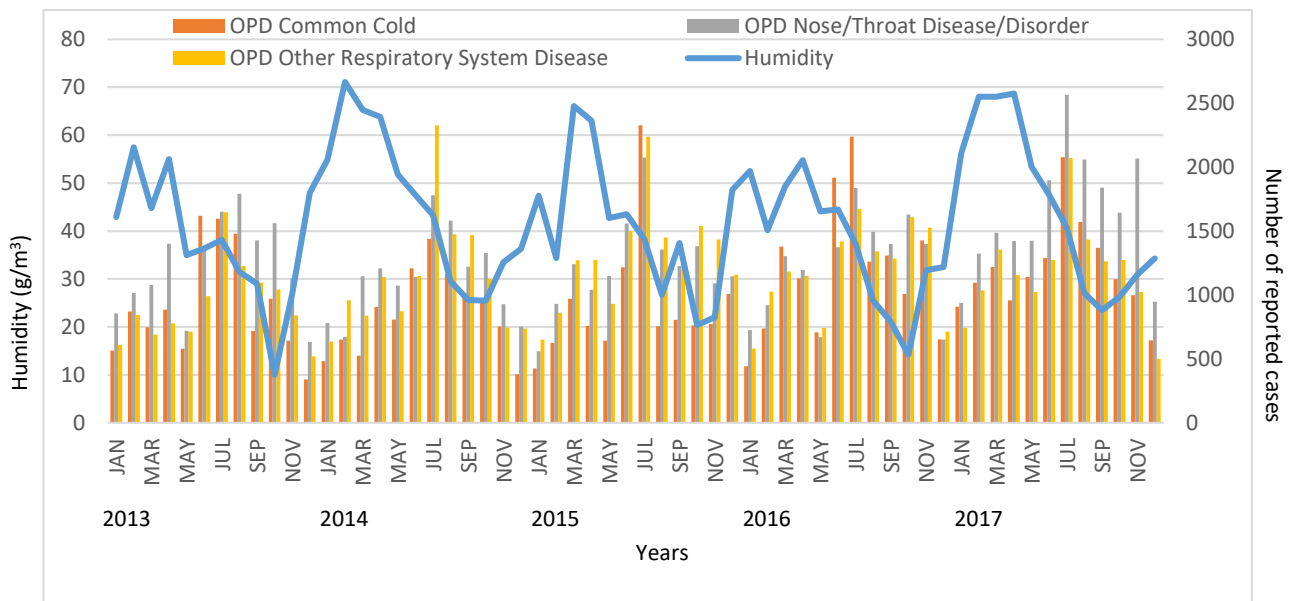


Figure 7b: Monthly pattern of OPD Common Cold, OPD Other Respiratory Disease, and OPD Nose/Throat Diseases/Disorder with the humidity trend over the years of 2013 to 2017.

Figures 8a and 8b below illustrate a monthly pattern of the selected respiratory disease and rainfall. The figures show that there is no association between the selected diseases with rainfall except for nose and throat disease as shown in figure 8b. The occurrence of nose and throat is negatively associated with rainfall. During the dry months of June to August when there is no rainfall, the disease cases of nose and throat increase.

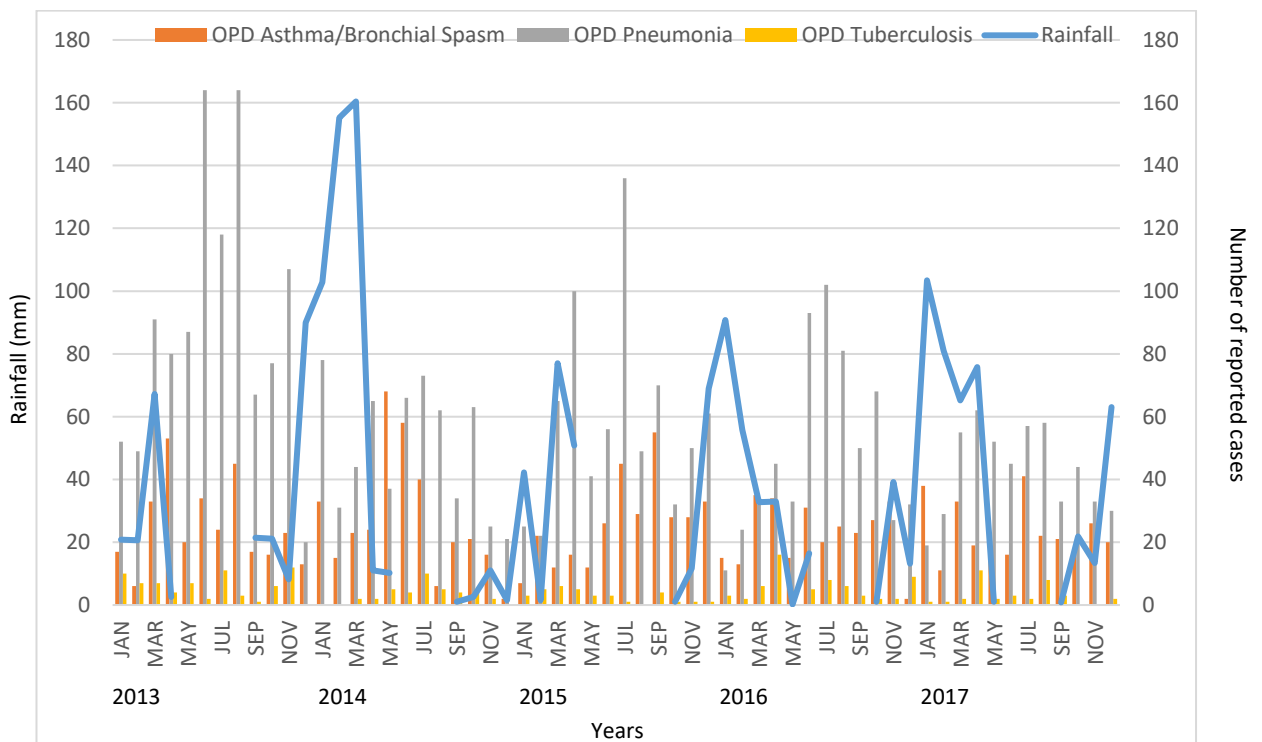


Figure 8a: The monthly pattern of OPD Asthma/Bronchial, OPD Pneumonia, and OPD Tuberculosis with the rainfall trend during the study period of 2013- 2017 in the Windhoek’s informal settlements.

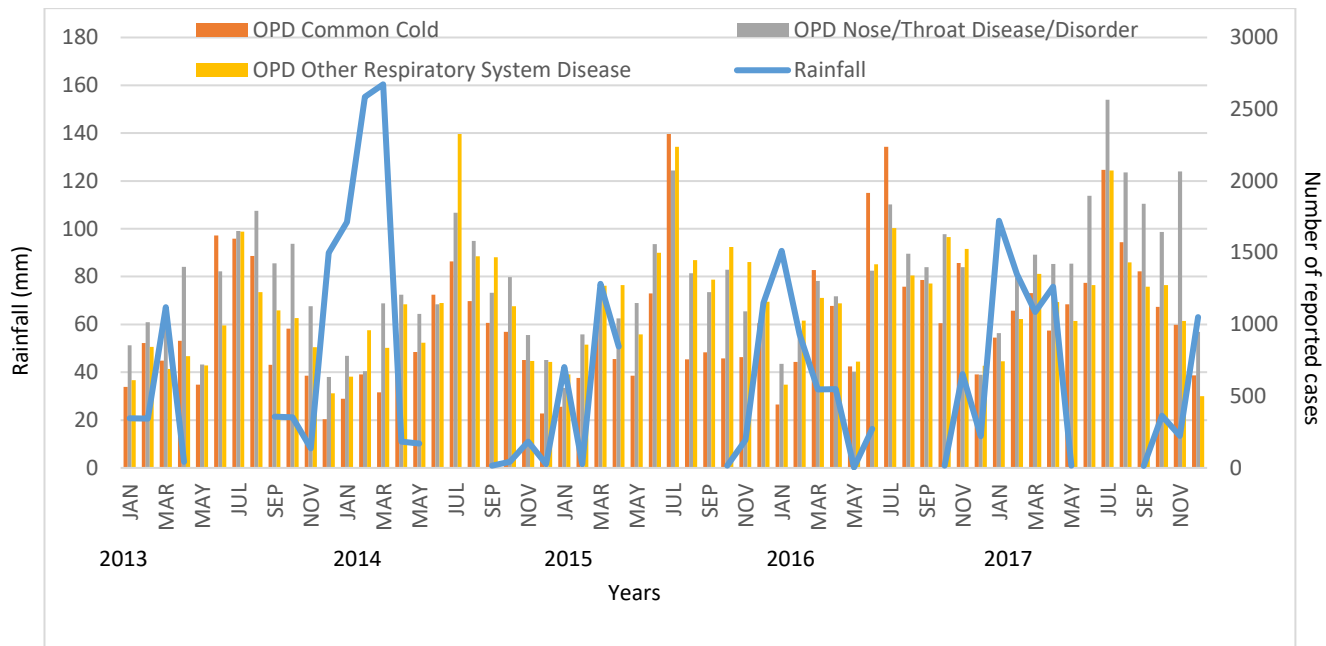


Figure 8b: Monthly pattern of OPD Common Cold, OPD Other Disease, and OPD Nose/Throat Diseases/Disorder with the rainfall trend over the years 2013-2017.

CHAPTER V

5. Discussion

5.1 Introduction

This chapter focuses on the discussion of findings from the study. The chapter starts with the discussion on how the health of people with different gender and age categories are affected by climatic factors and continues to illustrate which seasons had the highest and lowest disease occurrences and what factors that could be attributed to that. The chapter discusses results on the association between climatic factors and respiratory disease and linking this with findings from similar studies.

5.2 Discussion

The impacts of climate change have been well reported. A technical contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change indicated that as a result of climate change, "... extreme weather and climate events have significant impacts on economic sectors, natural resources, ecosystems, livelihoods, and human health" (47).

Several factors compound the magnitude or severity of the impacts of climate change and its factors on human health. These factors include the geographic location of the dwelling and the quality of shelter it provides (48), the divergence of the survival and stability of causative agent in the air, a decreased host immunity as well as behavioural changes of individuals (41). Informal settlements within urban areas were singled out as particularly vulnerable to climate change due to the "self-built substandard houses" and the lack of access to public services (48). Results found by Mourtzoukou (25) also

showed that mortality from respiratory diseases showed a significant association ($P < 0.05$) with several personal cold exposure factors: people who lived in cooler homes, wore fewer clothes, were less active outdoors, and generally took fewer protective measures against cold were more likely to die from respiratory disease.

The present study aimed to examine the association between health and climatic factors in Windhoek's informal settlements. The association between temperature, humidity, and rainfall with respiratory diseases was established.

5.2.1 Effects of climatic factors on gender

The findings of the study show that females accounted for a higher percentage of respiratory disease than males within the study period. The study could not isolate all other environmental and occupational factors known to contribute to respiratory diseases to ascertain that the observed results are only as a result of climatic factors. Omonijo (9) reported that environmental and occupational factors contribute to a higher percentage of respiratory diseases among men more than women do. This can be explained by a higher percentage of men working mainly in the mining and fishing sectors, two sectors where air pollution is known to be high.

At a household level, Pinkerton *et al.*, (42) explain that health disparity can be attributed to the different roles played in the households and within the society. Women and children have the highest exposure to household air pollution due to their domestic roles, especially their involvement in cooking. Air pollution coupled with very cold or very warm days causes breathing problems, which could explain the high prevalence of respiratory disease in women than men. A study conducted in Secunda, South Africa, found that there was a significant increase in hospital admissions with increasing air pollution on warm days (51). Olutola (51) confirms that children aged

0-14 years and women were particularly at risk to be admitted to hospital on warm days.

5.2.2 Effects of climatic factors on different age groups

Low temperatures are associated with increased morbidity, especially in the vulnerable population groups, namely the children and the elderly (25).

Rudan (52) states that Pneumonia is a major health problem worldwide and is one of the primary causes of death in children under five years of age and is closely associated with climate in its development.

Our study found that the highest number of respiratory diseases occurred in the age group greater than 18 years with a percentage of 45% followed by the age group less than 5 years with 38%. This concurs with results observed by Omonitjo (9).

Generally, Children have weaker immune systems making them more susceptible to pathogens causing respiratory diseases. According to Garenne in Sverdlik (3), profound risks to children often stem from informal settlements' inadequate sanitation, water and housing, minimal access to health care, and they may be linked to "...a high prevalence of extreme poverty, insecurity, and violence." This could explain the findings of our study as the Namibian informal settlements are challenged with improper sanitation and housing.

Sverdlik (3) also noted that the leading causes of under-five mortality included pneumonia. Although often preventable or easily treated, conditions such as Pneumonia are widespread among most urban children living in informal settlements. Children's vulnerability is also increased as children's lung development proceeds

through the proliferation of pulmonary alveoli and capillaries until the age of 2 years. Children's lungs grow through alveolar expansion until the age of 5-8 years (53), Therefore exposure to smoke dust, pollens, and some other weather variables that trigger the occurrence of respiratory diseases increase their susceptibility to pathogens that the children's immune system cannot withstand. This explains the high occurrence of respiratory diseases (specifically common cold, nose and throat diseases, and Pneumonia) in children under 5 years in the study.

5.2.3 Association between temperature and respiratory disease

The results of this study show an association between low temperature and respiratory diseases. This is consistent with several studies that show that exposure to cold temperatures has been associated with increased incidences and severity of respiratory tract infections (9, 25, 35, 54, 69). The number of common cold cases reported were highest during the winter months. Common cold is mainly caused by viruses. It is understood that viruses, such as Rhinovirus and influenza virus, that cause common cold thrive well in chilly temperatures (54) when the human immune system is at its weakness. According to Makinen et al., (35) cold temperature and low humidity favour the spread of the influenza virus. Thus suggesting that cold temperatures and lower humidity are contributing factors to respiratory tract infection. This is mainly because the viruses causing common cold, especially influenza, are found to be more stable in cold and dry periods. Lowen and Steel (54) attempted to explain this phenomenon indicating, "Influenza virus was consistently found to be stable at low relative humidity and relatively unstable at an intermediate relative humidity (50%)". During our study period, the relative humidity decreases over the winter period from an

average of 45% to 27%. This could explain the high occurrence of common cold observed in the study.

Cold weather may increase the incidence of disease by several mechanisms. During the cold season, people tend to spend more time indoors and the resulting indoor population density can promote the person-to-person transfer of disease especially in overcrowded homes such as the informal settlements. Cold dry air may also cause drying of the respiratory mucosa. The loss of moisture and heat from the bronchial mucosa may lead to increased disease susceptibility (55).

Common cold, primarily a viral infection, can be accompanied by bacterial infections leading to more severe complications, such as lower respiratory tract infections, including pneumonia. The current study showed that pneumonia had a stronger association with air temperature as compared to humidity and rainfall. It is observed that the cases of pneumonia are higher when the temperature is low. Air temperature is known to cause profound physiologic changes such as an increase in viscosity and cardiac output leading to dehydration and endothelial cell damage (9). The high occurrence of Pneumonia is associated with a minimum temperature range of 5.4 °C - 10.7 °C and a maximum temperature range between 22.2 °C and 25.7 °C. Different countries around the globe have pneumonia occurrences at different air temperatures and this may be due to differences in housing conditions and by the process of acclimatization to the local climate.

In addition to cold weather, Sohn *et al.*, (53), proposed that the temperature change (minimum to maximum) during the seasons could be another factor that is likely to contribute to the prevalence of pneumonia. They propose that less tolerance to this pattern of temperature change can compound the prevalence of pneumonia. The temperature difference between the average maximum and minimum temperatures for the study period is 15.42 °C. The influence of this was not investigated in this study.

The highest occurrence of bronchial asthma was during the winter months of April to July. Although the results of this study confirm reports of a weak association between temperature and asthma prevalence, other elements not investigated in this study are said to influence the prevalence and severity of asthma. These are absolute humidity and wind speed (56), and altitude, land area and geographic area, exposure to aeroallergens of biological origin, air pollution, and social deprivation (57).

The reported cases of Tuberculosis in the study area was 0.11% of the total number of cases. This suggests a low prevalence of tuberculosis in the informal settlement. About 94% of tuberculosis cases were recorded in the elderly category of 18 years and above. The majority of the TB cases were recorded during early winter, however; the statistical analysis of the study did not show any significant correlation between tuberculosis and the climatic factors under study. Some reviews by (58 and 59) showed that there is a link between vitamin D and the occurrence of Tuberculosis. These reviews suggest that vitamin D deficiency coupled with an impaired host defense to *Mycobacterium Tuberculosis* leads to an increased chance of primary TB contraction and that higher altitude with a higher UV-B exposure leads to increased vitamin D,

which might enhance immune response and decrease reactivation of TB. During the winter months, the temperatures are very low and the UV index is lower in winter than in summer. The immune's system ability to fight diseases also varies throughout the year with the level of B-lymphocytes being lower in winter than in summer. These changes in vitamin D and human immunity could explain the higher cases of TB recorded in winter than in summer in the study.

5.2.4 Association between rainfall and respiratory disease

The relationship between rainfall and climatic factor was only established in nose and throat disease. This could be due to changes in barometric pressure and pollen after rain that affect sinus. The barometric pressure in the air changes frequently and without most people noticing it a majority of the time. However, individuals who regularly suffer from sinus headaches and migraines can feel this pressure disproportionately.

During the study period, rainfall was generally low and this could have contributed to its limited influence on the occurrence of the diseases under study. It should however not be concluded that rainfall has no influence on health in the informal settlement. Cann et al (60) recognised an increase in diarrheal disease following heavy rainfall and flooding events (60). Informal settlements located in river valleys and on hillslopes, episodes of heavy rain could be detrimental as shacks could be washed away and water contaminated by runoff (61). It was observed by Hales (62) that during water shortages, people tend to use water bodies for multiple purposes (e.g., for cleaning, bathing, and drinking) “with a consequent increase of the risk of microbial contamination and human exposure to pathogens” (62). The outbreaks of Hepatitis E in informal settlements of Windhoek illustrated that lack of public service (ablution facilities), overcrowding, and lack of access to water facilities and information can

increase the risk of disease outbreaks. Many other researchers such as Babin (55) report of disease increase caused by climatic rainfall changes.

5.2.5 Association between humidity and respiratory disease

The study also revealed that Humidity was only associated with nose and throat disease amongst the respiratory diseases under study. The study results indicate that Nose and throat disease was high amongst the children and the elderly. It is well known that age is one of the risk factors associated with seasonal influenza. Seasonal influenza tends to target children younger than 12 months old and the elderly of 65 years and older. This concurs with the results obtained in the study.

Ambient humidity is important in the transmission of influenza because it can affect the size of the respiratory particle (63). When the air is dry, large drops partially evaporate, creating smaller, lighter drops that are more likely to remain airborne for extended periods. Based on studies of aerosol dynamics, a typical respiratory particle exposed to an ambient relative humidity of 80% can remain airborne for up to 1 h. When the relative humidity is decreased to 20%, the same particle can remain airborne for more than 24 h (63). When considering the combined effects of ambient humidity and temperature on influenza transmission, it appears as though airborne transmission is more sensitive to changes in these variables than contact and droplet modes. As temperature and humidity fluctuate with the seasons in temperate climates, and as influenza epidemics exhibit a distinct seasonality in these areas, it is believed that the airborne route is the dominant mode of transmission in temperate regions (63).

Climate change studies suggest that the impacts of climate change are more profound in disadvantaged communities “exacerbating already difficult living conditions and contributing to poor health outcomes”. Dwellings in informal settlements in Windhoek are generally built from corrugated iron shack (64). Iron as a good conductor of heat and cold is regarded to be inadequate to protect against climate variability, especially extreme heat and cold conditions. Another worrying fact is that many informal settlements in Windhoek are located in river valleys and hillsides (64). Satterthwaite et al. argue that the type of dwellings coupled with unfavourable locations are “vastly inadequate in protecting from current climate variability and future climate change” (48). It is therefore important to ensure proper dwellings are constructed for the less fortunate as to mitigate the harmful effects of climate change. Although the increased incidence in respiratory disease is not fully explained by a simple drop or rise in temperature, humidity, and rainfall, there is enough correlation with temperature and humidity changes that one should be aware of a possible increase following a period of cold weather. Such awareness should be incorporated into surveillance systems and in adaptive mechanisms for vulnerable communities.

6. CHAPTER VI

Conclusion and recommendations

6.1 Conclusion

Based on the findings of this study, it is obvious that some climatic factors, especially maximum and minimum temperatures, have an influence on respiratory diseases. Although not statistically significant as an element, humidity has a role to play. It was evident that the level of humidity combined with temperature determines the severity of respiratory diseases. It is therefore important that, during periods of extreme temperatures, special care be taken to keep warm when outdoors and the heating of dwelling to increase the indoor temperature during the winter period and keeping cool in summer periods. In informal settlements, due care is essential to ensure heating with fuelwood does not cause indoor pollution related diseases.

This study however did not include objective evidence such as virological analysis to support these observations. Some of the above-mentioned mechanisms in the literature and physiological responses may have accounted for the increased occurrences of RTIs in the cold. This needs therefore to be investigated further in another research.

The study also showed the disease patterns of respiratory diseases and illustrated that the majority of respiratory disease occurrences were observed during winter seasons than other seasons. The objectives of this study were met.

How climatic indicators affect the health of informal settlements residents in the study area has been demonstrated. However, to enrich further work in this area of study, it is proposed to include household studies to capture indoor climatic conditions. The proposal is based on the understanding that iron is a good conductor of heat and cold, thus the indoor temperatures might be the same as outdoor temperatures or residents might have mechanisms to regulate the indoor temperature (heating and cooling). Heating and cooling affect air humidity, another element to consider. Complimenting knowledge generated by this study with elements highlighted will give more conclusive evidence of the interaction of climatic conditions and human response to these and health.

As Namibia is developing adaptation and mitigation strategies to climate change, the public health sector can provide vital information on how disease-causing agents (virus and bacteria) could be affected by and behave in changing climatic conditions. Research in this area is essential if the public health sector is to be prepared to deal with changing climatic conditions and potential changes in disease patterns.

How the climate could influence the transmission and outcome of infectious diseases needs to be elucidated for appropriate preparedness of the health system in Namibia and around the world.

There is a need for a better understanding of the underlying mechanisms of human reactions to the changing weather to develop appropriate policies for Namibia with a real impact on the susceptibility of humans to deleterious effects of the phenomenon.

6.2 Recommendations and areas for further research.

It is recommended that measures to prevent or mitigate the occurrence and prevention of respiratory infections be included in the preparation and handling of harmful human health effects of climate change. These measures could include ensuring appropriate shelters for the informal settlers, ensuring that appropriate winter clothing and blankets are provided to the poor and most vulnerable. Education and societal awareness be part of the disaster preparedness strategies.

To the best of my knowledge, this is the first study to investigate association between climate indicators and health in informal settlements in Windhoek. As Namibia is regarded to be at high risk of climate change, the impacts of changing climatic indicators on health must be closely monitored in informal settlement to advise municipalities and local authorities planning of infrastructure development and service delivery, and health officers in managing of diseases and other health interventions.

Further studies focusing on the effects of climatic indicators and health should do a comparative analysis in both informal and formal settlements to see if the numbers of cases differ. Additionally, in-depth investigation and/or consideration of the indoor (inside the dwelling) temperature and humidity could provide more clarity.

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Annexes

Annexure A:

1. Statistical analysis of OPD Asthma/Bronchial Spasm

a) Association between OPD Asthma/Bronchial Spasm and maximum temperature

Correlations

		Maximum temperature	OPD Asthma/Bronchial Spasm
Maximum temperature	Pearson Correlation	1	-.332**
	Sig. (2-tailed)		.010
	N	60	60
OPD Asthma/Bronchial Spasm	Pearson Correlation	-.332**	1
	Sig. (2-tailed)	.010	
	N	60	60

** . Correlation is significant at the 0.01 level (2-tailed).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.332 ^a	.110	.095	12.844

a. Predictors: (Constant), Maximum temperature

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1184.246	1	1184.246	7.179	.010 ^b
	Residual	9567.937	58	164.964		
	Total	10752.183	59			

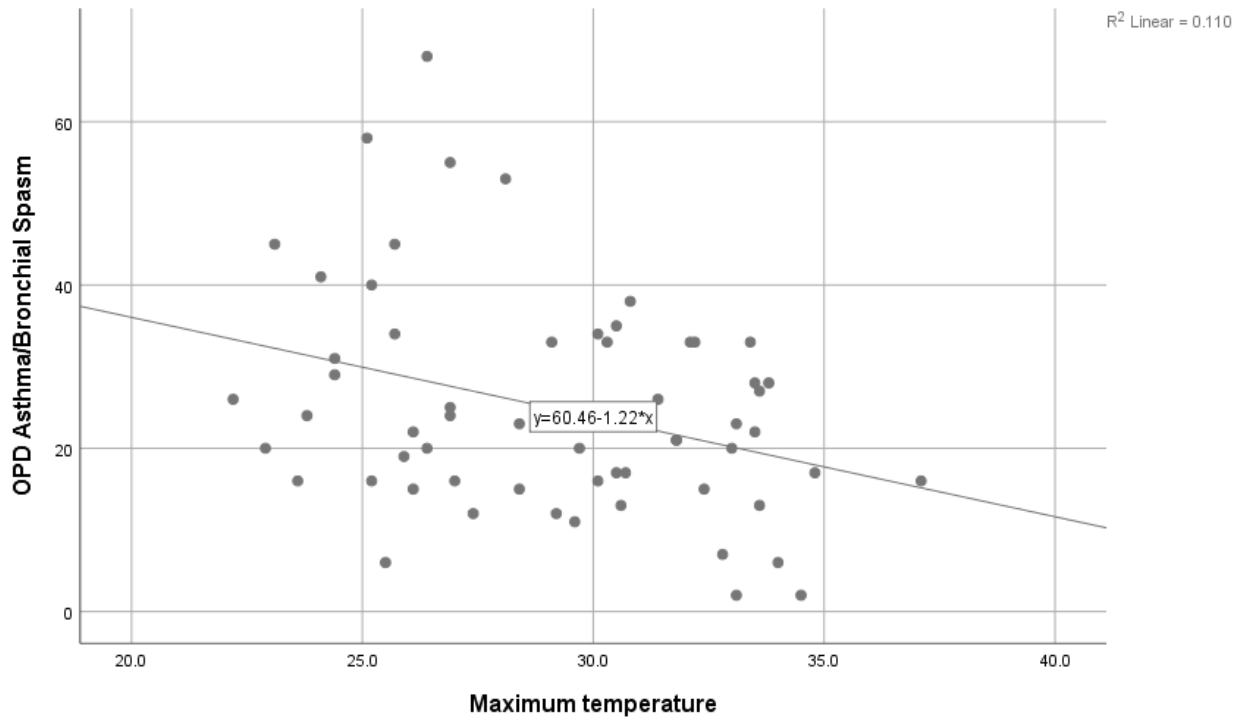
a. Dependent Variable: OPD Asthma/Bronchial Spasm

b. Predictors: (Constant), Maximum temperature

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	60.459	13.381		4.518	.000	33.674	87.243
	Maximum temperature	-1.221	.456	-.332	-2.679	.010	-2.133	-.309

a. Dependent Variable: OPD Asthma/Bronchial Spasm



b) Association between OPD Asthma/Bronchial Spasm and minimum temperature

Correlations

		Minimum temperature	OPD Asthma/Bronchial Spasm
Minimum temperature	Pearson Correlation	1	-.373**
	Sig. (2-tailed)		.003
	N	60	60
OPD Asthma/Bronchial Spasm	Pearson Correlation	-.373**	1
	Sig. (2-tailed)	.003	
	N	60	60

** . Correlation is significant at the 0.01 level (2-tailed).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.373 ^a	.139	.124	12.633

a. Predictors: (Constant), Minimum temperature

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1495.991	1	1495.991	9.374	.003 ^b
	Residual	9256.192	58	159.590		
	Total	10752.183	59			

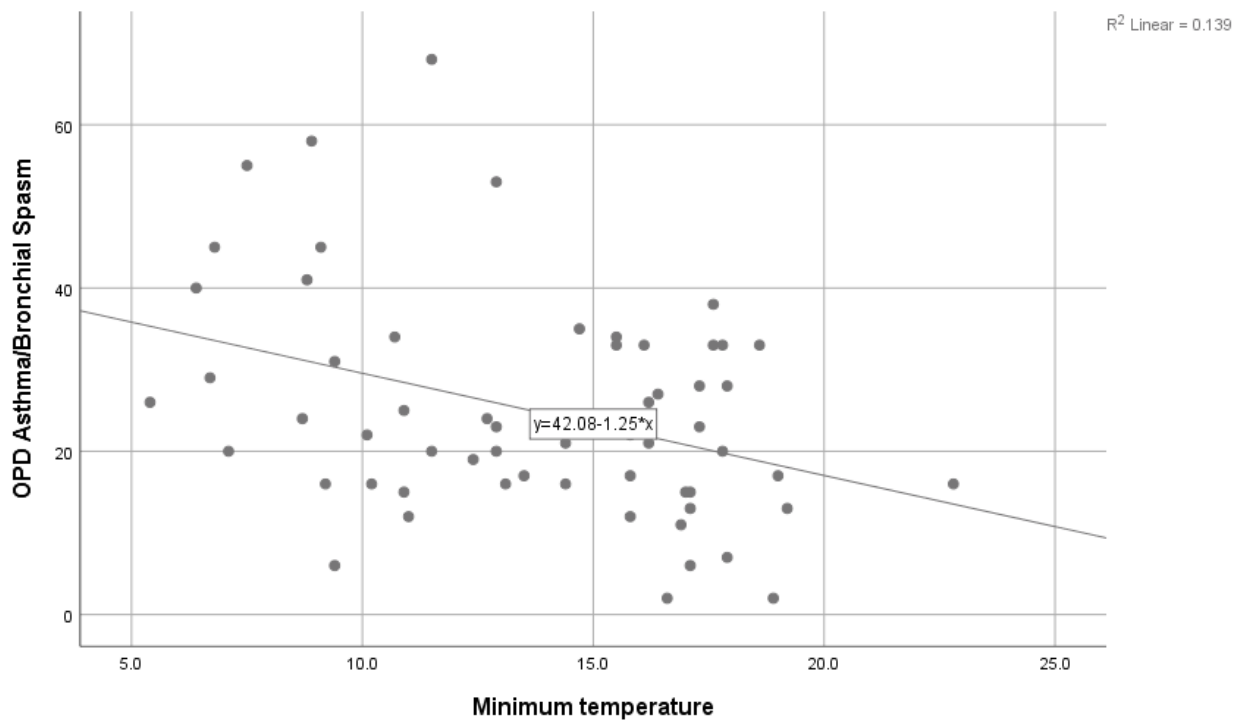
a. Dependent Variable: OPD Asthma/Bronchial Spasm

b. Predictors: (Constant), Minimum temperature

Coefficients

Model		Unstandardized Coefficients		Standardized	t	Sig.	95.0% Confidence Interval	
		B	Std. Error	Coefficients			for B	Lower Bound
1	(Constant)	42.081	5.849		7.194	.000	30.373	53.790
	Minimum temperature	-1.252	.409	-.373	-3.062	.003	-2.071	-.433

a. Dependent Variable: OPD Asthma/Bronchial Spasm



c) Association between OPD Asthma/Bronchial Spasm and humidity

Correlations

		Humidity	OPD Asthma/Bronchial Spasm
Humidity	Pearson Correlation	1	.039
	Sig. (2-tailed)		.769
	N	60	60
OPD Asthma/Bronchial Spasm	Pearson Correlation	.039	1
	Sig. (2-tailed)	.769	
	N	60	60

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.039 ^a	.002	-.016	13.605

a. Predictors: (Constant), Humidity

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.174	1	16.174	.087	.769 ^b
	Residual	10736.009	58	185.104		
	Total	10752.183	59			

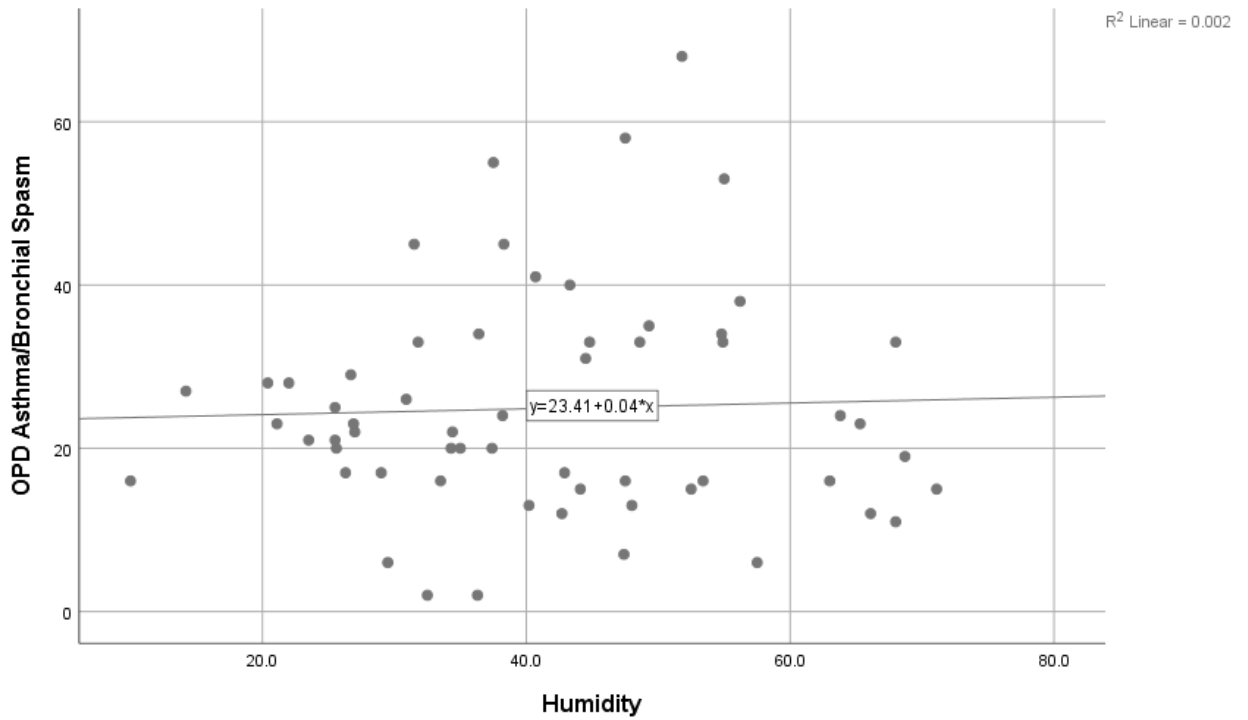
a. Dependent Variable: OPD Asthma/Bronchial Spasm

b. Predictors: (Constant), Humidity

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	23.409	5.288		4.427	.000	12.824	33.994
	Humidity	.036	.120	.039	.296	.769	-.205	.277

a. Dependent Variable: OPD Asthma/Bronchial Spasm



d) Association between OPD Asthma/Bronchial Spasm and rainfall

Correlations

		Rainfall	OPD Asthma/Bronchial Spasm
Rainfall	Pearson Correlation	1	-.045
	Sig. (2-tailed)		.776
	N	42	42
OPD Asthma/Bronchial Spasm	Pearson Correlation	-.045	1
	Sig. (2-tailed)	.776	
	N	42	60

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.045 ^a	.002	-.023	12.716

a. Predictors: (Constant), Rainfall

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13.261	1	13.261	.082	.776 ^b
	Residual	6468.072	40	161.702		
	Total	6481.333	41			

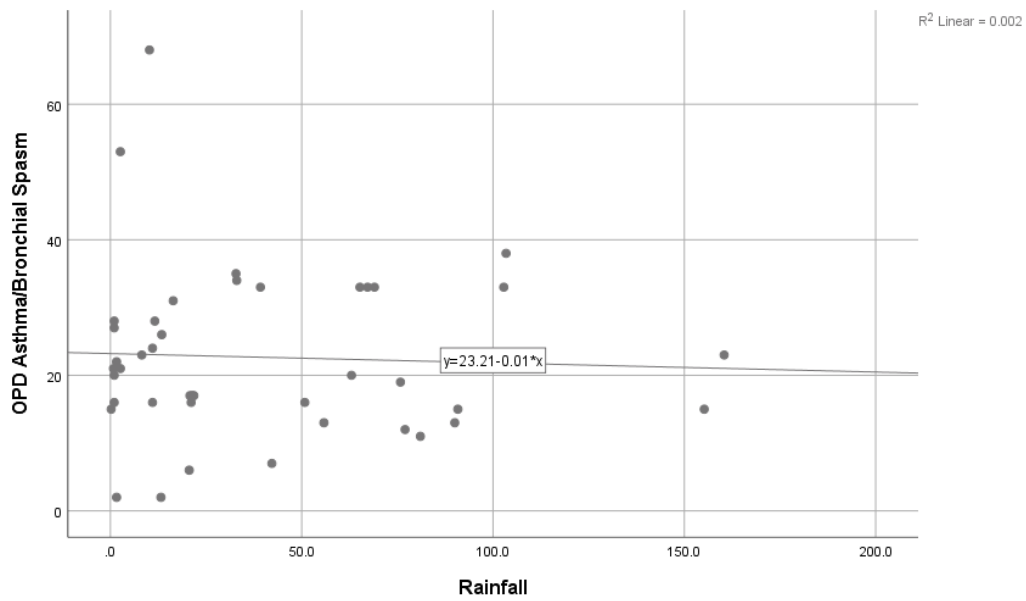
a. Dependent Variable: OPD Asthma/Bronchial Spasm

b. Predictors: (Constant), Rainfall

Coefficients

Model		Unstandardized Coefficients		Standardized	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Coefficients Beta			Lower Bound	Upper Bound
1	(Constant)	23.208	2.724		8.519	.000	17.702	28.714
	Rainfall	-.014	.048	-.045	-.286	.776	-.110	.083

a. Dependent Variable: OPD Asthma/Bronchial Spasm



2. Statistical analysis of OPD Common Cold

a) Association between OPD Common Cold and maximum temperature

Correlations

		Maximum temperature	OPD Common Cold
Maximum temperature	Pearson Correlation	1	-.563**
	Sig. (2-tailed)		.000
	N	60	60
OPD Common Cold	Pearson Correlation	-.563**	1
	Sig. (2-tailed)	.000	
	N	60	60

** . Correlation is significant at the 0.01 level (2-tailed).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.563 ^a	.317	.306	367.931

a. Predictors: (Constant), Maximum temperature

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3651713.669	1	3651713.669	26.975	.000 ^b
	Residual	7851663.981	58	135373.517		
	Total	11503377.650	59			

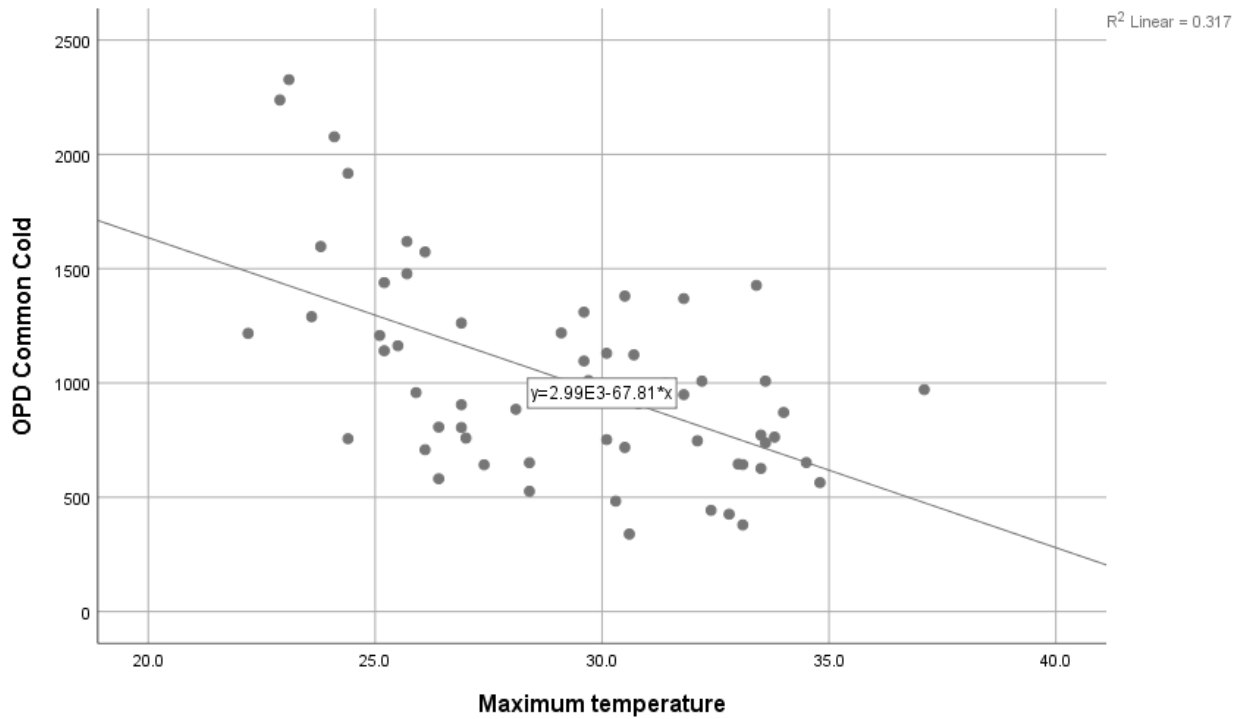
a. Dependent Variable: OPD Common Cold

b. Predictors: (Constant), Maximum temperature

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	2991.652	383.315		7.805	.000	2224.363	3758.941
	Maximum temperature	-67.805	13.055	-.563	-5.194	.000	-93.938	-41.672

a. Dependent Variable: OPD Common Cold



b) Association between OPD Common Cold and minimum temperature

Correlations

		Minimum temperature	OPD Common Cold
Minimum temperature	Pearson Correlation	1	-.573**
	Sig. (2-tailed)		.000
	N	60	60
OPD Common Cold	Pearson Correlation	-.573**	1
	Sig. (2-tailed)	.000	
	N	60	60

** . Correlation is significant at the 0.01 level (2-tailed).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.573 ^a	.328	.316	365.105

a. Predictors: (Constant), Minimum temperature

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3771882.732	1	3771882.732	28.296	.000 ^b
	Residual	7731494.918	58	133301.637		
	Total	11503377.650	59			

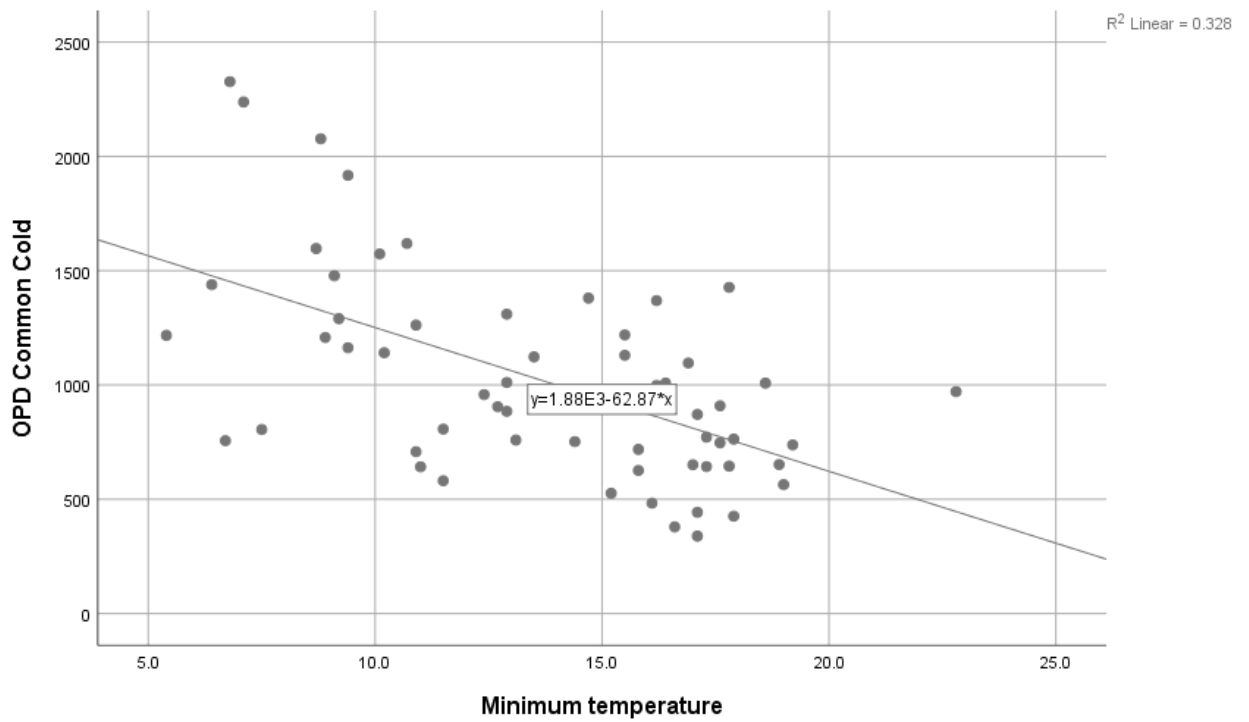
a. Dependent Variable: OPD Common Cold

b. Predictors: (Constant), Minimum temperature

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1879.712	169.047		11.119	.000	1541.328	2218.095
	Minimum temperature	-62.873	11.820	-.573	-5.319	.000	-86.533	-39.214

a. Dependent Variable: OPD Common Cold



c) Association between OPD Common Cold and humidity

Correlations

		Humidity	OPD Common Cold
Humidity	Pearson Correlation	1	-.136
	Sig. (2-tailed)		.299
	N	60	60
OPD Common Cold	Pearson Correlation	-.136	1
	Sig. (2-tailed)	.299	
	N	60	60

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.136 ^a	.019	.002	441.190

a. Predictors: (Constant), Humidity

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	213735.913	1	213735.913	1.098	.299 ^b
	Residual	11289641.737	58	194648.995		
	Total	11503377.650	59			

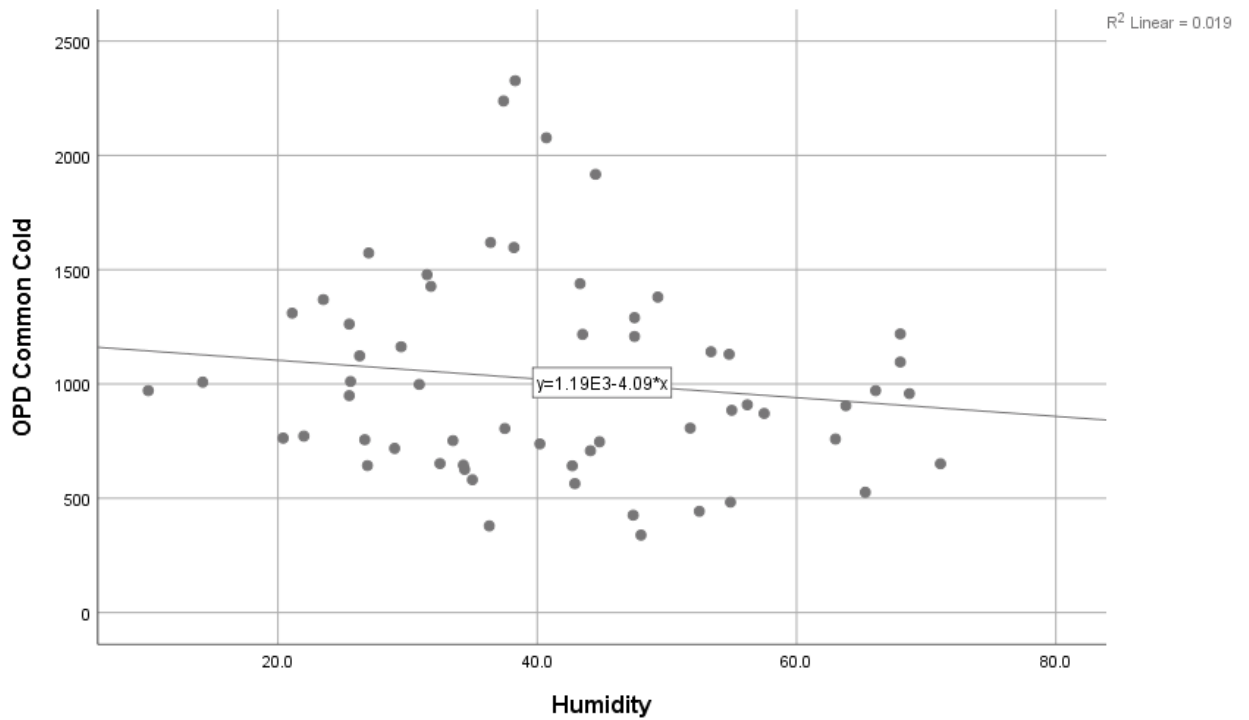
a. Dependent Variable: OPD Common Cold

b. Predictors: (Constant), Humidity

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1185.643	171.484		6.914	.000	842.381	1528.905
	Humidity	-4.090	3.903	-.136	-1.048	.299	-11.904	3.723

a. Dependent Variable: OPD Common Cold



d) Association between OPD Common Cold and rainfall

Correlations

		Rainfall	OPD Common Cold
Rainfall	Pearson Correlation	1	-.256
	Sig. (2-tailed)		.101
	N	42	42
OPD Common Cold	Pearson Correlation	-.256	1
	Sig. (2-tailed)	.101	
	N	42	60

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.256 ^a	.066	.042	307.921

a. Predictors: (Constant), Rainfall

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	266608.319	1	266608.319	2.812	.101 ^b
	Residual	3792623.324	40	94815.583		
	Total	4059231.643	41			

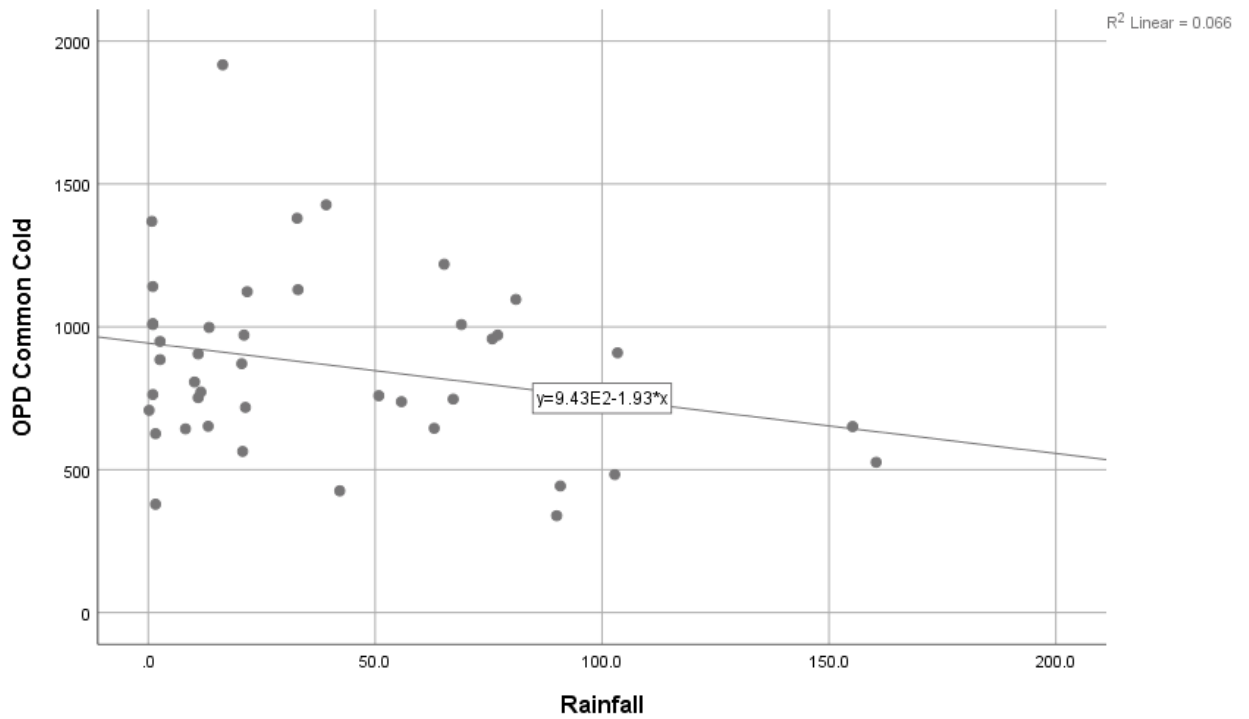
a. Dependent Variable: OPD Common Cold

b. Predictors: (Constant), Rainfall

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	943.100	65.970		14.296	.000	809.770	1076.430
	Rainfall	-1.932	1.152	-.256	-1.677	.101	-4.260	.396

a. Dependent Variable: OPD Common Cold



3. Statistical analysis of OPD Nose/Throat disease

a) Association between OPD Nose/Throat Disease/Disorder and maximum temperature

Correlations

		Maximum temperature	OPD Nose/Throat Disease/Disorder
Maximum temperature	Pearson Correlation	1	-.442**
	Sig. (2-tailed)		.000
	N	60	60
OPD Nose/Throat Disease/Disorder	Pearson Correlation	-.442**	1
	Sig. (2-tailed)	.000	
	N	60	60

** . Correlation is significant at the 0.01 level (2-tailed).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.442 ^a	.195	.181	377.429

a. Predictors: (Constant), Maximum temperature

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2005368.759	1	2005368.759	14.077	.000 ^b
	Residual	8262256.224	58	142452.694		
	Total	10267624.983	59			

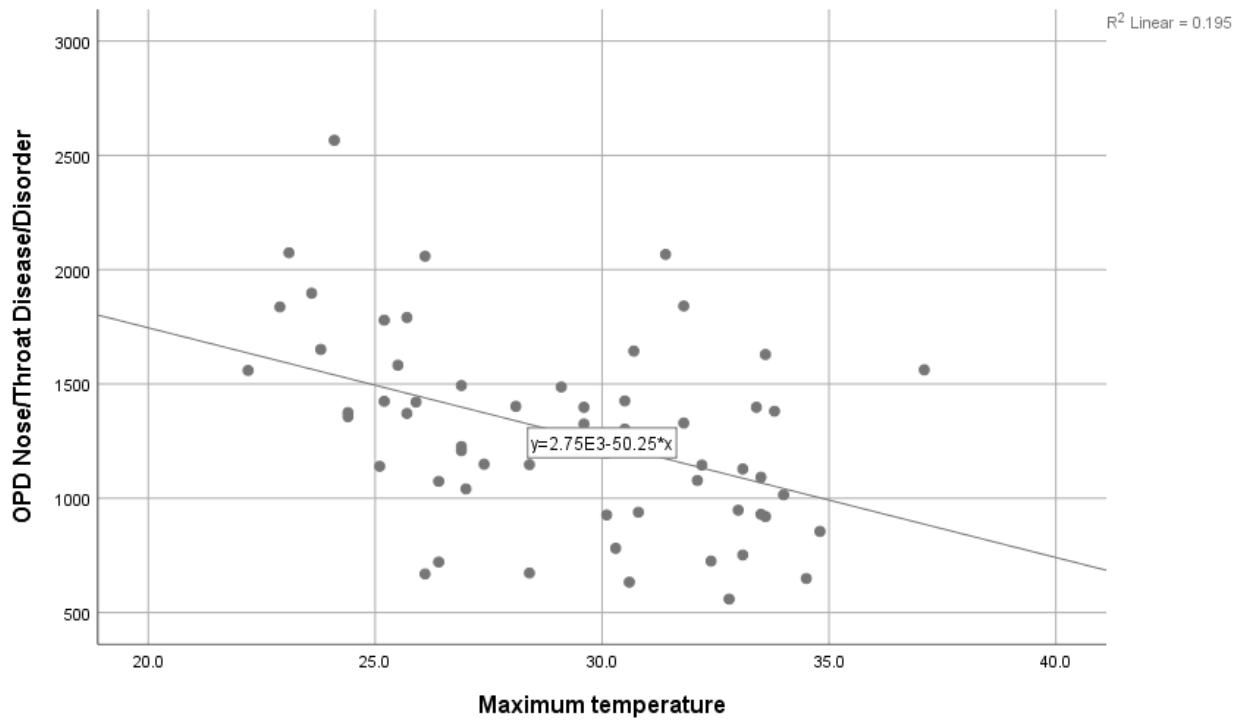
a. Dependent Variable: OPD Nose/Throat Disease/Disorder

b. Predictors: (Constant), Maximum temperature

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	2750.767	393.210		6.996	.000	1963.671	3537.863
	Maximum temperature	-50.247	13.392	-.442	-3.752	.000	-77.054	-23.440

a. Dependent Variable: OPD Nose/Throat Disease/Disorder



b) Association between OPD Nose/Throat Disease/Disorder and minimum temperature

Correlations

		Minimum temperature	OPD Nose/Throat Disease/Disorder
Minimum temperature	Pearson Correlation	1	-.491**
	Sig. (2-tailed)		.000
	N	60	60
OPD Nose/Throat Disease/Disorder	Pearson Correlation	-.491**	1
	Sig. (2-tailed)	.000	
	N	60	60

** . Correlation is significant at the 0.01 level (2-tailed).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.491 ^a	.241	.228	366.442

a. Predictors: (Constant), Minimum temperature

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2479397.641	1	2479397.641	18.464	.000 ^b
	Residual	7788227.342	58	134279.782		
	Total	10267624.983	59			

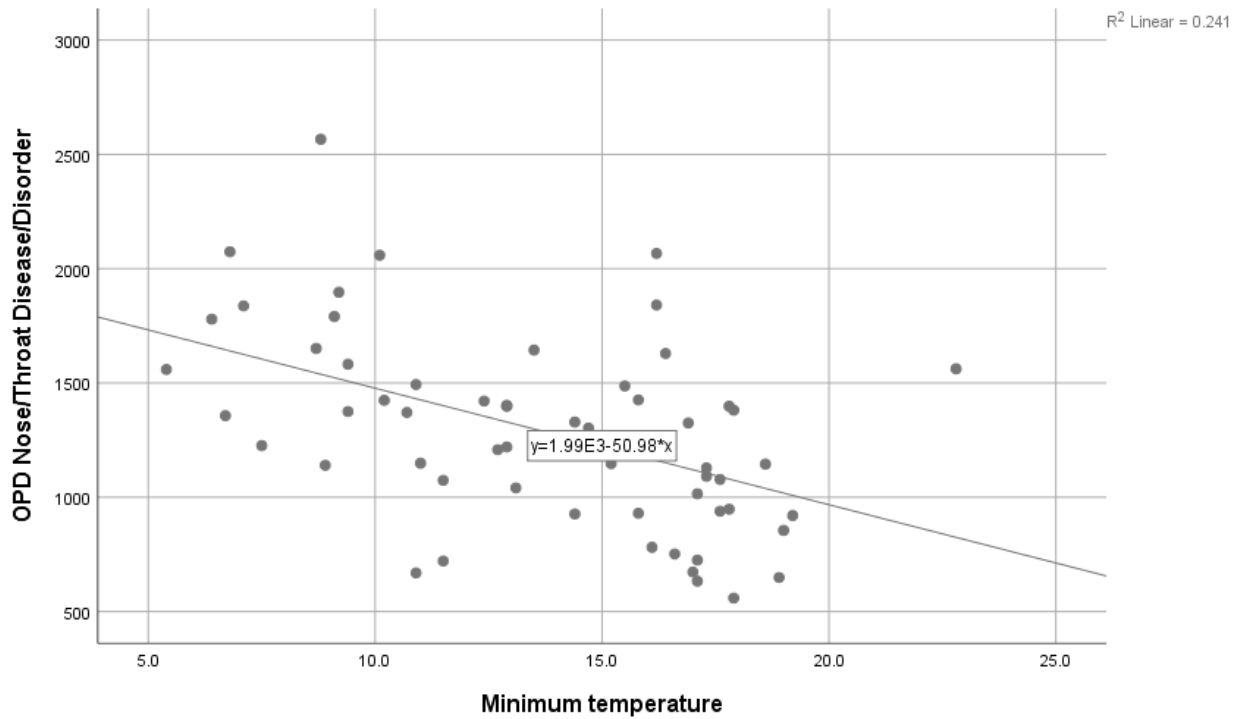
a. Dependent Variable: OPD Nose/Throat Disease/Disorder

b. Predictors: (Constant), Minimum temperature

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1986.961	169.666		11.711	.000	1647.338	2326.584
	Minimum temperature	-50.975	11.863	-.491	-4.297	.000	-74.721	-27.229

a. Dependent Variable: OPD Nose/Throat Disease/Disorder



c) Association between OPD Nose/Throat Disease/Disorder and Humidity

Correlations

		Humidity	OPD Nose/Throat Disease/Disorder
Humidity	Pearson Correlation	1	-.285*
	Sig. (2-tailed)		.027
	N	60	60
OPD Nose/Throat Disease/Disorder	Pearson Correlation	-.285*	1
	Sig. (2-tailed)	.027	
	N	60	60

*. Correlation is significant at the 0.05 level (2-tailed).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.285 ^a	.081	.066	403.240

a. Predictors: (Constant), Humidity

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	836688.188	1	836688.188	5.146	.027 ^b
	Residual	9430936.796	58	162602.359		
	Total	10267624.983	59			

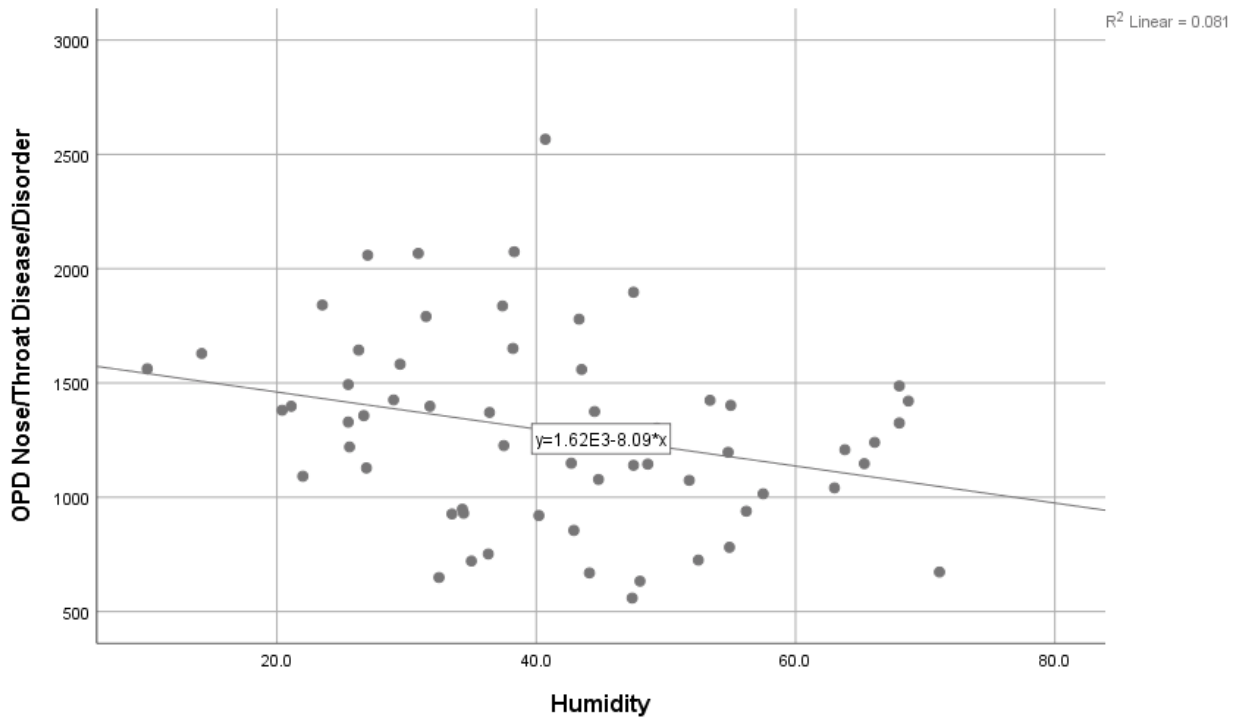
a. Dependent Variable: OPD Nose/Throat Disease/Disorder

b. Predictors: (Constant), Humidity

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1622.164	156.733		10.350	.000	1308.429	1935.899
	Humidity	-8.093	3.568	-.285	-2.268	.027	-15.234	-.951

a. Dependent Variable: OPD Nose/Throat Disease/Disorder



d) Association between OPD Nose/Throat Disease/Disorder and rainfall

Correlations

		Rainfall	OPD Nose/Throat Disease/Disorder
Rainfall	Pearson Correlation	1	-.319*
	Sig. (2-tailed)		.039
	N	42	42
OPD Nose/Throat Disease/Disorder	Pearson Correlation	-.319*	1
	Sig. (2-tailed)	.039	
	N	42	60

*. Correlation is significant at the 0.05 level (2-tailed).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.319 ^a	.102	.079	328.355

a. Predictors: (Constant), Rainfall

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	489190.982	1	489190.982	4.537	.039 ^b
	Residual	4312684.851	40	107817.121		
	Total	4801875.833	41			

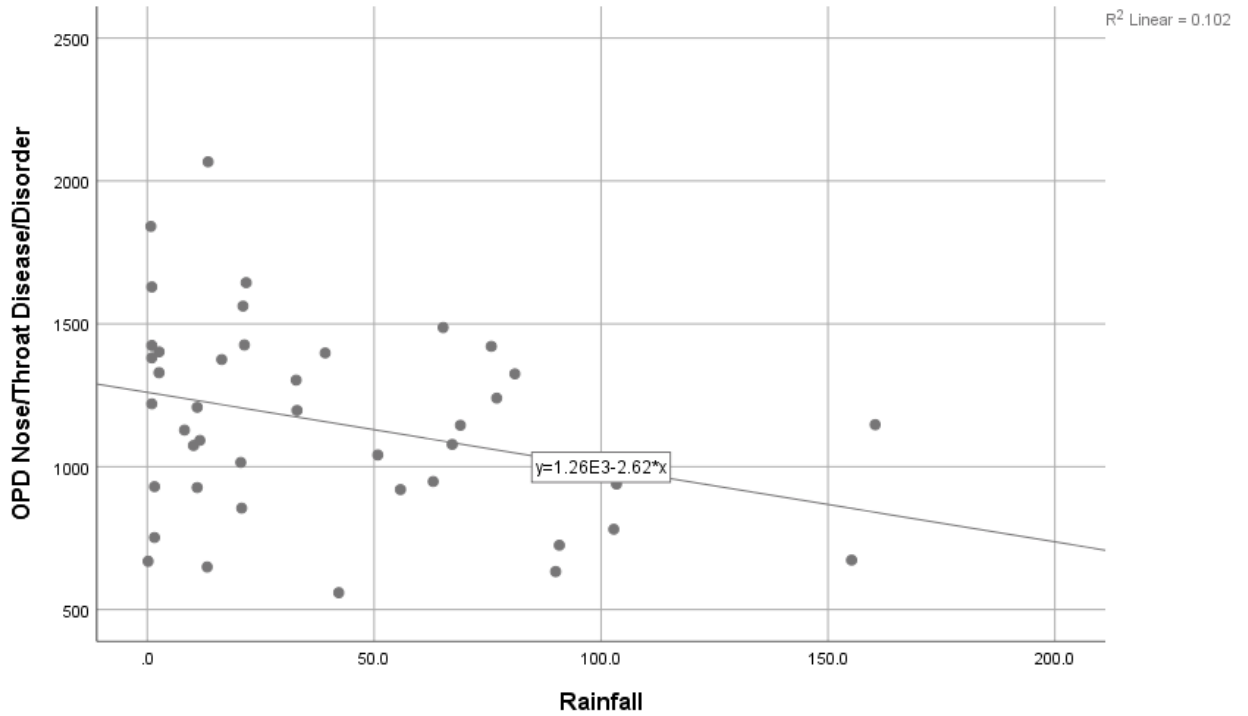
a. Dependent Variable: OPD Nose/Throat Disease/Disorder

b. Predictors: (Constant), Rainfall

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1260.121	70.348		17.913	.000	1117.943	1402.299
	Rainfall	-2.616	1.228	-.319	-2.130	.039	-5.099	-.134

a. Dependent Variable: OPD Nose/Throat Disease/Disorder



4. Statistical analysis of OPD other respiratory disease

a) Association between OPD Other Respiratory System Disease and maximum temperature

Correlations

		Maximum temperature	OPD Other Respiratory System Disease
Maximum temperature	Pearson Correlation	1	-.478**
	Sig. (2-tailed)		.000
	N	60	60
OPD Other Respiratory System Disease	Pearson Correlation	-.478**	1
	Sig. (2-tailed)	.000	
	N	60	60

** . Correlation is significant at the 0.01 level (2-tailed).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.478 ^a	.229	.215	351.114

a. Predictors: (Constant), Maximum temperature

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2120777.239	1	2120777.239	17.203	.000 ^b
	Residual	7150313.161	58	123281.261		
	Total	9271090.400	59			

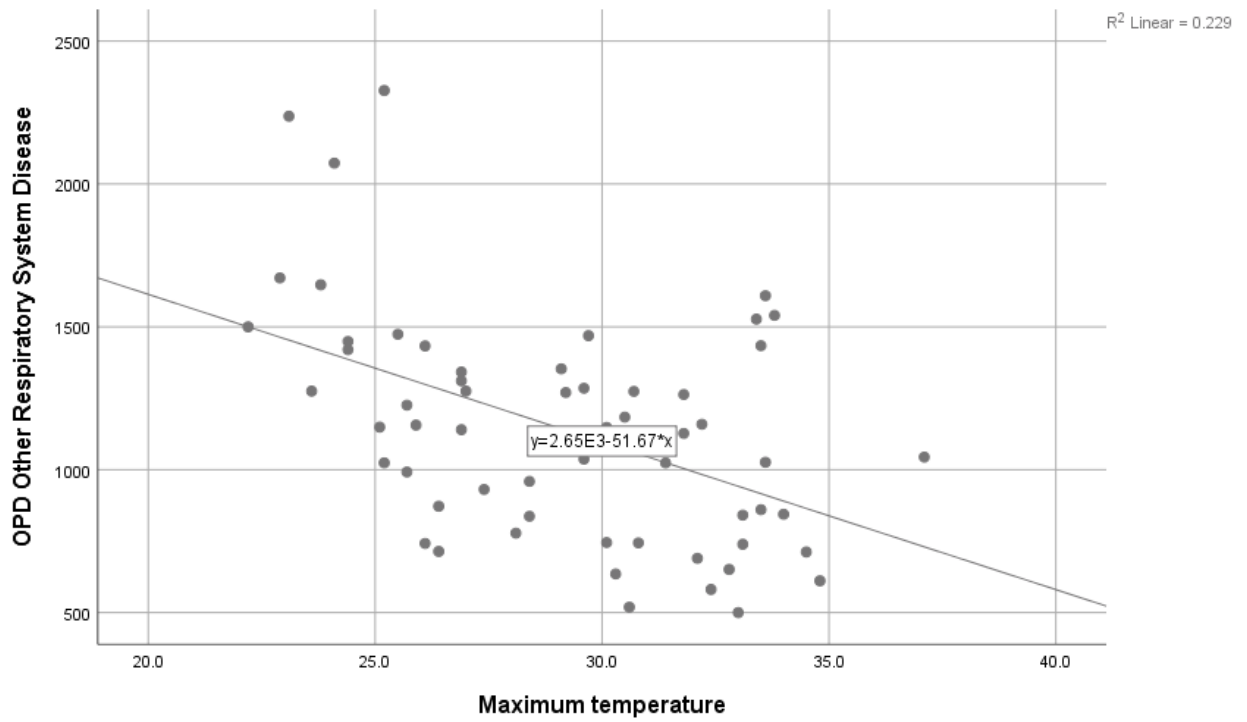
a. Dependent Variable: OPD Other Respiratory System Disease

b. Predictors: (Constant), Maximum temperature

Coefficients^a

Model		Unstandardized Coefficients		Standardized	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	2647.086	365.795		7.237	.000	1914.867	3379.305
	Maximum temperature	-51.673	12.458	-.478	-4.148	.000	-76.611	-26.735

a. Dependent Variable: OPD Other Respiratory System Disease



b) Association between OPD Other Respiratory System Disease and minimum temperature

Correlations

		Minimum temperature	OPD Other Respiratory System Disease
Minimum temperature	Pearson Correlation	1	-.568**
	Sig. (2-tailed)		.000
	N	60	60
OPD Other Respiratory System Disease	Pearson Correlation	-.568**	1
	Sig. (2-tailed)	.000	
	N	60	60

** . Correlation is significant at the 0.01 level (2-tailed).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.568 ^a	.323	.311	329.018

a. Predictors: (Constant), Minimum temperature

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2992440.418	1	2992440.418	27.643	.000 ^b
	Residual	6278649.982	58	108252.586		
	Total	9271090.400	59			

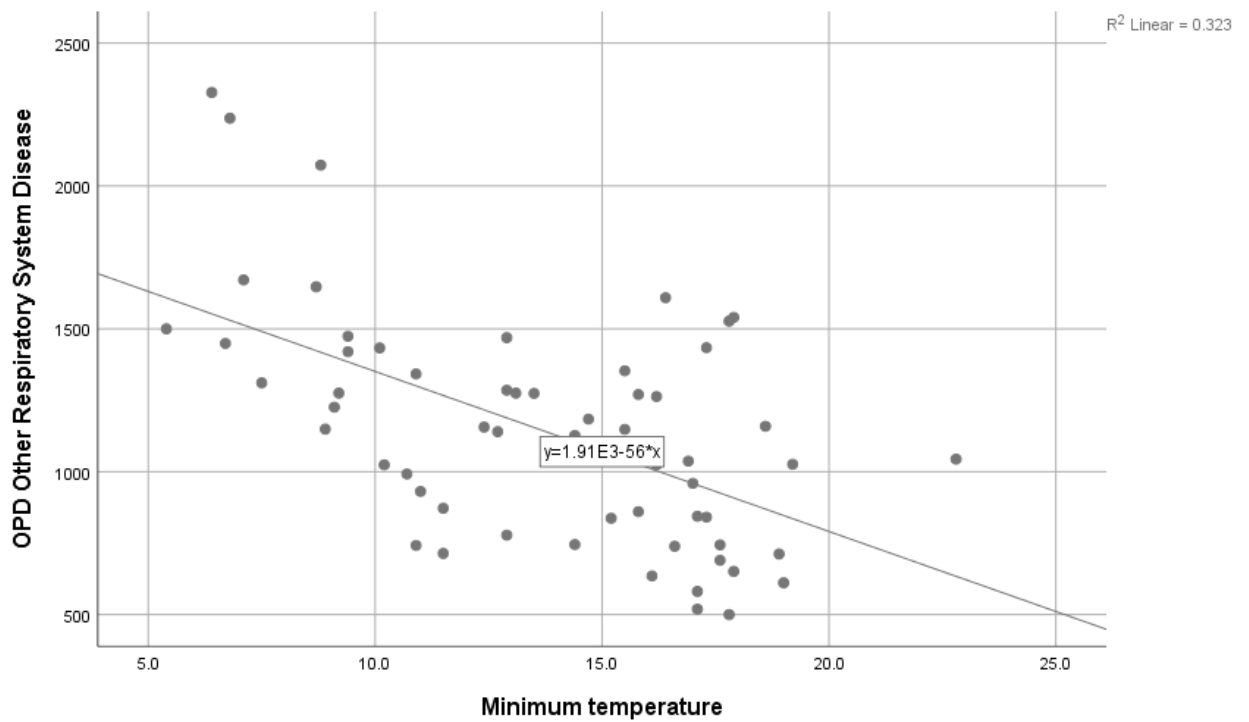
a. Dependent Variable: OPD Other Respiratory System Disease

b. Predictors: (Constant), Minimum temperature

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1910.778	152.338		12.543	.000	1605.841	2215.716
	Minimum temperature	-56.001	10.651	-.568	-5.258	.000	-77.322	-34.680

a. Dependent Variable: OPD Other Respiratory System Disease



c) Association between OPD Other Respiratory System Disease and humidity

Correlations

		Humidity	OPD Other Respiratory System Disease
Humidity	Pearson Correlation	1	-.236
	Sig. (2-tailed)		.070
	N	60	60
OPD Other Respiratory System Disease	Pearson Correlation	-.236	1
	Sig. (2-tailed)	.070	
	N	60	60

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.236 ^a	.055	.039	388.561

a. Predictors: (Constant), Humidity

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	514254.180	1	514254.180	3.406	.070 ^b
	Residual	8756836.220	58	150979.935		
	Total	9271090.400	59			

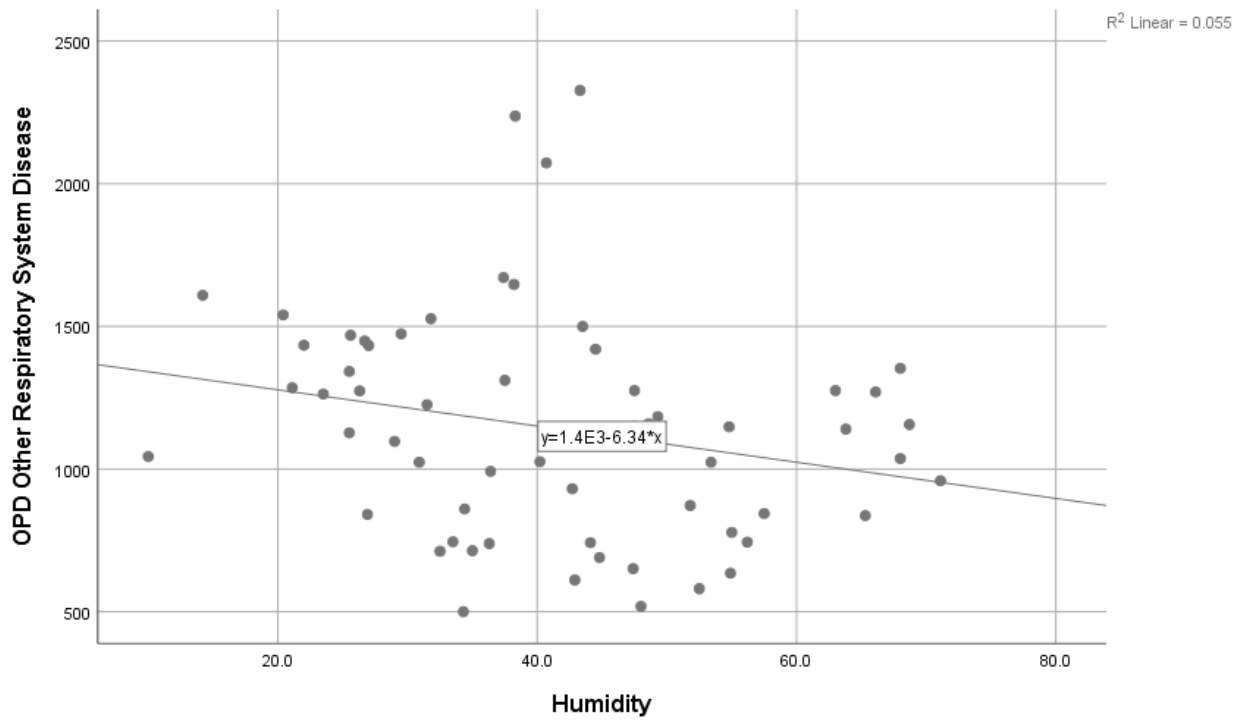
a. Dependent Variable: OPD Other Respiratory System Disease

b. Predictors: (Constant), Humidity

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1404.507	151.028		9.300	.000	1102.193	1706.822
	Humidity	-6.345	3.438	-.236	-1.846	.070	-13.226	.537

a. Dependent Variable: OPD Other Respiratory System Disease



d) Association between OPD Other Respiratory System Disease and rainfall

Correlations

		Rainfall	OPD Other Respiratory System Disease
Rainfall	Pearson Correlation	1	-.277
	Sig. (2-tailed)		.076
	N	42	42
OPD Other Respiratory System Disease	Pearson Correlation	-.277	1
	Sig. (2-tailed)	.076	
	N	42	60

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.277 ^a	.076	.053	294.778

a. Predictors: (Constant), Rainfall

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	287858.724	1	287858.724	3.313	.076 ^b
	Residual	3475751.181	40	86893.780		
	Total	3763609.905	41			

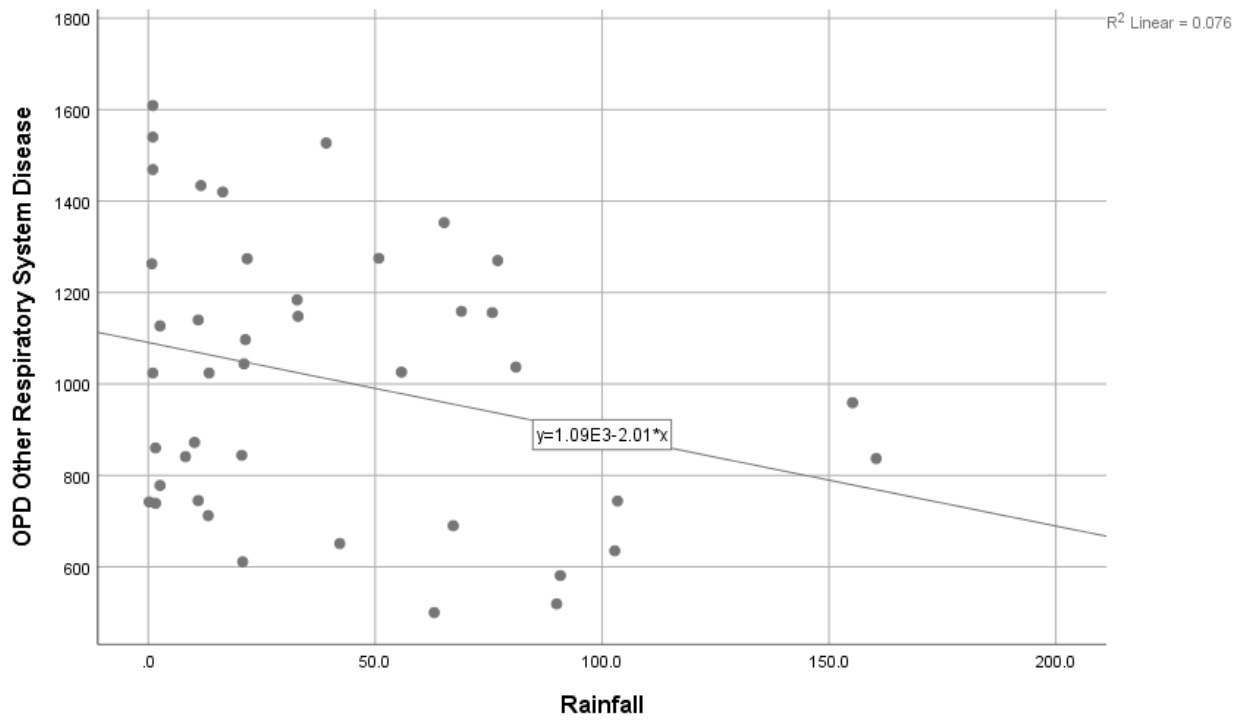
a. Dependent Variable: OPD Other Respiratory System Disease

b. Predictors: (Constant), Rainfall

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1090.695	63.154		17.270	.000	963.056	1218.334
	Rainfall	-2.007	1.103	-.277	-1.820	.076	-4.236	.222

a. Dependent Variable: OPD Other Respiratory System Disease



5. Statistical analysis for OPD Pneumonia

a) Association between OPD Pneumonia and maximum temperature

Correlations

		Maximum temperature	OPD Pneumonia
Maximum temperature	Pearson Correlation	1	-.444**
	Sig. (2-tailed)		.000
	N	60	60
OPD Pneumonia	Pearson Correlation	-.444**	1
	Sig. (2-tailed)	.000	
	N	60	60

** . Correlation is significant at the 0.01 level (2-tailed).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.444 ^a	.197	.184	29.935

a. Predictors: (Constant), Maximum temperature

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12788.462	1	12788.462	14.271	.000 ^b
	Residual	51973.722	58	896.099		
	Total	64762.183	59			

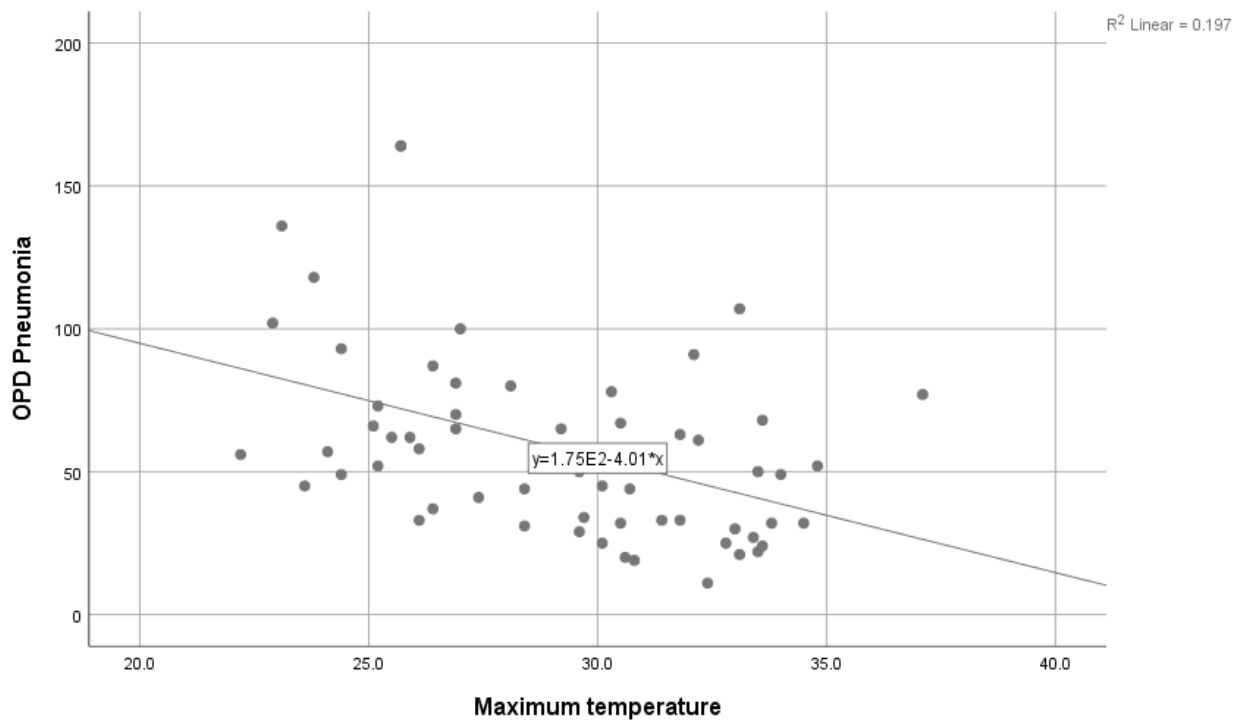
a. Dependent Variable: OPD Pneumonia

b. Predictors: (Constant), Maximum temperature

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	175.190	31.187		5.617	.000	112.763	237.616
	Maximum temperature	-4.013	1.062	-.444	-3.778	.000	-6.139	-1.886

a. Dependent Variable: OPD Pneumonia



b) Association between OPD Pneumonia and minimum temperature

Correlations

		Minimum temperature	OPD Pneumonia
Minimum temperature	Pearson Correlation	1	-.443**
	Sig. (2-tailed)		.000
	N	60	60
OPD Pneumonia	Pearson Correlation	-.443**	1
	Sig. (2-tailed)	.000	
	N	60	60

** . Correlation is significant at the 0.01 level (2-tailed).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.443 ^a	.196	.182	29.959

a. Predictors: (Constant), Minimum temperature

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12703.628	1	12703.628	14.153	.000 ^b
	Residual	52058.555	58	897.561		
	Total	64762.183	59			

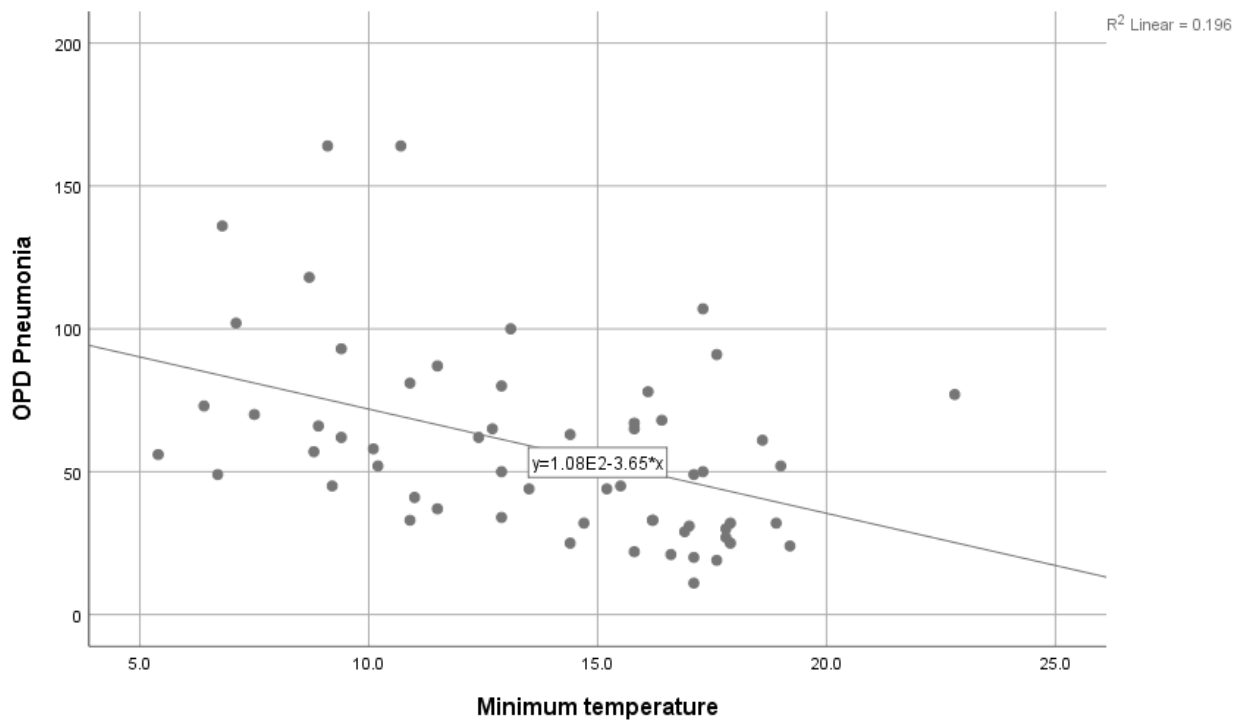
a. Dependent Variable: OPD Pneumonia

b. Predictors: (Constant), Minimum temperature

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	108.400	13.871		7.815	.000	80.633	136.166
	Minimum temperature	-3.649	.970	-.443	-3.762	.000	-5.590	-1.707

a. Dependent Variable: OPD Pneumonia



c) Association between OPD Pneumonia and humidity

Correlations

		Humidity	OPD Pneumonia
Humidity	Pearson Correlation	1	-.109
	Sig. (2-tailed)		.407
	N	60	60
OPD Pneumonia	Pearson Correlation	-.109	1
	Sig. (2-tailed)	.407	
	N	60	60

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.109 ^a	.012	-.005	33.216

a. Predictors: (Constant), Humidity

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	769.820	1	769.820	.698	.407 ^b
	Residual	63992.363	58	1103.317		
	Total	64762.183	59			

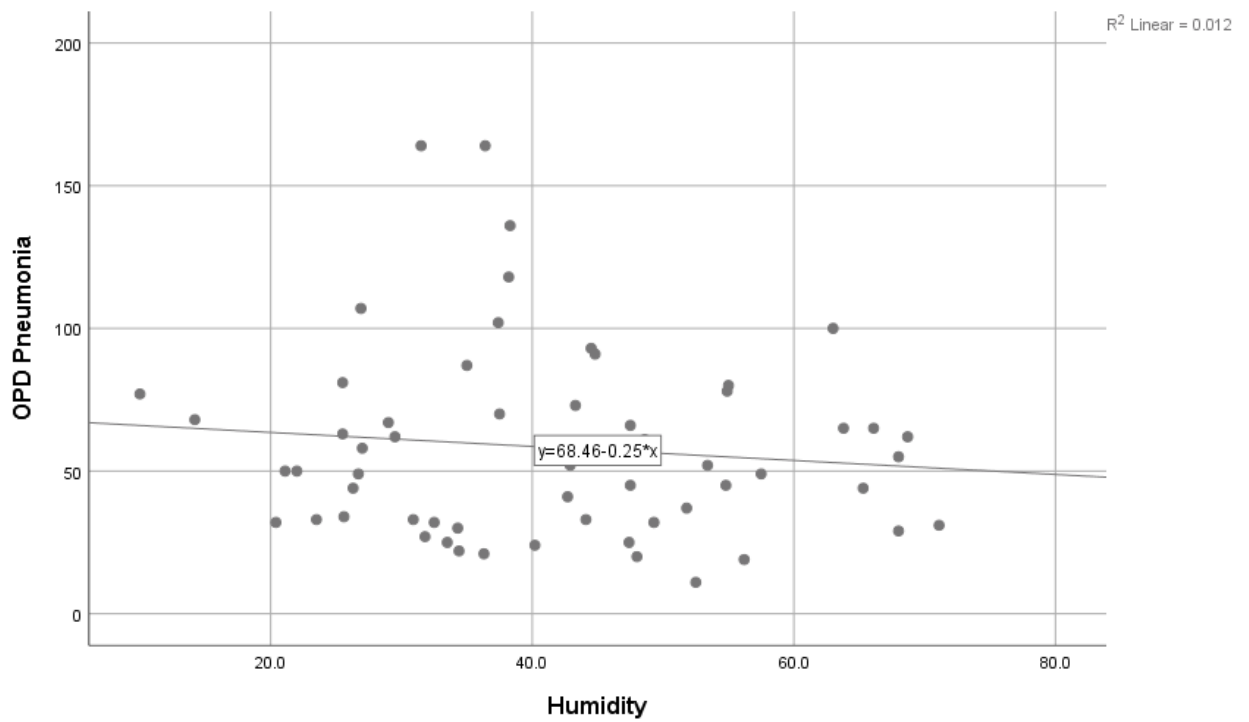
a. Dependent Variable: OPD Pneumonia

b. Predictors: (Constant), Humidity

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	68.455	12.911		5.302	.000	42.612	94.299
	Humidity	-.245	.294	-.109	-.835	.407	-.834	.343

a. Dependent Variable: OPD Pneumonia



d) Association between OPD Pneumonia and rainfall

Correlations

		Rainfall	OPD Pneumonia
Rainfall	Pearson Correlation	1	-.111
	Sig. (2-tailed)		.482
	N	42	42
OPD Pneumonia	Pearson Correlation	-.111	1
	Sig. (2-tailed)	.482	
	N	42	60

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.111 ^a	.012	-.012	24.387

a. Predictors: (Constant), Rainfall

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	299.027	1	299.027	.503	.482 ^b
	Residual	23788.878	40	594.722		
	Total	24087.905	41			

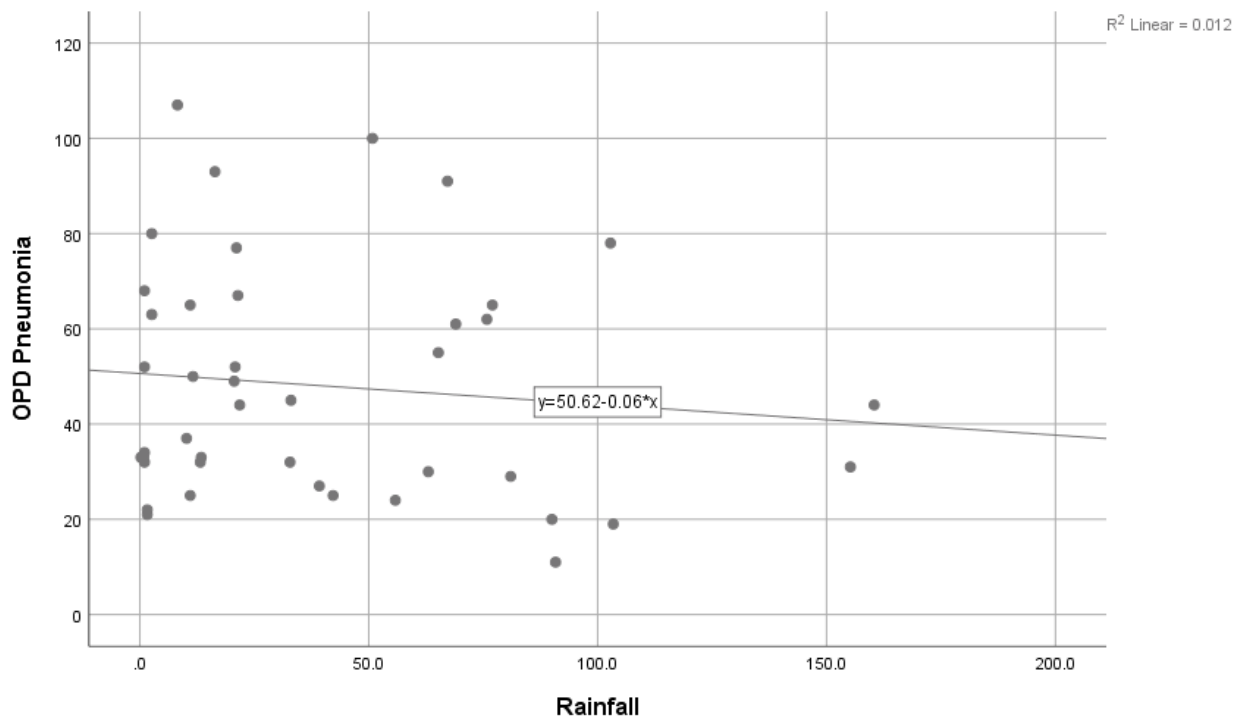
a. Dependent Variable: OPD Pneumonia

b. Predictors: (Constant), Rainfall

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	50.618	5.225		9.688	.000	40.058	61.177
	Rainfall	-.065	.091	-.111	-.709	.482	-.249	.120

a. Dependent Variable: OPD Pneumonia



6. Statistical analysis of OPD tuberculosis

a) Association between OPD Tuberculosis and maximum temperature

Correlations

		Maximum temperature	OPD Tuberculosis
Maximum temperature	Pearson Correlation	1	-.028
	Sig. (2-tailed)		.843
	N	60	52
OPD Tuberculosis	Pearson Correlation	-.028	1
	Sig. (2-tailed)	.843	
	N	52	52

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.028 ^a	.001	-.019	3.406

a. Predictors: (Constant), Maximum temperature

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.458	1	.458	.039	.843 ^b
	Residual	580.062	50	11.601		
	Total	580.519	51			

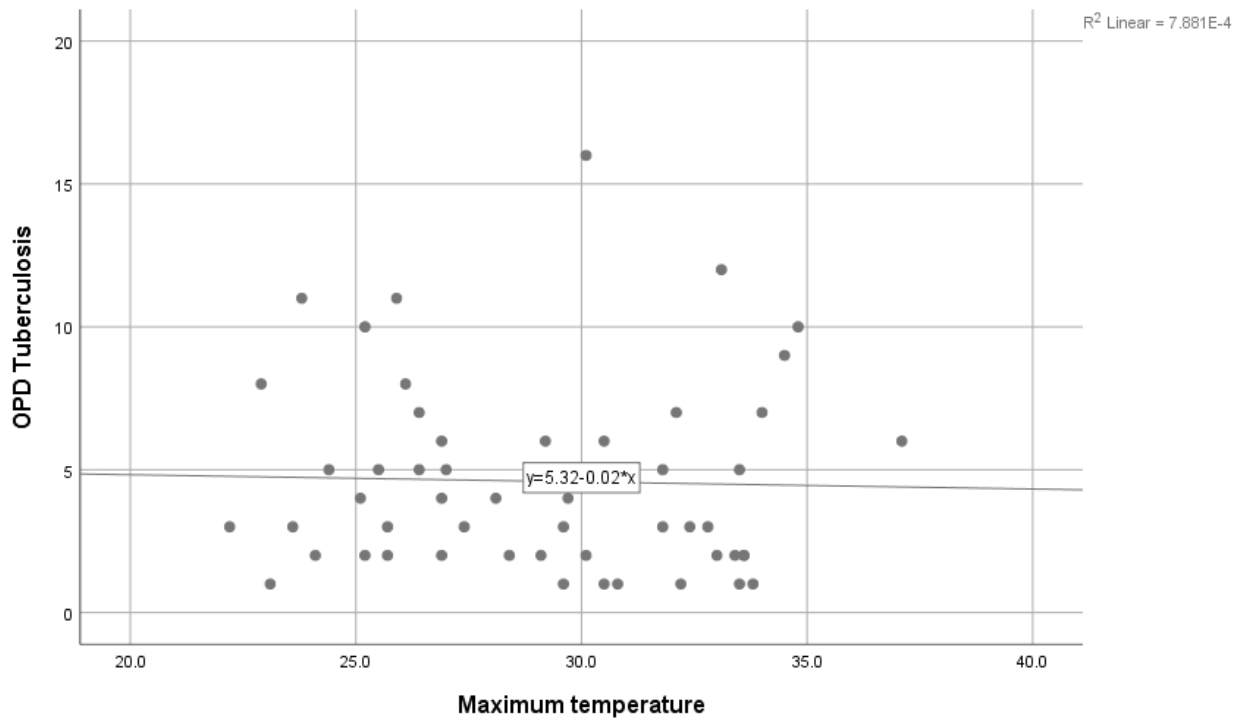
a. Dependent Variable: OPD Tuberculosis

b. Predictors: (Constant), Maximum temperature

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	5.322	3.686		1.444	.155	-2.081	12.725
	Maximum temperature	-.025	.126	-.028	-.199	.843	-.277	.227

a. Dependent Variable: OPD Tuberculosis



b) Association between OPD Tuberculosis and minimum temperature

Correlations

		Minimum temperature	OPD Tuberculosis
Minimum temperature	Pearson Correlation	1	-.062
	Sig. (2-tailed)		.662
	N	60	52
OPD Tuberculosis	Pearson Correlation	-.062	1
	Sig. (2-tailed)	.662	
	N	52	52

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.062 ^a	.004	-.016	3.401

a. Predictors: (Constant), Minimum temperature

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.242	1	2.242	.194	.662 ^b
	Residual	578.277	50	11.566		
	Total	580.519	51			

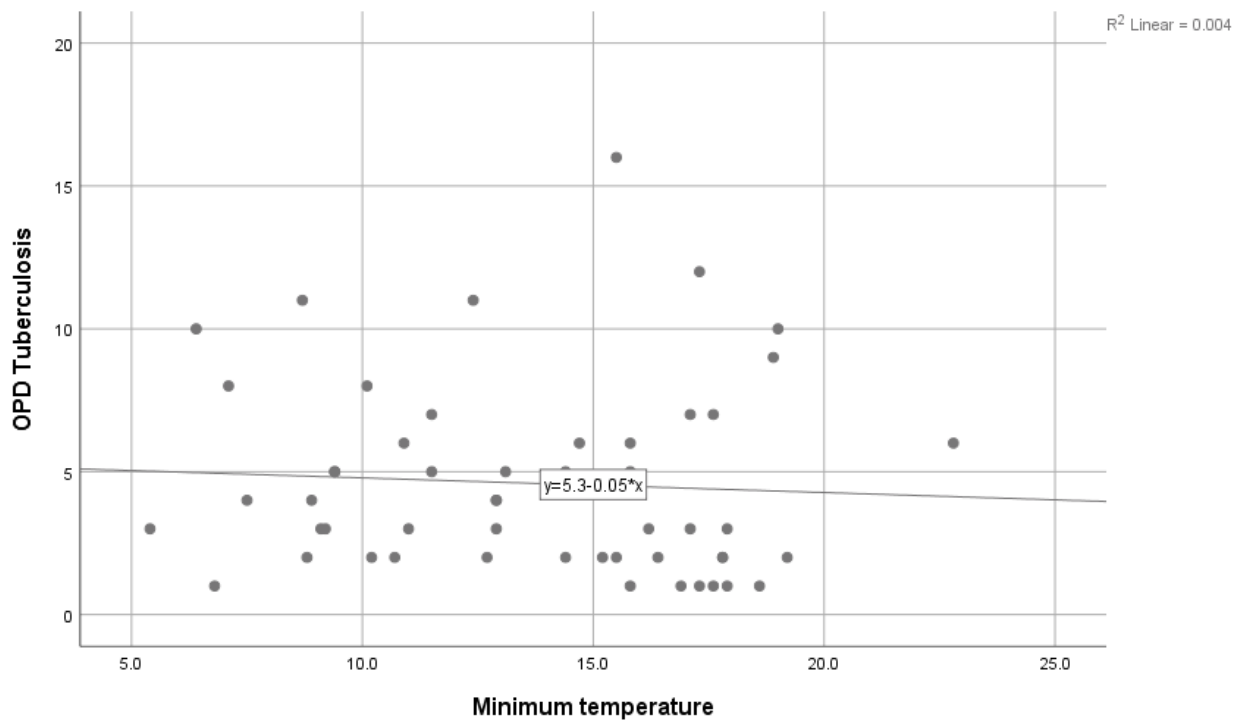
a. Dependent Variable: OPD Tuberculosis

b. Predictors: (Constant), Minimum temperature

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	5.296	1.657		3.196	.002	1.967	8.624
	Minimum temperature	-.051	.116	-.062	-.440	.662	-.285	.182

a. Dependent Variable: OPD Tuberculosis



c) Association between OPD Tuberculosis and humidity

Correlations

		Humidity	OPD Tuberculosis
Humidity	Pearson Correlation	1	.047
	Sig. (2-tailed)		.739
	N	60	52
OPD Tuberculosis	Pearson Correlation	.047	1
	Sig. (2-tailed)	.739	
	N	52	52

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.047 ^a	.002	-.018	3.404

a. Predictors: (Constant), Humidity

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.297	1	1.297	.112	.739 ^b
	Residual	579.223	50	11.584		
	Total	580.519	51			

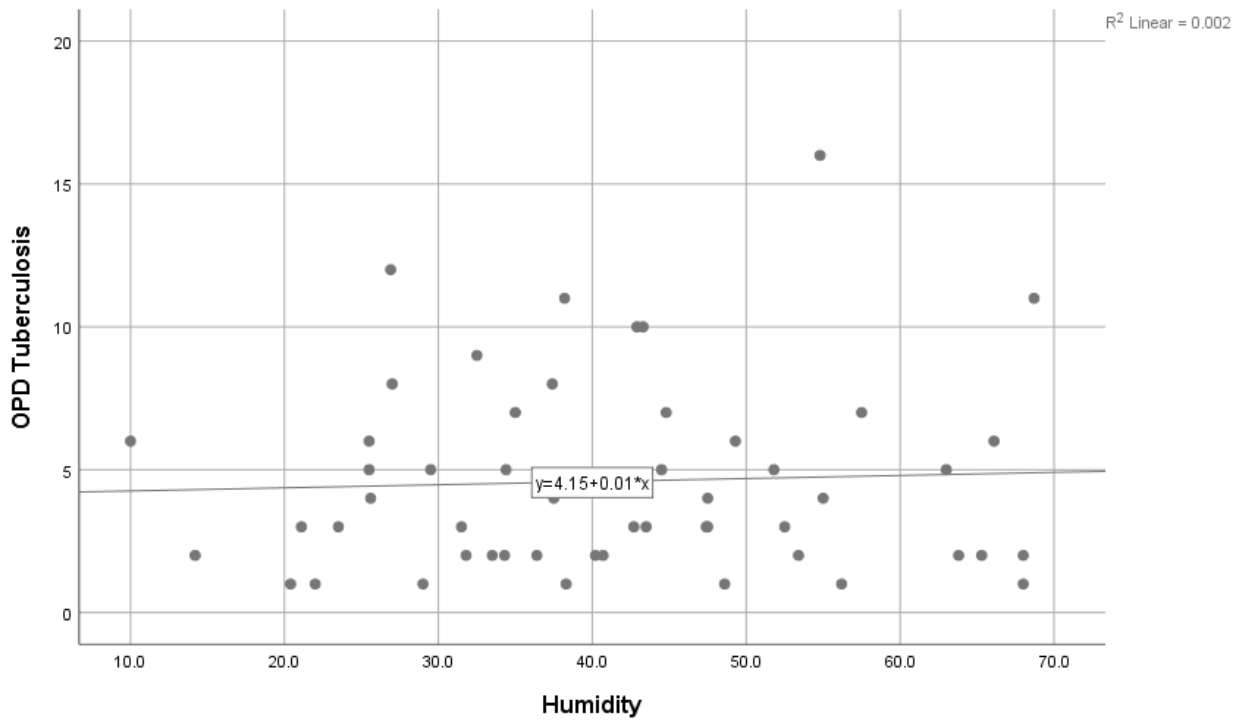
a. Dependent Variable: OPD Tuberculosis

b. Predictors: (Constant), Humidity

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	4.149	1.417		2.929	.005	1.304	6.995
	Humidity	.011	.032	.047	.335	.739	-.054	.076

a. Dependent Variable: OPD Tuberculosis



d) Association between OPD Tuberculosis and rainfall

Correlations

		Rainfall	OPD Tuberculosis
Rainfall	Pearson Correlation	1	-.134
	Sig. (2-tailed)		.444
	N	42	35
OPD Tuberculosis	Pearson Correlation	-.134	1
	Sig. (2-tailed)	.444	
	N	35	52

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.134 ^a	.018	-.012	3.613

a. Predictors: (Constant), Rainfall

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.827	1	7.827	.600	.444 ^b
	Residual	430.858	33	13.056		
	Total	438.686	34			

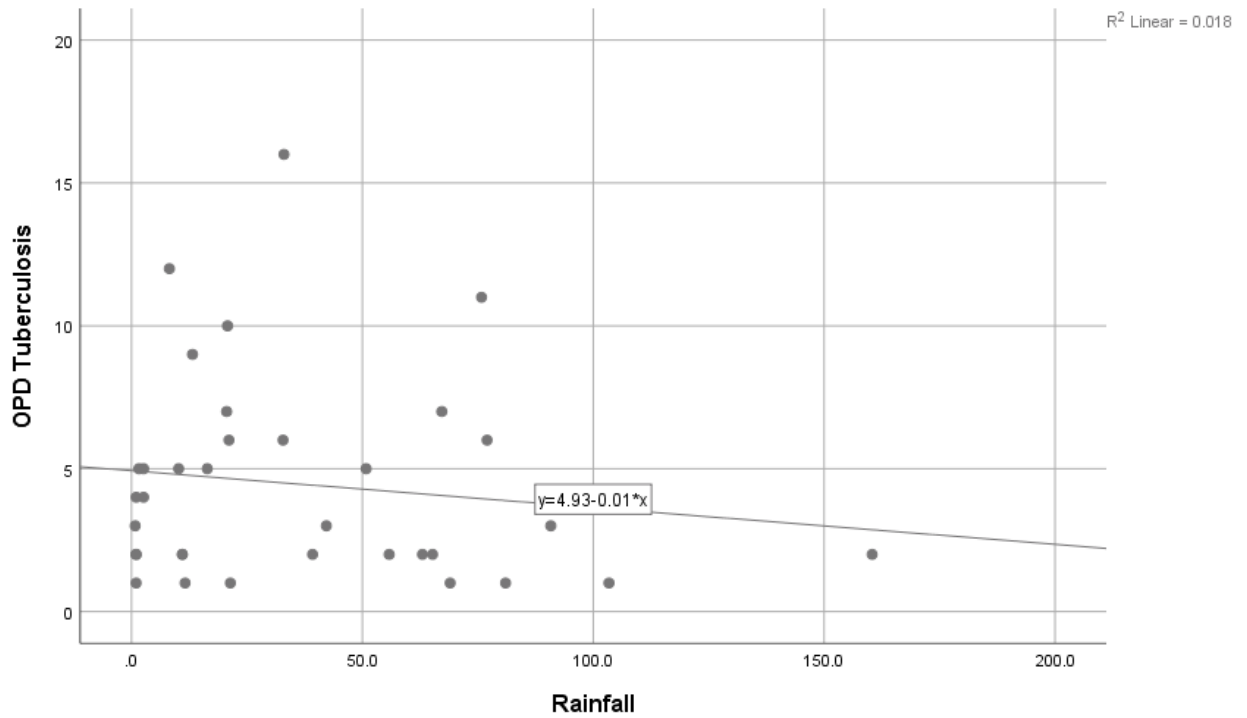
a. Dependent Variable: OPD Tuberculosis

b. Predictors: (Constant), Rainfall

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	4.929	.863		5.712	.000	3.174	6.685
	Rainfall	-.013	.017	-.134	-.774	.444	-.047	.021

a. Dependent Variable: OPD Tuberculosis



Annexure B: Permission letter from the University of Namibia

CENTRE FOR POSTGRADUATE STUDIES

University of Namibia, Private Bag 13301, Windhoek, Namibia
340 Mandume Ndemufayo Avenue, Pioneers Park
☎ +264 61 206 3275/4662; Fax +264 61 206 3290; URL: <http://www.unam.edu.na>



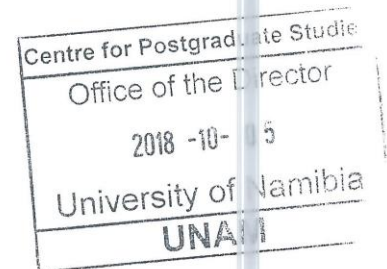
RESEARCH PERMISSION LETTER

Date: 02/10/2018

Student Name: Amunime,

Student number: 200410733

Programme: Master in Public Health



Approved research title: Correlation between climate change indicators and health in informal settlement in Windhoek, Namibia.

TO WHOM IT MAY CONCERN

I hereby confirm that the above mentioned student is registered at the University of Namibia for the programme indicated. The proposed study met all the requirements as stipulated in the University guidelines and has been approved by the relevant committees.

The proposal adheres to ethical principles as per attached Ethical Clearance Certificate. Permission is hereby granted to carry out the research as described in the approved proposal.

Best Regards



Prof Marius Hedimbi

Director: Centre for Postgraduate Studies

Tel: +264 61 2063275

E-mail: directorpgs@unam.na

05/10/18
.....

Date

Annexure C: permission letter from the ministry of Health and Social Services



REPUBLIC OF NAMIBIA

Ministry of Health and Social Services

Private Bag 13198
Windhoek
Namibia

Ministerial Building
Harvey Street
Windhoek

Tel: 061 – 203 2537
Fax: 061 – 222558
E-mail: btjivambi@mhss.gov.na

OFFICE OF THE PERMANENT SECRETARY

Ref: 17/3/3 JA

Enquiries: Mr. B. Tjivambi

Date: 21 September 2018

Ms. Julia Amunime
Private Bag 25313
Windhoek

Dear Ms. Amunime

Re: Correlation between climate change indicators and health in informal settlement in Windhoek, Namibia

1. Reference is made to your application to conduct the above-mentioned study.
2. The proposal has been evaluated and found to have merit.
3. **Kindly be informed that permission to conduct the study has been granted under the following conditions:**
 - 3.1 The data to be collected must only be used for academic purpose;
 - 3.2 No other data should be collected other than the data stated in the proposal;
 - 3.3 Stipulated ethical considerations in the protocol related to the protection of Human Subjects should be observed and adhered to, any violation thereof will lead to termination of the study at any stage;

- 3.4 A quarterly report to be submitted to the Ministry's Research Unit;
- 3.5 Preliminary findings to be submitted upon completion of the study;
- 3.6 Final report to be submitted upon completion of the study;
- 3.7 Separate permission should be sought from the Ministry for the publication of the findings.
4. All the cost implications that will result from this study will be the responsibility of the applicant and **not** of the MoHSS.

Yours sincerely,

MR. B.T. NANGOMBE
PERMANENT SECRETARY





REPUBLIC OF NAMIBIA
Ministry of Health and Social Services

Private Bag 13322
Windhoek
Namibia

Khomas Regional Office
Directorate: Khomas Region
Florence Nightingale Street

Tel: 061 – 203 5029
Fax no. 061 - 235997
Telefax (Intern) 264 61 235997

Enq: Mr. B. Isaacs

Ref no. S 4/9

Date: 24 October 2018

OFFICE OF THE REGIONAL DIRECTOR

STAFF MATTER: CONFIDENTIAL

**MS. JULIA AMUNIME
PRIVATE BAG 25313
WINDHOEK**

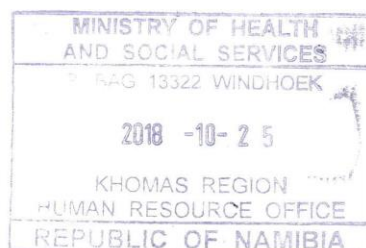
RE: CORRELATION BETWEEN CLIMATE CHANGE INDICATORS AND HEALTH IN INFORMAL SETTLEMENT IN WINDHOEK, NAMIBIA.

Dear Ms. Amunime

I have pleasure to inform you that permission, as per Permanent Secretary's approval has been granted for you to conduct a research on 'Correlation between climate change indicators and health in informal settlement' in Windhoek District, in Khomas Region for a period of two (2) weeks.

Yours sincerely

**M. E. MUREMI
REGIONAL DIRECTOR
KHOMAS REGION**



"Health for All"