COMPARING THE EFFECTS OF UNREGULATED OPEN DUMPSITE POLLUTION ON CHILD GROWTH AND MATERNAL HEALTH IN NAIROBI SLUMS, KENYA: A CROSS-SECTIONAL STUDY

BY

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DECLARATION

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ABSTRACT

Research on the impact of environmental pollution on the growth of children in Africa has been relatively limited. Globally, pollution is associated with one out of every six deaths, totaling 9 million deaths. Sub-Saharan African countries contribute to the third-highest pollution-related deaths, with 980,000 deaths. Well-established negative health effects from pollution include an increased likelihood of cancer, impaired reproduction, and heightened susceptibility to diseases. In Kenya, the compromised immune system due to malnutrition and lack of safe water may exacerbate these effects. Korogocho slum has one of the largest dumping sites in Dandora estate which has been present for 40 years. No study has investigated the potential impact of this dump site on the health of children and the reproductive health of mothers in its vicinity. This study aimed to assess the effects of prolonged exposure to toxic pollutants from the dumpsite.

Objectives: 1. Determine the growth status of children aged between 6 years to 12 years exposed to the effects of unregulated open dumpsite pollutants for more than 5 consecutive years with non-exposed children. 2. Compare the clinical symptoms of children between exposed and unexposed populations 3. Compare the birth outcomes of women in the last 5 years between the exposed and non-exposed groups

Method: This was a cross-sectional comparative study that randomly recruited 140 children (70 exposed and 70 unexposed) aged between 6 years -12 years and a sufficient sample size of 70 mothers/caregivers (35exposed and 35unexposed) from Korogocho A (exposed) and Kibera Slums (unexposed). Anthropometric measurements were taken from the children: mean weight, height, HAZ, WAZ and BAZ scores calculated. A structured questionnaire was used to obtain recall information of the clinical symptoms and birth outcome from the 70 randomly selected mothers/caregivers. Descriptive statistics was used to analyze categorical as well as continuous data using measures of central tendency. Chi -square test was performed for all co-variates to check statistical significance between exposed and non-exposed group and independent t-test carried out to detect differences in the anthropometric mean with the significance level set at 0.05.

Results: The mean age and parity of women in Korogocho were 32.6 (sd 2.8) and 3 (sd 1.4), respectively, while in Kibera, the mean age and parity were 39.6 (sd 4.2) and 2 (sd 0.7), respectively. The pregnancy and birth outcomes varied between the two populations. The exposed population had a significantly higher proportion of birth-related complications, with 7 (19%) cases, including Convulsions 3 (42%), Postpartum hemorrhage 2 (29%), and Infection 2 (29%), compared to the unexposed population, which had 2 (5.9%) cases, including Convulsion 1 (50%) and Infection 1 (50%) (p=0.024). A higher proportion of miscarriages was recorded in the exposed group, with 7 (19%) cases compared to 1 (2.9%) in the unexposed group (p = 0.053). However, no significant differences were noted in the birthweight outcomes (p = 0.651) and the occurrence of fetal congenital anomalies (p = 0.583) between the two populations.

The mean age of children was; Korogocho 9.2 (sd2.07) and Kibera 8 (sd0.08). The mean difference in the height and weight between the exposed and unexposed children was 0.2cm and 1.2kgs respectively. The difference in the mean HAZ, WAZ and BAZ scores (Male and Female) for the children from the exposed and unexposed population was not statistically significant (p= 0.586), (p = 0.483), (p = 0.07) and (p = 0.474) respectively. However, Clinical symptoms varied significantly between the two groups; coughing (p=0.001), eye irritation (p= 0.001) and stomach-ache (p=0.001), with unexposed population experiencing less than 50% of the 10 clinical symptoms reported.

Conclusion: Overall, the study notes an increased proportion of maternal and fetal-related complications in pregnancy among women residing near an unregulated waste dumpsite (exposed). The maternal birth-related complications included convulsions/eclampsia, postpartum hemorrhage and infection. Miscarriage was noted as a significant fetal complication. In children, the proportion of children suffering from various morbidities was significantly higher in the exposed group, with these children (exposed) also noted to be shorter and of lesser body weight.

Recommendations: The Nairobi County government should urgently take steps and enact environmental protection policies, addressing household and industrial waste management as well as act on relocating the Dandora dumpsite.

Future research studies in this area should consider prospective cohort study design, which will ideally explore mobility of children from the exposed area and also account for acute morbidity experienced in the follow-up period.

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

BAZ: Body mass index for age Z-score

BMI: Body Mass Index

eCRFs: Electronic Case Record Forms.

H/A: Height for age

HAZ: Height for age Z- score

H.H: Households

IREC: Institutional research and ethics committee

MDG: Millennium Development Goals

MOH: Ministry of Health

NACOSTI: National Commission for Science Technology and Innovation

NEMA: National Environmental Management Authority

SD: Standard Deviation

SDG: Sustainable Development Goals

SPSS: Statistical Package for social Sciences

UN: United Nations

W/A: Weight for Age

W/H: Weight for Height

WAZ: Weight for age Z-score

WHO: World Health Organization.

DEFINITION OF TERMS

Child Growth Status: Growth is defined as the increase in body size over a period of time, and the child growth status is arrived at after performing a growth assessment.

Child mobility: The ability and freedom of movement and exploration for young children.

Growth assessment: Basic assessment that involves using the children's age, sex and measurements of height and weight to calculate their height for age, weight for age, weight for height and Body Mass Index (BMI) for age.

Exposed group: Refers to the group of children drawn for the population living in Dandora dumpsite and its environs.

Unexposed group: Refers to the group of individuals not exposed to the Dandora waste dumpsite pollution.

Malnutrition: This refers to imbalance in the nutritional intake verses what the body needs to function and maintain healthy cells and tissues. Malnutrition can be classified into two using the NCHS/WHO 2017 growth reference: undernutrition which includes: Stunting- characterised by a low height for age score (HAZ-score<-2SD median NCHS/WHO2017 reference), underweight characterised by low weight for age (WAZ Score <-2 median NCHS/WHO2017 reference) and wasting characterized by a low weight for height (WHZ Score< -2SD median NCHS/WHO2017 reference).

And the second category overnutrition or obesity or overweight which is characterized by a high body mass index for age BAZ (BAZ Score > +2 Z-score median NCHS/WHO2017 reference):

Household: Refers to a social unit of people living together under the same roof and composing a family

Slum: This refers to a densely populated urban area characterised by overcrowding, poor housing abject poverty, lack of basic water and sanitation facilities.

Preterm birth: This refers to the birth of a live baby before 37 completed weeks of pregnancy. Parity: This refers to the number of times a woman has given birth to a foetus that is more than 28 weeks in gestation age regardless of if the baby is born alive or dead.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background information

1.1.1 The burden of pollution

One of the biggest hazards to human health in the twenty-first century is pollution, which is defined as "the introduction into the environment of substances harmful to humans or other living organisms" (Manisalidis et al., 2020). Because there is a close relationship between the environment we live in and our health, everything that has a negative influence on the environment will have a serious and negative impact on human health.

The potential of pollution to cause diseases has been widely neglected because of the long period between exposure and the emergence of the disease, the intricate combination of pollutants that can lead to poor health, and the complexity of understanding the cause-and-effect relationship, further intensifying the complexity.

Recent evidence documenting the burden of disease and economic costs linked to pollution, along with governments' political commitment towards a pollution free planet (A Global Response to Pollution, n.d.), promises to end the neglect of recognizing pollution as a significant public health threat.

Moreover, the threat of environmental pollution on human health is only now being well understood, with various studies noting the interrelation between increasing levels of environmental pollution and an increase in non-communicable diseases as well as this being one of the single most important modifiable risk factors for non-communicable diseases (Sebiany et al., 2018), (Dhimal et al., 2021). In addition, pollution has also been shown to contribute to the threat of communicable diseases by altering human immunity and increasing the virulence of infectious pathogens (Dhimal et al., 2021).

Globally, it is estimated that one out of every six deaths, translating to 9 million deaths, is associated with pollution (Mayor, 2017). This is three times the number of deaths caused by HIV/AIDS, Tuberculosis and Malaria combined (Landrigan et al., 2015) .

However, most concerning is the fact that the burden of environmental pollution disproportionately affects low- and middle-income countries, which accounts for 95% of all pollution-related mortalities globally, with Africa accounting for 980,000 deaths, the third highest number of pollution-related mortalities in the world, although this figure may underestimate the true impact due to the timeframe considered (Landrigan et al., 2018), (World Health Organization, 2018).

Furthermore, the most vulnerable in our society, for example, children and those with low incomes, are more likely to be affected by air pollution, as they lack the financial resources to access healthcare or select a place to live, further validating the notion of environmental injustice.

1.1.2 The Effects of Pollution on Children and Women:

Despite the potentially harmful effects dumpsite-related pollutants pose on the health of pregnant mothers and their unborn children, there is limited data available in Kenya on the same. Research studies on the effects of environmental pollution on children's growth and the reproductive health of women in Africa have remained a relatively under-researched area. Studies from developing countries highlight environmental pollution's detrimental effects on this population from pregnancy, prenatal stage, and childhood to adulthood.

Environmental pollution has been linked to various immediate maternal health consequences, such as hypertension in pregnancy, fibroids and infertility, and long-term consequences, such as breast cancer and metabolic disorders (Boyles et al., 2021). In addition, poor infant outcomes such as preterm birth (Malley et al., 2017) , low birth weight (Maisonet et al., 2001) ; (Forouzanfar et al., 2016) early infant death (Pereira et al., 1998) and congenital anomalies (Yao et al., 2016) have been observed in populations exposed to high levels of environmental pollution.

In the prenatal stage, environmental pollution and related exposure to industrial chemicals, such as Bisphenol (BPA), has been shown to be capable of inducing human epigenetic alteration, which may play a role in disease causation and further linked to an increased likelihood of cancer, increased weight and impaired reproduction (Hou et al., 2012). In addition, in utero or early life, exposure to various stressors, such as harmful environmental conditions, has also been associated with later-life susceptibility to diseases. This was well captured in a review by (Maisonet et al., 2001) which followed a cohort of individuals prenatally exposed to arsenic, who later in adulthood were found to have increased cardiovascular mortality as well as impaired lung function in Bangladesh and Chile.

Pregnancy presents a highly vulnerable period for both the mother and infant with exposure to potentially toxic environmental conditions being linked to adverse maternal and foetal health effects. In several studies, exposure to pollutant gases such as Nitrogen dioxide, particulate matter (PM 2.5), traffic pollution and heavy metal environmental contaminants such as Cadmium has been found to be associated with an increased risk of occurrence of hypertension in pregnancy (Rosen et al., 2018) (Program, 2019).

In addition, environmental pollutants such as Arsenic and Lead were associated with an increased risk of abortion and low birth weight (Quansah et al., 2015) (Borja-Aburto et al., 1999). The risk of congenital anomalies has also been noted in several studies to be high in the offspring of women exposed to high concentrations of sulphur dioxide (SO2) gas in the second trimester, with sulphur dioxide (SO2) gas, exposure in the first trimester being linked to intrauterine growth restriction and low birth weight (Y. Liu et al., 2019). (Yao et al., 2016).

Dumpsites are a significant source of toxic environmental pollutants ranging from toxic gases such as methane, carbon dioxide, sulphur dioxide, and dust particles as well as heavy metals such as lead, Cadmium, arsenic and mercury.

1.1.3 Dandora Dumpsite and its Impact on Health

In developing countries, exposure to pollution in children poses a unique concern, where children are already susceptible due to inadequate nutrition and lack of access to safe water and sanitation. In these settings, pollution has been found to contribute to impairing both innate and adaptive immune functions, consequently leading to recurrent infections and malnutrition, a vicious cycle which ultimately impairs bone metabolism resulting in re-tarded growth and stunting (Sinharoy et al., 2020).

Korogocho slum hosts one of the largest dumping sites in Africa - the Dandora dumpsite, which has been present for over 40 years. No study has looked at this dump site's possible effect on the health of children and the reproductive health of women of childbearing age living around it. This study was designed to assess the effects of longstanding exposure to the toxic pollutants from this dump site.

In its 40 years of existence, the Dandora dumpsite, once an abandoned limestone quarry, has gradually grown to become a significant public health problem affecting the lives of close to an estimated 900,000 residents of nearby slums dwellings; Korogocho, Babandogo, Mathare and Dandora (Ogola & Moschetti 2009). However, despite its detrimental impact on the environment, as highlighted by available environmental research studies (UNEP, 2018, Onyari, 2017, Bruce, 2016), Dandora dumpsite has attracted significantly few public health studies and even fewer studies focusing on the effects of the pollution related to the dumpsite on the health of the population residing within its environs.

Several environmental studies have highlighted the extensive air, soil and water pollution the Dandora dumpsite has impacted around its environs, most of which has also seen worrying levels of particulate matter (PM2.5), heavy metals and coliform contamination of the groundwater and soil in these areas as well as the Nairobi River which streams next to the dumpsite further affecting more inhabitants downstream (Odhiambo, 2017,Bruce, 2016).

In one of the epidemiological studies, Njoroge G. Kimani, (2007) noted that children residing within the Dandora dumpsite, and its environs were at an increased risk of developing serious health and nutritional problems due to exposure to a wide range of toxins, such as organophosphate compounds, toxic gas emissions and heavy metals found in the dumpsite.

The study noted that compared to others, these children were prone to developing liver and renal dysfunction as well as respiratory, haematological and gastrointestinal diseases that compromised their growth.

Avis, (2018) investigating air pollution related to the Dandora dumpsite. Found that levels of air pollution recorded in Dandora were between 47.4mcg/m3 to 94mcg/m3, exceeding by four to nine times the permissible upper limits of air pollution of 10mcg/m3 as recommended by the (WHO, 2018).

Exposure to such high levels of air pollution related to the dumpsite, as noted by Egondi et al., (2018), was associated with a 21% increased risk of morbidity and a 12% increased risk of mortality among children aged under five years residing within the environs (Korogocho and Viwandani) of the dumpsite.

Further, Njoroge G. Kimani, (2007), in a UNEP-sponsored pilot study looking at the implication of Dandora dumpsite to public health, noted that between 2004 and 2009, there was a record 440% increase in the number of upper respiratory infections among residents of Dandora.

In another epidemiological study by De Vita et al., (2019) titled "Malnutrition, morbidity and infection in the informal settlements of Nairobi" the study noted that children residing within the environs of Dandora dumpsite (Korogocho and Viwandani) were prone to frequent infections due to poor WASH conditions. This study further noted the existence of a strong mutual relationship between infection and malnutrition, with the prevalence of malnutrition recorded in the study being 26% stunting, 6.3% wasting and 13.16% underweight.

It is evident that the environment and health have a strong relationship, and if the environment is contaminated, it will have a deleterious effect on the health and progress of the local population. The effects of these issues are significantly more evident in the informal communities, which are commonly referred to as slums. These areas are often characterized by poverty, overcrowding, inadequate sanitation and limited access to quality health care, which together form the ideal conditions for the ongoing cycle of childhood infection and malnutrition, which is the primary risk for growth retardation.

The paucity of research studies in our country on the effects of environmental pollution on the population's health has seriously undermined the implementation of meaningful policy changes and public health interventions to halt and reverse the severe threat of pollution on the health of our children and the general population. Furthermore, the cost implications of diseases and disabilities associated with environmental pollution are significant enough to derail any meaningful national development.

This study aimed at establishing epidemiological evidence as well as quantifying the disability associated with longstanding exposure to a host of environmental pollutants present along an unregulated solid waste dumpsite among children aged 6-12 years and women residing in the Korogocho-A area. This area hosts Kenya's largest unregulated solid waste dumpsite - the Dandora dumpsite, Nairobi.

1.2 Problem Statement

Residence near dumpsites compromises the health of children already plagued by the dual burden of malnutrition and infection, with exposure to complex pollutants such as heavy metals, persistent organic compounds, and toxic fumes such as methane and hydrogen sulphide found in these dumpsites increasing the risk of malnutrition and infection resulting to growth retardation, a finding supported by only limited studies in our setting.

A Standardized Monitoring and Assessment of Relief and Transitions (SMART) methodology survey of nutrition in the slums of Nairobi noted that, of the ten slums surveyed, Korogocho slum had the highest rate of growth faltering (stunting) among children aged 6 to 59 months; recording a stunting prevalence rate of 31.8% which was above the national stunting prevalence rate of 26% (Nutrition | UNICEF Kenya, 2021.; Nutrition Survey Conducted in the Slums of Nairobi County Concern Worldwide-Kenya, 2017).

Stunting is irreversible and is associated with detrimental life term consequences such as; lower cognitive function and educational performance (Walker et al., 2000), risk of cardiovascular diseases such as hypertension (Gaskin et al., 2000), poor psychological functioning evidenced by anxiety disorders, depression and low self-esteem (Walker et al., 2007). In slum communities, children represent the most promising opportunity to break free from the cycle of poverty, yet their growth is hindered by the adverse environment in which they live.

Moreover, maternal-related complications and mortality are more prevalent among women residing in slum areas. According to the findings of a study conducted by (Ziraba et al., 2009), the maternal mortality ratio of women residing in the Korogocho slum was estimated to be 706 deaths per 100,000 live births, exceeding the national estimated maternal mortality ratio of 560 deaths per 100,000 live births.

These prevalence studies acknowledge the detrimental health impacts associated with residing in the Korogocho slum, which accommodates the country's largest open dumpsite known as the Dandora dumpsite. This study was aimed at investigating the association between the physical growth of children, women's birth outcomes, and their residence in close proximity to an unregulated open dumpsite situated in Korogocho.

1.3 Justification

Given the limited number of epidemiological studies in Kenya exploring the immediate and long-term effects of unregulated dumping sites on the overall health of the most at-risk population groups- children and women of reproductive age. This study extends Njoroge G. Kimani (2007) work by exploring further the effects of unregulated waste dumpsite on the growth status of children and the birth outcomes of women of reproductive age by determining the physical growth of children and retrospectively reviewing the birth outcomes of women in the Korogocho and Kibera slums.

It's worth noting that by addressing environmental pollution, our country stands the chance of explicitly contributing to the achievement of eight (8) of the seventeen (17) key 2030 Sustainable Development Goals (SDG).

These fundamental goals include Improvement in health (SDG3), decreasing poverty levels (SDG1), effective management of water and sanitation (SDG6), addressing inequalities or social injustice within countries (SDG10), enhancing the sustainability of cities and human settlements (SDG11), tackling of climate change thus addressing global warming (SDG13), protecting of the ecosystem (SDG15), and effective conservation of the seas, oceans and marine life (SDG14). (Schwan, 2019)

1.4 Research Question

What are the effects of living close to an open dumpsite on the physical growth of children and the birth outcomes of women of reproductive age?

1.5 Objectives

1.5.1 Broad Objective

The study aimed to establish the correlation between prolonged exposure (more than five consecutive years) to open dumpsite pollution within 200 meters of the Dandora dumpsite and its effects on the physical growth of children aged 6years to 12 years and the birth outcomes of women of reproductive age.

1.5.2 Specific Objectives

1. To determine the growth status of children aged between 6 years to 12 years exposed to the effects of unregulated open dumpsite pollutants for more than five consecutive years.
2. To determine the occurrence of acute physical clinical symptoms among children aged between 6 years and 12 years exposed to the effects of unregulated open dumpsite pollutants for more than five consecutive years
3. To determine the pregnancy and birth outcomes of women exposed to the effects of unregulated open dumpsite pollutants for more than five consecutive years.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Sources of Environmental Pollution

There exists a strong interrelation between the environment and health, consequently anything that impacts negatively on the environment produces serious detrimental human health effects. Moreover, the exponential increase in population throughout the last century from an estimated 1 billion people at the beginning of the 19th century, to the current global population estimate of 7 billion people (Hawks et al., 2000), has seen an aggressive modification of the natural environment to meet the growing population demand. By enhancing agricultural productivity, through use of fertilizers and pesticides, unregulated farming activities and deforestation coupled with dumping of commercial and household waste along with increased fossil fuels use, has contributed to alarming levels of environmental pollution.

For developing countries like Kenya, rapid population growth has seen a wave of urbanisation resulting to stretching of the available urban resources. This coupled with poor urban planning in the face of acute urban population growth has led to heightening of the existing social and economic disparities, with increased informal settlements (slums) running on the outskirts of high-rise affluent neighbourhoods (Faye et al., 2016)(Haregu et al., 2017). Sadly, most of the household and industrial waste generated in these affluent neighbourhoods end up in unregulated dumpsites located in the slums further compromising the health of a population living in abject poverty (Adegun, 2018),(African Population and research Centre & Urban Africa Risk Knowledge, 2018).

2.2 Health Effects of Environmental Pollution on Children

Children are more vulnerable to the effects of environmental pollution largely due to several reasons. First, children have a large body surface area to volume ratio meaning that they can compared to a grown adult, inhale and ingest significantly larger proportions of both air and food respectively and hence increasing the risk of inhaling and ingesting significantly larger quantities of environmental toxins.

Secondly, children have a weaker immune system, hence making them easily susceptible to diseases as a result of exposure to environmental toxins. Osseiran & Chirscaden, (2017) noted that unhealthy environment contributed to 1 in every 4 under 5 deaths, with an estimated annual loss of 1.7 million children to pollution. The study also noted that respiratory infection, diarrhoea and prematurity as the leading causes of under 5 mortalities.

Exposure to unsolicited domestic and industrial solid waste related environmental pollutants has been found to negatively impact the health of children in various ways. Humphrey, (2009) noted that poor sanitation, hygiene along with resultant enteropathy due to contaminated environment was significantly associated with poor growth in children, marked by stunting.

In one of the earliest studies looking at the effects of urban dumpsites on the growth of children, Paigen et al., (1987) noted that, children less than 18 years who were born and had spent at least 75% of their lives in the love canal area, were significantly shorter with a mean stature for age of 46.6 compared with 53.3 for children born in the control area. Moreover, the study also noted a positive dose response association between the distance from the love canal dumpsite and increased prevalence of seven health problems namely;

seizures, learning difficulties, hyperactivity, eye and skin problems abdominal pain and incontinence.

In a 6-month prospective study of the physical growth of children aged 0-3years residing near a solid waste disposal site Filigrana et al., (2011) noted that, exposed children (those residing near a solid waste disposal site) had lower growth indices compared to a similar population not exposed to a waste disposal site. Children in the exposed population had an average weight for height Z score of 0.16 SD less than the control population. The study also noted that, children who had lived 50% of their lives in the exposed area, had a significantly lower height for age Z score (HAZ) by an average of (0.12).

Another study by Jedrychowski et al., (2002) in Krakow Pollard among preadolescent children living in a highly polluted area, similar findings were noted, with the growth of children exposed to outdoor pollution noted to be impaired by an average of 1.5 cm compared to the control group.

Humphrey, (2009),Ercumen et al., (2019),Gladstone et al., (2019). Noted that growth of children was affected by a complex synergism of multiple factors in the environment that included air pollution, water and soil pollution. These findings were informed by a randomised control trial that had sought to address water and sanitation – largely hypothesised as the major causes of diarrhoea and associated growth faltering among children aged less than 2 years. By setting up safe water and sanitation facilities along with nutrition supplements for both nursing mothers and children in the intervention arm of the study, the study failed to note any significant difference in the growth and development between the intervention arm and the control arm of the study.

In Kenya, there are limited studies on growth of children living near unregulated solid waste dumpsites. In one of the few studies, De Vita et al., (2019) in an epidemiological study titled, "Malnutrition, morbidity and infection in the informal settlements of Nairobi" the study noted that children residing within the environs of Dandora dumpsite (Korogocho and Viwandani) were prone to frequent infections due to poor WASH conditions. This study further noted the existence of a strong mutual relationship between infection and malnutrition, with the prevalence of malnutrition recorded in the study being 26% stunting, 6.3% wasting and 13.16% underweight.

2.3 The Long-term Consequences of Stunting

Stunting, defined as "a height for age of more than two standard deviations below the WHO growth standards median " (The World Health Organization WHO, 2015), is irreversible and is associated with detrimental life term consequences such as; lower cognitive function and educational performance (Walker et al., 2000), risk of cardiovascular diseases such as hypertension (Gaskin et al., 2000), poor psychological functioning evidenced by anxiety disorders, depression and low self-esteem (Walker et al., 2007)

Children contribute minimally to the degradation of the environment but bear the brunt of the consequences of environmental pollution. Demonstrating the effects of environmental pollution on the growth of children will significantly contribute to the body of evidence required to catalyse change in environmental management.

2.4 Maternal Health Effects of Environmental Pollution and Pregnancy Outcomes

Pregnancy is a period marked by significant physiological changes in the mother as well as rapid cell division, cellular development, organogenesis that results to ultimately gives rise to a fully developed foetus. External stressors such as environmental pollution have been found to negatively affect the health of both the mother and the unborn child. By disrupting the normal maternal physiological processes as well as interrupting in diverse ways the process of foetal development, environmental pollution has been linked to poor maternal and infant outcomes in pregnancy.

Neonatal birth outcomes are considered strong predictors of the health of the infant with low birth weight and regressed growth in the early years of a child's life being linked to poor health and increased risk of death. Moreover, several studies have linked poor birth outcomes such as low birth weight and intrauterine growth restriction (IUGR) to occurrence of cardiovascular diseases such as hypertension, coronary arterial disease, stroke as well as metabolic conditions such as diabetes mellitus (Eriksson et al., 2000).

In a systematic review of literature looking at the relationship between environmental contaminants and preeclampsia (elevated blood pressure in pregnancy), (Rosen et al., 2018) noted that, from the 28 studies published between 2008 - 2018, there was a strong association between heavy metal exposure (Cadmium), and preeclampsia, with suggestive evidence of association between nitrogen dioxide (NO_2), particulate matter ($PM_{2.5}$) and exposure to traffic on the occurrence of preeclampsia.

Several studies in developing countries have examined the relationship between environmental pollution and birth outcomes. In one prospective cohort study carried out by (Green et al., 2009) in California looking at the effects of vehicular traffic on birth outcomes. The study noted that persons living within 50 meters of a road with heavy vehicular traffic were at 3 times (AOR = 3.11; 95% CI, 1.26–7.66) increased risk of spontaneous abortion compared to the control group.

In another study by (Kang et al., 2020) looking at the association between in vitro fertilization success rate and air pollution in South Korea.

The study noted that the rates of spontaneous abortion following in vitro fertilization and embryonic transfer were highest between March and April, coinciding with months that had the highest concentration of particulate matter (PM), Sulphur dioxide, carbon monoxide and nitrogen dioxide and lowest in the months of July and September, which were months with the lowest concentration of air pollution.

Maroziene & Grazuleviciene, (2002) in an epidemiological study looking at the association between air pollution and risk of adverse birth outcomes in Lithuania, noted that the risk of preterm birth increased by 25% for every 10mcg/m^3 increase in nitrous oxide concentration. In addition, the study also noted a significant increase in low birth weight with every increase in formaldehyde levels in the air.

There’s only a limited number of studies available in the developing countries highlighting maternal and infant health effects of pollution. In one cross-sectional study that’s pooled data sets from the Demographic Health Surveys (DHS) of 15 African countries namely: Tanzania, Uganda, Burundi, Ethiopia, Malawi, Zambia, Zimbabwe, South Africa, Cameroon, Mali, Nigeria, Chad, Benin, Guinea and Angola, looking at the relationship between maternal exposure to particulate matter, low birth weight and pre-term birth in Africa. Bachwenkizi et al., (2022) noted that an increase in particulate matter ($PM_{2.5}$) was associated with an increased odds ratio of 1.28 (95% CI: 1.23, 1.34) and 1.08 (95% CI: 1.01, 1.16) for low-birth-weight and pre-term birth respectively.

2.5 Conceptual Framework

The Dandora landfill is composed of unsolicited waste ranging from agricultural, hospital, industrial and domestic waste all generated from the capital city -Nairobi. This unsolicited waste is responsible for altering the environment around the dumpsite presenting a significant health hazard.

The burning and decay of this waste is responsible for releasing dangerous fumes to the air.

Thick smoke is a common feature in the dumpsite and its environs along with toxic gases such as methane, hydrogen-sulfide and ammonia. These gases are detrimental to the human health and longstanding inhalation is responsible for respiratory disorders.

Leachate that is formed by the decomposing waste contains toxic substances such as heavy metals, persistent organic compounds, dissolved methane and sulphate which is usually absorbed in the soil and ultimately finds its way into the ground water, eventually leaking into nearby streams and rivers (Iravanian & Ravari, 2020). Human exposure to these toxins through food, water and air causes widespread inflammation in the body. This coupled with poor nutrition results to weakened immune system giving rise to recurrent infections which further increases the metabolic needs of the body. Sickness contributes to anorexia and catabolism leading to redirecting of essential nutrients to immune response hence impairing growth (Sinharoy et al., 2020).

Toxic gases such as methane, hydrogen-sulphide, sulphur dioxide, ammonia, carbon monoxide have been linked to adverse maternal and foetal health effects such as increased risk of occurrence of hypertension in pregnancy (Rosen et al., 2018) (Program, 2019), congenital anomalies intrauterine growth restriction and low birth weight (S. Liu et al., 2003); (Yao et al., 2016). In addition, heavy metals in dumpsites such as Arsenic and Lead have been associated with increased risk of aborting and low birth weight (Quansah et al., 2015)

Pro inflammatory cytokines released in chronic upregulation of immune response have also been shown to suppress Growth Hormone and the insulin Like Growth Factor 1 (iLGF1) responsible for linear growth in children hence further impairing growth in children (Witkowska-Sędek & Pyrżak, 2020).

In pregnancy, exposure to environmental contaminants has been shown to interfere with citation of the placenta by interfering with trophoblast migration (Rosen et al.,2018). Impaired placentation is associated with poor remodelling of the spiral uterine arteries, a key finding in preeclampsia.

Impaired spiral arteries also translate to poor maternal-foetal perfusion of essential nutrients, leading to impaired intrauterine foetal growth characterised by preterm birth and low birthweight.

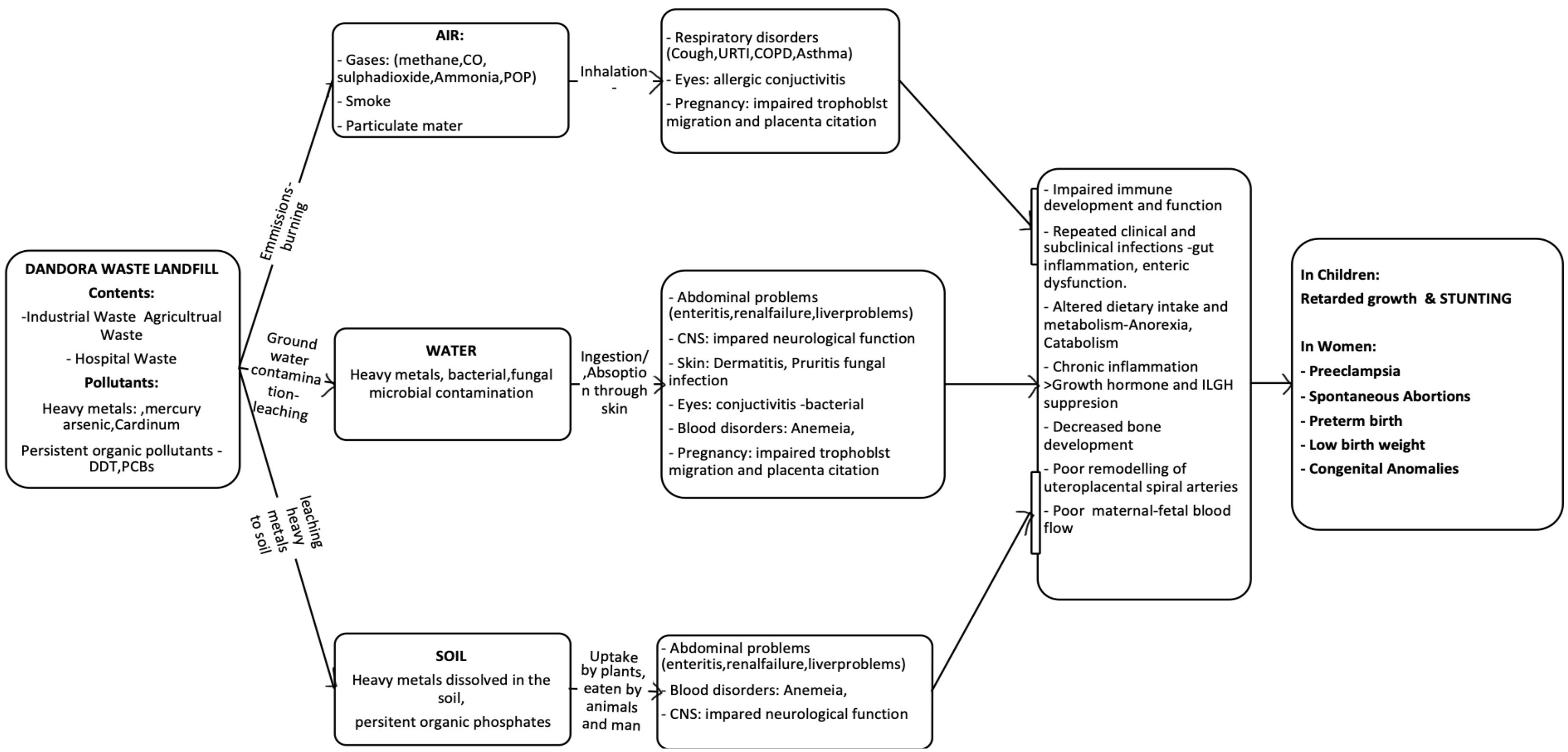

Figure 1: Conceptual Model

CHAPTER THREE

3.0 METHODOLOGY

Introduction

This methodology section addresses the techniques employed in conducting this study. It outlines the tools, the process of data collection, and the subsequent data analysis.

3.1 Study Design

This study was a comparative cross-sectional investigation that involved the collection of social demographic, clinical symptoms, and anthropometric-related data from selected respondents, categorized into two groups based on their exposure to the Dandora open dumpsite.

3.2 Study Area

3.2.1 Exposed Study Area: Korogocho

The chosen study site was Korogocho A village, situated in the Korogocho slum (see Appendix IV). Korogocho, translating to "shoulder to shoulder" in Swahili, stands as one of Kenya's largest slums within Kasarani Subcounty, approximately 11 kilometers from the capital city, Nairobi. Hosting around 200,000 residents in its 1.5-square-kilometer expanse, the slum comprises eight villages: Korogocho A, Korogocho B, Nyayo, Gitathura, Gorgon A, Grogon B, Kisumu Ndogo, and Highridge.

Positioned adjacent to Nairobi's largest dumpsite, the Dandora dumpsite, Korogocho faces an especially significant impact. Specifically, Korogocho A village, purposively selected for this study, is less than 50 meters from the Dandora dumpsite, aligning with the predominant wind direction from the dumpsite (Nairobi & IFRA, 2011).

The selection of Korogocho A village was deliberate due to its heightened likelihood of receiving the highest concentration of wind-dispersed pollutants and increased environmental pollutants, given its proximity to the dumpsite. Notably, Korogocho slum is recognized for having one of the highest rates of malnutrition in Kenya (De Vita et al., 2019).

3.2.2 Unexposed Study Area: Kibera.

Located 5 kilometers from the capital city Nairobi, Kibera slum stands as one of the largest slums in Africa (see Appendix IV). The name "Kibera" originates from the Nubian language, specifically "Kibra," which translates to "Forest." This area was initially settled by the British government after the First World War (Desgroppes & Taupin, 2011). Comprising 14 informal villages—Olympic, Soweto West, Soweto East, Gatwekera, Raila, Karanja, Kisumu Ndogo, Makina, Kambimuru, Mashimoni, Lindi, Laini Saba, Kianda, and Silanga (Mutisya, n.d.)—Kibera slum is estimated to be home to around 250,000 people, occupying a 2.5-square-kilometer area (Map Kibera Project, 2013). Approximately 40% to 50% of this population consists of children and youth under 18 years old (Amélie & Sophie, 2019).

Kibera slum shares a sociodemographic profile and childhood malnutrition levels similar to the study population in Korogocho (Njoroge N, 2017). The key distinction lies in the absence of an unregulated waste dumpsite, making Kibera the chosen unexposed population for this study.

3.3 Study Population

The study recruited children aged between 6 and 12 years old, along with their mothers or caregivers, from two distinct populations distinguished solely by their exposure status to environmental pollution linked to an unsolicited waste dumpsite – specifically, the

Dandora dumpsite. Participants exposed to the Dandora waste dumpsite were chosen from Korogocho A village in the Korogocho slum, constituting the exposed (study) population. The study populations from the two areas under investigation, namely Korogocho slum and Kibera slum, exhibited close similarities. Both groups lived in conditions of abject poverty, experienced overcrowding, had poor environmental sanitation, and lacked access to clean water.

3.4 Inclusion Criteria

Children between the ages of 6 and 12, encompassing both male and female genders, are the focus of this study. Specifically, the study targets those residing in the selected informal settlements of Korogocho (for the exposed group) and Kibera slums (for the unexposed group) for a minimum of 5 consecutive years leading up to the study. During this period, these children spent over 75% of their time in the respective study areas, and their participation is contingent upon the consent of their parents or guardians.

Additionally, the study involves female caregivers who have experienced one or more pregnancies between December 1, 2016, and December 31, 2021, leading up to the study date. Their recruitment into the study is contingent upon their consent.

3.5 Exclusion Criteria

Children who had injuries or disability, as well as children with known chronic disease condition were excluded.

Nulliparous women and women less than 18 years and more than 45 years were excluded from the study.

3.6 Sample Size Calculation

3.6.1 Children Sample Size Calculation

The study used **G*Power method** to calculate children sample size. The G* power method of sample size calculation makes use of the G* power calculator, which is a free to use statistical software. The software allows for the user to calculate power for several statistical tests such as t-test and Chi-square test, which were applied in this study (How to Determine Sample Size From G*Power, 2021.).

In order to detect an effect size of Cohen's d = 0.5 with 90% power (alpha = .05, two-tailed) (Erdfelder et al., 2009a)(Cohen, 2013), G*Power suggested we needed 70 participants per groups (N = 140) in an independent samples t-test as shown in the figure below. Therefore, the study enrolled 140 children, 70 on the exposed group and 70 on the non-exposed group.

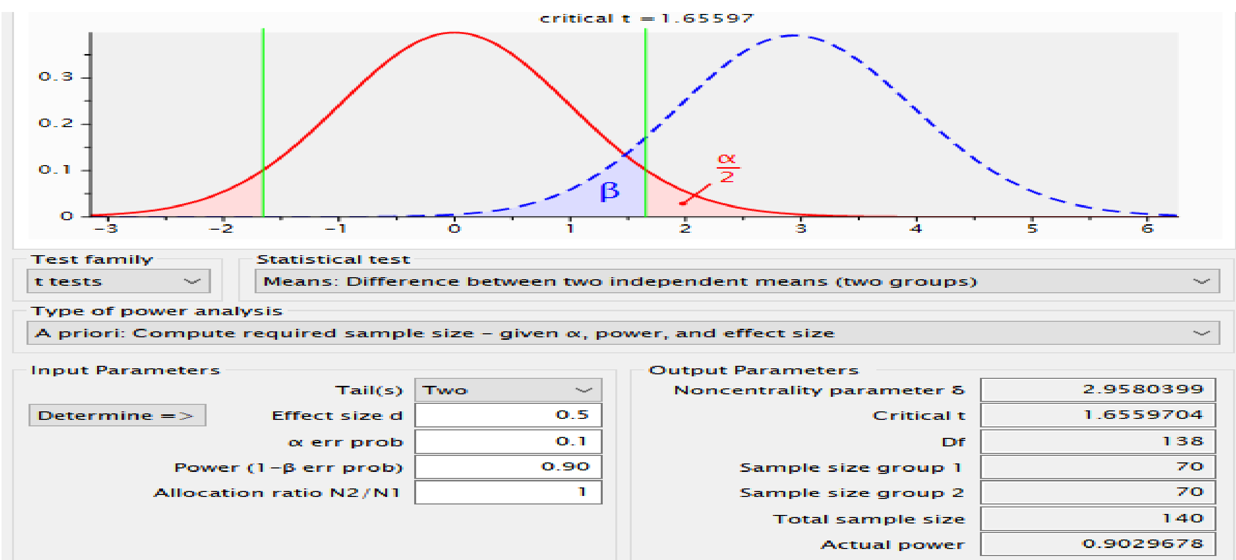

Figure 2: Sample Size Calculation

3.6.2 Women Sample Size Determination

In selecting the female study population sample size, the study employed non-probability convenience sampling methodology for the study population. (Andrade, 2020) noted that "convenience and purposive samples that were randomly drawn from their subpopulation can indeed be probability samples if the findings are generalized only to the subpopulations from which they were drawn". For the study a sample size of 70 women (35 exposed and 35 unexposed) was enrolled. These population would be drawn from the randomly selected households.

The women sample size selected was sufficient to address one of the objectives of the study; determining the pregnancy and birth outcomes of women. In addition to the sample size being adequate, there was reduced exposure to the number of interviews that were conducted reducing risk of exposure to COVID-19 for the principal investigator as well as the research assistants and the women/caregivers selected for the study.

3.7 Data Collection Tools

3.7.1 Questionnaire

The structured questionnaire used to collect social, demographic, clinical symptoms as well as birth outcome details from randomly selected women in the study population was pre-tested during the pilot stage of the research in Kibera. Any errors and poorly understood questions in the questionnaire were revised to facilitate correct response from the participants, the research assistants were also able to familiarize themselves with the tool.

The social demographic details collected from the women/caretakers in the study households included: House building material, education level, occupation, length of stay in the area and average monthly income.

Clinical symptoms: The questionnaire section on clinical symptoms collected information on presence or absence of self-reported clinical symptoms within a period of past 3 months among the children population. Some of the symptom categories that had been reported in a similar study by Norsa'adah et al., (2020)include: Itching or irritation in the eyes, Skin rashes, Itching or irritation of nose, Headache, Excessive tiredness of doing daily chores, Excessive day time sleepiness, Sore throat, Diarrhoea, Stomach-ache and Coughing.

Maternal and child health - Birth outcome history: In the last portion of the questionnaire, mothers were asked about their childbirth history for the period of the last five years to the study date. The details asked included; number of children she has had withing the last five years, complications experienced during delivery, birthweight of the babies, child death which included stillbirths, neonatal deaths and early infant deaths, abortion and congenital malformations in the new-borns.

3.7.2 Anthropometry

Anthropometric measurements are defined as "non-invasive quantitative measurements of the body" and it provides important details on the nutritional status of a child or adult. Anthropometry is important in evaluating the overall growth and development of a child and gives an accurate reflection of a child's health and wellness (Casadei & Kiel, 2022).

An anthropometric data recording sheet pretested during the pilot stage of the research in Kibera was used to document anthropometric measurements of randomly selected children aged 6-12 years. Anthropometric data which included: weight to the nearest 0.25 Kgs and height to the nearest 0.25 centimetres was collected by trained research assistants using a calibrated weighing scale model **TCS-200-RT** and a stadiometer respectively. The results of these measurements were used in calculating mean Height, Weight, Mean Height for age Z-score, Mean Weight for age Z-sore and Mean BMI for age Z-score (BMI kg/m2).

The anthropometric data was collected using electronic Case Record Forms (eCRFs) designed and managed in a secure online database using the Open Data Kit (ODK) application, with research assistants using tablets to complete the eCRFs based on the contents of the participants.

3.7.3 Description of the Procedure

Physical Growth Determination:

Measurement of the weight was carried out using a calibrated digital weighing scale model TCS-200-RT. Height was measured by obtaining the highest distance from the ground to the highest point of the head in standing position without shoes and feet together using a stadiometer.

Anthropometric indices (weight and height) were calculated and reported in age-appropriate Z-scores (body mass index (BMI kg/m^2) (BAZ), height for age (HAZ) and weight for age (WAZ) weight for height (WHZ) using the WHO 2007 growth standards. (Z-scores is a measure of the number of standard deviations (SD) a value is from the mean).

Children were further categorized depending on their nutritional status in comparison to the median of a WHO reference population into the following groups: well nourished, stunted, wasted or underweight (de Onis & Blössner, 1997).

Z-scores were interpreted as follows:

- -1> HAZ/WAZ/ < 0 Normal (well-nourished)
- -2 >HAZ/WAZ < -1 Marginally Stunted (mildly Malnourished)
- -3 >HAZ/WAZ <-2 Moderately Stunted (moderately Malnourished)

- HAZ/WAZ < -3 Severely Stunted (severely Malnourished)

Body mass index Z score (BAZ):

- < −3 Z-score: Severe malnutrition
- ≥ −3 and < −2 Z-score: Moderate malnutrition
- ≥ −2 z-score and ≤ +1 Z-score: Normal nutritional status
- +1 and ≤ +2 Z-score: Overweight
- +2 Z-score: Obesity

The indices (BAZ, WAZ, HAZ,) are outcomes that assess different malnutrition forms in children. Height for age Z Score (HAZ): a low HAZ score of (< –2 SD) means Stunted growth, which indicates a child has had long-term nutritional deficiency or a chronic illness. Weight for age Z score (WAZ): A low score (<–2 SD) means Wasting which indicates recent or severe weight loss(*Malnutrition*, n.d.).

3.7.4 Data Management

Data collected was exported to excel and finally to STATA version 15 where it was cleaned and managed. To validate the data entry process, the Electronic Case Report Forms (eCRFs) were programmed with online validation checks, automated range and logic checks to identify any data entry mistakes before they are saved. All devices used for data entry, laptops or tablets, were encrypted and password protected.

3.7.5 Data Entry and Validation

To prevent errors in data, all data collected during the day by the investigators was reviewed in the evening for any obvious outliers and impossible entries such as age, weight or height that was deemed impossible for the study population. The (eCRFs) also had a provision for data validation which along with the investigators input ensured only quality data reflecting the actual measurements taken was analyzed.

The data was then transferred from the eCRFs for analysis on the computer using STATA version 15.

For qualitative information, the information was reviewed with each word noted. The details were then coded in to respective themes for analysis.

3.7.6 Data Analysis

Data analysis was done using STATA version 15 after cleaning and coding it. With all available data included in the analyses. Descriptive statistics was used to handle the demographic characteristics, with generation of percentages and rates for the various underlying specific objectives and with the use of graphs and tables.

Anthropometric indices were calculated and reported in age-appropriate Z-scores (body mass index (BMI kg/m^2) (BAZ), height for age (HAZ) and weight for age (WAZ) weight for height (WHZ) using the WHO 2007 growth standards. Then further categorization depending on the nutritional status in comparison to the median of a WHO reference population into the following groups: well nourished, stunted, wasted or underweight was done.

Chi -square test of association was used to assess relationship and level of significance between area of residence (exposed/non-exposed) and the sociodemographic characteristics as well as the pregnancy outcomes. To detect differences in the growth status between the exposed and the unexposed population.

Independent t-test was used to compare calculated means from the anthropometric scores obtained: For the anthropometric scores, Z-scores had been calculated and summarized descriptively showing means and standard deviations.

All statistical tests were carried out at 0.05 (p=0.05) level of significance (Erdfelder et al., 2009b).

3.8 Sampling Procedure

Participants not exposed to the environmental pollution related to an unsolicited waste dumpsite were randomly recruited from Laini-Saba village in Kibera slum. This was the unexposed population. Participants from the exposed population were drawn from Korogocho A, selected due to its close proximity to the Dandora open dumpsite.

Selection of study participants was restricted to households having at least one (1) child aged 6-12 years and one (1) woman/caregiver meeting the inclusion criteria.

Where more than 1 child in a household met the inclusion criteria, simple random sampling method was used to choose the study participant for enrolment. For this, numbered and folded pieces of paper according to the number of eligible children was drawn and placed in a container by the research assistant, after which the eligible children were asked to draw from the container randomly and whoever picked the lowest number was enrolled for the study

3.8.1: Korogocho Slum (Exposed study population)

Korogocho slum has a total of Eight villages, namely: Kisumu Ndogo, Grogon-A, Grogon-B, Korogocho-A, Korogocho-B, Highridge, Gitathura and Nyayo. Of these eight villages, KorogochoA was purposively selected from other villages in the wider Korogocho slum due to its close proximity to the Dandora dumpsite. The village is situated within 50 meters of the dumpsite and largely exposed to higher levels of toxic emissions from the dumpsite by virtue of its close proximity. The village is also in the predominant wind direction from the dumpsite and hence exposed to high levels of wind dispersed pollutants emanating from the dumpsite.

All accessible households in KorogochoA village totaling 446 were visited by the principal investigator along with the research assistant accompanied by a local leader appointed from the area chief’s office. A typical household in KorogochoA consisted of individuals either a man and woman along with their children living in a single room house, which was the case in most households, or only a woman living with her children in one single room and in few cases either a man or a woman living alone in the single room houses. Most houses were single rooms made of bricks with corrugated iron sheets roofing, few of the houses were constructed of tin walls with corrugated iron roofing and others having soil walls with corrugated roofing.

Of the 446 households visited in Korogocho A village, 220 were selected for the study since they had the population of interest, children aged 6-12 years and women who were either mothers or caretakers of the children and both fit the inclusion criteria for the study. These households were purposively marked with numbers from house numbered one (1) which was located at the northern most end of the village, at a slight elevation through to house numbered 220 at the southern end of the village which was on a level plane, with consideration for ease of carrying the research equipment and accessibility to the households, which was easier moving from up - down.

The selection of respondent households was done through systematic random sampling, whereby the total number of households (220) selected was divided by the required sample size of (70) for children aged 6-12 years and (35) for women, with the result of an average of 3 and 6 respectively.

Systematic random sampling was used to recruit one child aged between 6 -12 years and randomly enroll him/her into the study from every 3rd household and in every 6th household, one child along with her mother/caregiver were randomly enrolled starting from house number one (1).

Only one child per household was recruited for the study. In instances where a household was found to have more than one (1) eligible child, simple random sampling was used in selecting the participant for the study. For this, numbered and folded pieces of paper according to the number of eligible children was drawn and placed in a container by the research assistant, after which the eligible children were asked to draw from the container randomly and whoever picked the lowest number was enrolled for the study. For households that declined to consent, the researcher moved on to the immediate next house.

The 35 randomly enrolled women were invited to take a structured interview to analyse the social demographic characteristics, their past 5 years birth history as well as respond on the clinical symptoms experienced by their children, who had as well been recruited in the study.

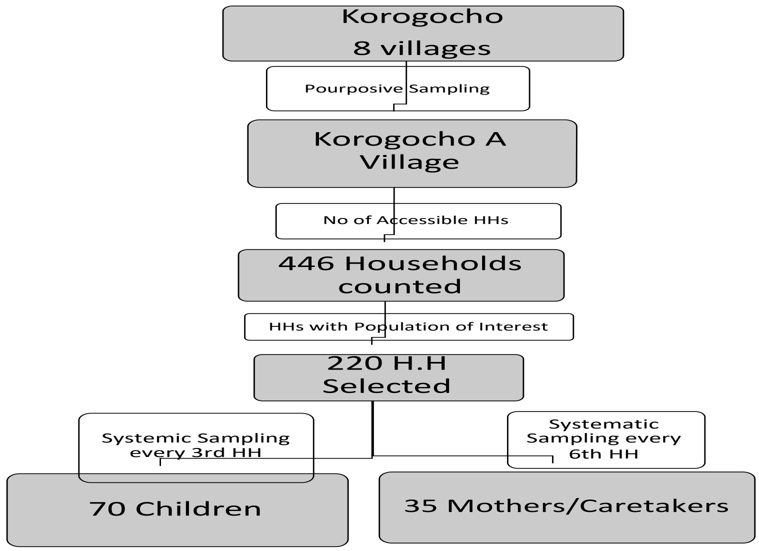

Figure 3: Sampling Korogocho Slum

3.8.2 Kibera - Laini Saba (unexposed study population)

Kibera selected as the unexposed population has a total of fourteen (14) villages, namely: Gatwekera, Raila, Karanja, Lindi, Olympic, Makina, Kambi, Soweto West, Kambi Muru, Soweto East, Silanga, Mashimoni, Laini Saba and Kisumu Ndogo.

Selection of one study village from the fourteen (14) villages was carried out using the lottery method of random sampling. To accomplish this, names of the 14 villages were written on pieces of paper which were then folded and placed in a ballot box, the research assistant was then blindfolded and allowed to draw only one piece of folded paper. The randomly picked paper with the selected village name, Laini Saba was then read out to the rest of the team as the village randomly picked for the study.

The principal investigator along with the research assistant and an area representative assigned to the study team by the area Chief, surveyed Laini Saba village and purposively selected households that were along both sides of the major all-season path that runs through the village transecting it into two.

A total number of 680 households were visited, of these 430 households had the study population, children aged 6 to 12 years and their mothers/caregivers. These households were numbered with consent from the household heads, starting from the northern most house, purposively selected, being uphill followed by households on both sides of the village path downhill, this was done after considering the ease of access in carrying out the study.

Systematic random sampling was done to select the study households from the 430 eligible households. This was achieved by dividing the total number of eligible households by the required sample size of (70) for children aged between 6 – 12 years and (35) for mothers/caregivers. This gave us an average of 6 and 12 households. Thus, the study randomly enrolled one child in every 6th household but in every 12th household the study randomly enrolled one child and the mother/caregiver, with the count starting from house number (one) 1.

Only one child per household in Kibera -Laini Saba was recruited for the study. In instances where a household was found to have more than 1 eligible child, simple random sampling was used in selecting the participant for the study.

For this, numbered and folded pieces of paper according to the number of eligible children was drawn and placed in a container by the research assistant, after which the eligible children were asked to draw from the container randomly and whoever picked the lowest number was enrolled for the study. For households that declined to consent, the researcher moved on to the next house.

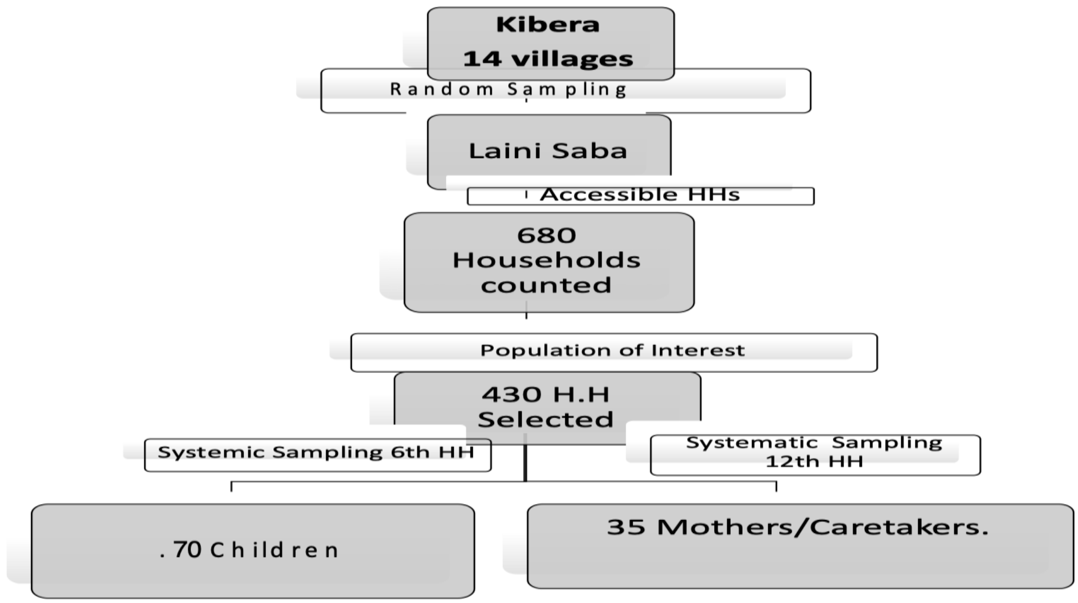

Figure 4: Sampling Kibera Slum.

3.9 Piloting

Households in Kibera slums Olympic village were conveniently selected for the pre-testing of the research questionnaire, electronic case record system capturing anthropometric data, and the use of a weight and height scale. A total of ten households were selected for the pilot study. Simple random sampling was employed to select five women and ten children from these households. The principal investigator listed house numbers on pieces of paper, folded them, and placed them in a box. Subsequently, five pieces of paper with the corresponding household numbers were drawn. The recruited women participants were from the selected households, and in each of the ten households, one child aged between 6 to 12 years was randomly recruited.

Anthropometric measurements (height and weight) were conducted by study assistants, following a demonstration by the principal investigator to ensure the correct technique was consistently used for reliable and accurate results. No major challenges were encountered during the pilot study..

3.10 Validity

To ensure the generation of research findings adhered to sound scientific research methods, the following processes were implemented. Purposive sampling was employed to select the study cluster (village) in the exposed population, specifically choosing the village closest to the Dandora waste landsite (within 50 meters) and in the predominant wind direction. In the unexposed population, random selection of the study cluster (village) was conducted, providing an equal chance for any one of the 14 villages in Kibera to be selected.

In both study groups, systematic sampling was utilized to identify and obtain the study population. All research instruments underwent pretesting and piloting before their deployment in the study.

The study utilized a medical electronic weigh scale model TCS-200-RT, equipped with an inbuilt stadiometer that demonstrated a high degree of accuracy and self-calibration. Additionally, children were weighed barefoot and with light clothing on.

3.11 Reliability

In ensuring the study results would be reproducible using the same methodology and instruments the following key approaches were used in the methodology.

The collection of data in the field involved two research assistants accompanied by the principal investigator. Measurements were repeated twice with an average of readings being recorded as the final score.

In addition, details of the maternal birth history were counterchecked/confirmed on the antenatal clinic card ensuring that right information was captured.

3.12 Ethical Issues and Logistics.

Ethical clearance for the research was sought and obtained from Moi University Institutional Research and Ethics Committee (IREC) and the National Commission for Science and Technology (NACOSTE) Written consent was also sought from the mother/caregiver of the child in the selected household after careful explanation of the study including the purpose as well as the measurements that will carried out on the child. Only consenting mothers/caregivers as well as children of consenting mothers/caregivers were recruited in the study.

In Korogocho area, a qualified research assistant with a background in nutrition was recruited for the study. The research assistant was responsible to carrying out the anthropometric measurements of all the children recruited into the study under the supervision of the principal investigator. The principal investigator trained the research assistant and the community volunteer who would assist in the correct method of carrying out the anthropometric assessments, he also carried out the systematic random selection of households for the study. The principal investigator was also responsible for interviewing the selected participants and selection of the study households. In addition, the principal investigator was also responsible for ensuring the study was carried out in an ethically sound way and ensuring consent was obtained from the parents and guardians of the children participating.

The study enrolled the assistance of a community health volunteer who was drawn from the selected study area and well known to the residents of the area. The community health volunteer was appointed by the area chief and seconded to assist our team. The community volunteer's role was to guide the study team through the various households in the study area and introduce the team to the community as well as assisting in allaying any negative preconception from the community.

The community volunteer also guided the team in understanding the set-up structure on the slum and was an important guide in the sampling process of the households as the team had to number the households for convenience of sampling.

The team would meet at the chief's camp for brief planning and proceed to the community and there after meet at the same place to review the activities and achievements of the day.

Similar approach was also used in Kibera. The community health volunteer was appointed by the area chief to assist the research team's activities in the community with the meeting point being at the chief's camp where pre and post community activities review for the day was carried out.

Movement and activities within the community were caried out with strict adherence to the ministry of health directives for COVID-19 which included safe distancing and wearing of mask when carrying out interviews, sanitizing of the research instruments after each height and weight measurement.

3.13 Dissemination of Information

Results of the study will be disseminated to the Nairobi County Public Health and Sanitation Department, NEMA with recommendations to the same.

The study results and recommendations will also be submitted to the United Nations Habitat Office in Nairobi. There will also be submission of manuscripts to a peer-review journals for publication.

CHAPTER FOUR

RESULTS

4.0 Introduction

The results of the study are presented below as follows. Section 4.1 is a description of the sociodemographic characteristics of the participants in the study, which provides details of the educational level, housing characteristics, income as well as the number of rooms in the household unit.

Section 4.3 details the birth outcome of the women study population which includes the number of miscarriages, complications during pregnancy and delivery, the number of children who died within 5 years of birth, gestation age of pregnancies, birth weight of infants and presence of any congenital anomalies among children born within the last five years to the date of the study (1st December 2016- 31st December 2021).

Section 4.4 Presents the clinical symptoms, characteristics of the children study participants and gives a breakdown of 10 key clinical characteristics that the caregivers expressed as the commonest symptoms experienced by their children by reason of their residence.

Section 4.5 Presents the anthropometric measurement findings of the children in the study and further expressing the findings in age and gender appropriate WHO Z-scores.

4.1 SOCIODEMOGRAPHIC CHARACTERISTICS BY COMMUNITY

4.1.1 Characteristics of the Women/Caretakers

The study randomly recruited 70 women/caretakers from 650 eligible households (430 Kibera, 220 Korogocho) in the study areas. The mean age of women in Kibera was 39.6, with a standard deviation of 4.2, while the mean age of women in Korogocho was 32.6.

with a standard deviation of 2.8. These were mothers or caretakers to children aged six years to 12 years who were recruited into the study.

Table 1: Comparison of the Social Demographic Characteristics Between the Exposed and the unexposed Population

Characteristic:	**Kibera (n=35)**	**Korogocho (n=35)**
Mean age of Women	39.6 yrs (SD4.2)	32.6 (SD2.8)
Mean Parity	2 (SD 0.7)	3 (SD1.4)
Mean age of children	8 Years (SD0.08)	9 years (SD2.07)
Education Level **Competed primary school education**	88.9%	100%
Household income (Household income < 5,000ksh)	20%	42.86%
Household Building Materials:	47% Made of soil	81% Corrugated iron
Number of Rooms: Single room	58.82%	69.44%

4.1.2The Education Level of Mothers/Caregivers

The study assessed the level of education of the mothers/caregivers using a set of structured questions. These included details of any formal schooling and the level attained if the study participant had attended formal schooling as per the country's educational system. The level of education was classified into; no formal schooling, primary school graduate, high school graduate and college graduate.

The education level between the two groups varied marginally with the difference not statistically significant (Chi-Square P-value =0.168>0.05). 100 % of the women/caregivers in Korogocho reported to have through the formal education system as opposed to 88.9% of women/caretakers drawn from Kibera. 11.1% of women/ care givers in Kibera reported to have had no formal education.

4.1.3 Household Income

The study also compared the monthly household incomes of women/caregivers from the two study groups. The income was the gross household income, which was categorized into four categories. Those households earning less than 5,000 Ksh, households earning from 5000ksh to 15,000 Ksh, and households earning from 15,000 Ksh to 25,000 Ksh.

There was a statistically significant difference in the income levels of Women/caregivers representing households in the two study groups (Chi-Square P-value =0.012<0.05). The number of households that reported a combined household income of less than 5,000Ksh per month was higher in Korogocho at 42.86% compared to Kibera which had only 20% of the study households earning less than 5,000Ksh per month. Meaning that Korogocho had a higher poverty level as compared to Kibera.

4.1.4 Number of Rooms

There was a significant difference (Chi-Square P-value =0.027<0.05) in the number of rooms that each household had. In Korogocho 69.44% of the households were living in a single roomed house compared to 58.82% in Kibera. In addition, 27.78% of households in Korogocho were living in two roomed houses compared to only 14.71% in Kibera.

4.2 BIRTH OUTCOME CHARACTERISTICS

4.2.1 Introduction

The pregnancy, birth outcome and early childhood history of the randomly selected mothers/caretakers of reproductive age was obtained using a pretested structured questionnaire, the mothers/caregivers were also asked to provide the antenatal booklet where available to confirm details of the antenatal and postnatal histories.

Details of the number of miscarriages, complications during pregnancy and delivery, the number of children who died within 5 years of birth, gestation age of pregnancies, birth weight of infants and presence of any congenital anomalies among children born within the last five years to the date of the study (1st December 2016- 31st December 2021).

The mean age of the randomly selected women in Kibera was 39.6 with a standard deviation of 4.2 while the mean age women in Korogocho was 32.6. with a standard deviation of 2.8. The mean parity of mothers randomly selected from Korogocho was 3 with a standard deviation of 1.4 while the randomly selected mothers in Kibera had a mean parity of 2 with a standard deviation of 0.7.

4.2.2 Number of Miscarriages

In a period of 5 years (1st December 2016 to 31st December 2021), mothers randomly drawn from Korogocho had a higher rate of fetal wastage (miscarriage) compared to mothers drawn from Kibera.

Women drawn from Korogocho lost 7 (19.44%) of their pregnancies before 28 weeks of gestation, this was higher than Kibera which recorded 1 (2.94%) miscarriage (Chi-square P-value =0.05=0.053).

Table 2: Comparison of the Number of Miscarriages Experienced by Women in the Exposed and the unexposed Population Within the Last 5 Years

		Frequency (%)		
Characteristics	Overall	Kibera	Korogocho	Chi-Square test P-Value.
No of Miscarriages in The Last Five Years	**N=70**	**N=35**	**N=35**	
No	**61 (87.14)**	**34 (97.06)**	**27 (77.78)**	
Yes	**8 (11.43)**	**1 (2.94)**	**7 (19.44)**	**0.053**
Missing antenatal/clinical record/appointment card.	1 (1.43)	0 (0.00)	1 (2.78)	

4.2.3 Complications During Delivery.

History of complications experienced by the mothers during the process of delivery such as excessive bleeding, convulsions, blood transfusion during or after delivery, prolonged labor or perineal/cervical tears was obtained.

From the history, mothers selected from Korogocho had significantly higher maternal related complications, reporting 7 (19.44%) birth related complications, namely 3(8.14%), postpartum hemorrhage, 2(5.4%) convulsions, 1(2.7%) postpartum infection (puerperal sepsis), 1(2.7%) cervical tear. compared to 2 (5.9%) excessive bleeding, reported in mothers drawn from Kibera (Chi-square P-Value=0.024<0.05).

Eight (8) of the women reported to have had a miscarriage.

Table 3: Comparison of the Complications Experienced During Delivery in the Last 5 Years Between Women in the Exposed and the unexposed Population

		Frequency (%)		
Characteristics	Overall	Kibera	Korogocho	Chi-Square test P-Value.
Presence/Absence of Complications During Delivery	**N=70**	**N=35**	**N=35**	
No	54 (77.14)	32 (91.18)	22 (63.89)	0.024
Yes	9 (12.86)	2 (5.88)	7 (19.44)	
Missing (reported as miscarriage)	**8 (11.43)**	**1 (3.03)**	**7 (23.33)**	

4.2.4 Number of Children Who Died Within 5 Years of Birth.

The number of children that the mothers reported had died within the last five years (1st December 2016 to 31st December, 2021) were recorded. These were children who had died before cerebrating their 5th birthday and consisted of all intrauterine fetal deaths, neonatal, infant deaths and under 5 deaths. Mothers from Korogocho did not report of any childhood death within the period 0 (0%), but in Kibera, mothers reported 2 (2.9%) deaths which were due to pneumonia. There was no statistically significant difference in the number of childhood deaths between the two groups (Chi-square P-value = 0.572>0.05).

With regards to the number of children who died within 5 years of birth. The exposed population (Korogocho) had none 0 (0%) while in the unexposed population, 2 (5.71%) death was reported.

Table 4: Comparison of The Number of Children Who Died Within the Last 5 Years to the Study Period Between Women in the Exposed and the unexposed Population

		Frequency (%)		
Characteristics	Overall	Kibera	Korogocho	Chi-Square test P-Value.
No of Children That Died Within 5 Years of Birth	**N=70**	**N=35**	**N=35**	
From 1/12/2016 to 31/12/2021	2 (2.86)	2 (5.71)	0 (0.00)	0.572
None	**68 (97.14)**	**33 (94.29)**	**35 (100)**	

4.2.5 Preterm births among women

The total number of reported preterm births among women drawn from the study population in Korogocho (exposed) and Kibera (unexposed) was obtained. Mothers who delivered before 37 completed weeks of pregnancy were considered to have preterm birth and those who delivered at more than 38 weeks were considered as having had term deliveries. Of the total 70 mothers enrolled to the study only 40 mothers, 18 drawn from Kibera and 22 drawn from Korogocho had delivered within the last 5 years.

Of this, preterm birth (birth before 37competed weeks) was recorded in 3 of the deliveries with the highest number 2 (8.89%) being recorded in Kibera and only 1 (2.78%) in Korogocho. This difference was however not statistically significant (Chi-square P-value = 0.572>0.05).

Table 5: omparison of the Gestation Age of Pregnancies Between Women in the Exposed Population and the unexposed Population

		Frequency (%)		
Characteristics	Overall	Kibera	Korogocho	Chi-Square test P-Value.
Gestation age of pregnancies	**N=70**	**N=35**	**N=35**	
<37weeks	3 (4.23)	2 (8.89)	1 (2.78)	0.572
>37Weeks	37 (52.86)	17 (47.06)	20 (58.33)	
N/A (No term pregnancy within last 5 yrs/pregnant during the study.)	**30 (42.86)**	**16 (47.06)**	**14 (38.89)**	

4.2.6 Foetal Birth Weight

The birth weight of all children born within the last 5 years to mothers in the selected study population was obtained. The information on the outcome of delivery was initially obtained from the mothers' recollection and then confirmed from the antenatal clinic record book. From the 70 (100%) mothers in the study, only 40 (57.17%) reported to have had a term delivery in the period under study, 30 (42.86%) reported to have had either a miscarriage or were pregnant at the period of the study.

A total of 6 (8.57%) low birth weight deliveries were reported 3 (8.57%) from Kibera (unexposed population) and 3 (8.57) from Korogocho. There was no statistically significant difference in birth weights between the two-population (Chi-square P-value = 0.651>0.05).

Table 6: Fetal Birth Weight Comparison Between the Exposed Women Population and the unexposed Population

		Frequency (%)		
Characteristics	Overall	Kibera	Korogocho	Chi-Square test P-Value
Birthweight	**N=70**	**N=35**	**N=35**	
<2.5	6 (8.57)	3 (8.57)	3 (8.57)	0.651
>2.6	34 (48.57)	16 (45.71)	18 (5.42)	
	30 (42.86)	**16 (47.01)**	**14 (38.89)**	

4.2.7 Foetal Congenital Anomalies:

One congenital anomaly was reported of the 40 deliveries that were recorded in the study period from the two-study population. The congenital anomaly was reported in Kibera 1 (2.94%), with none reported in Korogocho. This difference however not statistically significant (Chi-square P-value = 0.583>0.05).

*Table 7: Comparison of the Occurrence of Fetal Congenital Anomalies Between Women in the Exposed and the unexposed Population***:**

		Frequency (%)		
Characteristics	Overall	Kibera	Korogoch	Chi-Square test P-Value.
Gestation age of pregnan-	**N=70**	**N=35**	**N=35**	
No	39 (55.71)	17 (42.50)	22 (55.01)	0.583
Yes	1 (1.43)	1 (2.94)	0 (0.00)	
	30 (42.86)	**17 (47.01)**	**13 (38.89)**	

4.3 CHILDREN POPULATION:

4.3.1 Characteristics of Children:

A total of 140 children were randomly selected from 650 eligible households (430 Kibera, 220 Korogocho) and enrolled into the study. These were children aged between 6 years to 12 years and had resided in the study area Kibera (exposed) and Korogocho (unexposed) for a consecutive period of not less than 5 years with more than 75% of the time spent in the study areas.

Of the 140 children selected, 70 were drawn from Kibera and 70 from Korogocho. The median age for the children from Kibera was **8** years with a standard deviation of (**0.08**), while children drawn from Korogocho had a median age of **9.2** years with a standard deviation of (**2.07).**

4.3.2 Clinical Symptoms Experienced by Children

All Seventy (70) mothers/caregivers participating in the study responded to one of the questionnaires administered by the principal researcher and the research assistant. The questionnaire gathered information on the frequency of occurrence of clinical symptoms among children in the selected study households over a period of 3 months to the study period. If the symptom/complaint occurred more than once every week, then this was regarded as a common clinical symptom and hence given a YES. Symptoms occurring less than once in a week were categorized as NO.

The clinical symptoms experience by the two study populations was as follows:

Table 8: Comparison of the Self-Reported Clinical Symptoms Between the Exposed Children Population and the unexposed Population

	Frequency (%)		
Clinical symptoms experienced:	**Kibera n=35**	**Korogocho n=35**	**P-Value.**
Cough	16(44.12%)	35(100.00%)	0.001*
Itching or irritation in the eyes	1(2.94%)	29(82.85%)	0.001*
Stomach-ache	6(17.14%)	22(62.85%)	0.001*
Headache	0(0.00%)	19(54.28%)	0.001*
Excessive tiredness of doing daily chores	0(0.00%)	15(42.86%)	0.001*
Sore throat	3(8.57%)	13(37.14%)	0.004*
Diarrhea	11(31.42%)	14(40.00%)	0.0474*
Excessive day time sleepiness	0 (0.00%)	6(17.14%)	0.008*
Skin rashes	0 (0.00%)	4 (11.42%)	0.09*
****Chi square test, statistically significant <0.05.***			

4.4.3 Cough

Cough was the most commonly reported symptom among children residing in Korogocho (exposed population). Of the 70 (100%) respondents, 51 (72.86%) reported their children experienced coughing most of the days. All the respondents from Korogocho 35 (100%) reported cough as a common complaint from their children, with only 16 (44.12) mothers from Kibera expressing cough as being a common complaint among their children.

The difference in occurrence of coughing between the two groups was statistically significant at (Chi-square P-value = 0.001<0.05).

4.5.2 Itching or Irritation in The Eyes

Korogocho had the highest number of children with itching or irritation of the eyes as a frequent complaint recording a total of 29 (82.85%) compared to Kibera, where only 1 (2.94%) mother expressed irritation or itching of the eyes as a frequent complaint by her child. The difference in occurrence of the symptom between the two groups was statistically significant at (Chi-square P-value = 0.001<0.05).

4.4.4 Stomach-ache

The number of children that complained of frequent stomachache was also significantly higher among children in Korogocho 22 (62.85%) compared to children in Kibera 6 (17.14%). The difference in frequency of occurrence of complaints of stomachache in children between the two groups was also statistically significant at: (Chi-square P-value = 0.001<0.05).

4.4.5 Headache

Headache was a serious and common complain among children in the study population 19 (54.28%) mothers from Korogocho noted that headache was a frequent complaint among the children with 0 (0.00%) none of the mothers in Kibera expressing this as a concern among their children. The difference was also noted to be statistically significant. (Chi-square P-value = 0.001<0.05).

4.4.6 Excessive Tiredness of Doing Daily Chores, Excessive Day Time Sleepiness, Sore Throat

With regards to routine daily activities, the mothers/caregivers of the children expressed that their children would frequently complain of feeling tired excessively and sleepy with constant pain in the throat.

These symptoms were more commonly reported among children in Korogocho; Excessive tiredness from doing chores by 15 (42.86%) of the mothers in Korogocho compared to 0 (0.00%) in Kibera, excessive daytime sleepiness by 6(17.14%) of the mothers from Korogocho compared to 0(0.00) from Kibera and sore throat by 13 (37.14) of the mothers from Korogocho compared to 3 (8.57) from Kibera.

The three symptoms were statistically significant at (Chi-square P-value = 0.001<0.05). (Chi-square P-value = 0.008<0.05). (Chi-square P-value = 0.004<0.05) respectively.

4.4.7 Diarrhoea, Skin Rashes, Itching and Irritation of The Nose

Complaints of Diarrhea, Skin rashes, and Irritation of the nose among children in the two groups was less common and did not vary significantly between the two groups. The Chi-Square test value for the three symptoms was: Diarrhea (Chi-square P-value = 0.0474>0.05), Skin rashes (Chi-square P-value = 0.09>0.05) and Irritation of the nose (Chi-square P-value = 0.05=0.05).

4.5 Anthropometric Measurements Results

Anthropometric data of children aged 6-12 years randomly selected from the two study areas Korogocho (exposed population) and Kibera (unexposed population) which included: weight to the nearest 0.25 Kgs and height to the nearest 0.25 centimetres was used in calculating mean Height and Weight, mean Height for age Z-score, mean Weight for age Z-sore and mean BMI for age Z-score (BMI kg/m2). With these results, the children were further categorized depending on their nutritional status in comparison to the median of a WHO reference population into the following groups: well nourished, stunted, wasted or underweight.

The mean weight, height, BMI and height for age Z-score for the two groups was compared and an independent sample t-test used to compare the differences in the groups mean.

4.5.1 Weight

There was a **1.2 kgs** mean difference in weight between the exposed and the non-exposed population. Children from Kibera (non-exposed) were heavier with a mean weight of 27.4

(SD7.1) compared to children from Korogocho, who had a mean weight of 26.3 (SD 5.7). However, the difference in mean weight between the two groups was not statistically significant at (Independent sample t- test) P value = 0.249>0.05

Table 9: Mean Weight Comparison Between Children Aged 6-12 From the Exposed and unexposed Population

Characteristics	**Kibera)**	**Korogocho**	**Independent t-test P-value**
	N =70 (34M/35F)	**N=70 (37M/33F)**	
Weight	Mean (SD)	Mean (SD)	
	27.5 (7.1)	**26.3 (5.7)**	**0.249**

4.5.2 Height

Children drawn from Kibera (unexposed population) were also slightly taller compared to children from Korogocho by an average of **0.2cm**. Although not statistically significant, the exposed children study population registered a mean height of 129.4cm (SD 9.6), while the unexposed children study population registered a mean height of 129.6 cm (SD 9.6) with an independent sample t-test P Value = 0.927>0.05.

Table 10: Mean Height Comparison Between Children Aged 6-12 From the Exposed and unexposed Population

Characteristics	**Kibera**	**Korogocho**	**Independent t-test P-value**
	N =70 (34M/35F)	**N=70 (37M/33F)**	
Height	Mean (SD)	Mean (SD)	
	129.6 (9.6)	**129.4 (9.6)**	**0.927**

4.5.3 Mean Height for Age Z-Score (HAZ)

The mean height for age Z-Score (HAZ) for the study population was -0.41 (0.9) for Korogocho (exposed population and - 0.35 (0.9) for Kibera (unexposed). With a HAZ score between -1 <HAZ <0 the population was classified as normal (well-nourished) according to the NCHS/WHO (2007) growth reference (WHO, 2007). The independence t-test for the group means was not statistically significant with a P value: (Independent sample t test P Value = 0.586>0.05). See table 4.19.

Table 11: Mean Height for Age Z-Score (HAZ) Comparison Between Children Aged 6-12 From the Exposed and unexposed Population

Characteristics	**Kibera)**	**Korogocho**	**Independent t-test P-value**
	N =70 (34M/35F)	**N=70 (37M/33F)**	
Height for age_ Z score (HAZ)	Mean (SD)	Mean (SD)	
	-0.35 (0.9)	**-0.41 (0.9)**	0.586

4.5.4 Weight for Age Z-Score (WAZ)

The weight for age Z- score was also notably different between the two-study population. Children drawn from Korogocho had a marginally lower mean WAZ of - 0.33(1.0) compared to children drawn from Kibera who had a mean WAZ score of -0.23(1.1). Children from the two groups were classified as having a normal nutritional status -1>WAZ<0, according to the NCHS/WHO (2007) growth reference (WHO, 2007). The difference between the two groups was however not significant with an independent sample t test P Value = 0.483>0.05. See table 4.20.

Table 12: Mean Weight for Age Z-Score (WAZ) Comparison Between Children Aged 6-12 From the Exposed and unexposed Population

Characteristics	**Kibera)**	**Korogocho**	**Independent t-test P-value**
	N =70 (34M/35F)	**N=70 (37M/33F)**	
Weight for age Z score (WHZ)	Mean (SD)	Mean (SD)	
	-0.23 (1.1)	**0.33 (1.0)**	**0.483**

4.5.5 Body Mass Index (BMI) for age Z-score (BAZ):

The mean BMI for age Z-score of male children drawn from Korogocho (exposed group) was marginally lower compared to that of children drawn from Kibera (unexposed group). With children drawn from Korogocho having a BAZ of -0.75 (1.3) and children from Kibera having a BAZ score of -0.23 (1.1). the difference in the BAZ for the male population was not statistically significant. The (independent t test P-Value = 0.07>0.05). See table 4.21.

Additionally, the female population also differed slightly in the BAZ, with the children from Korogocho (exposed group) recording a lower mean BAZ of -0.31 (0.9), with children drawn from Kibera recording a BAZ mean of -0.15 (0.9). The mean difference in BAZ scores however between the two groups was not statistically significant with an (Independent t-test P-Value = 0.474>0.05).

Overall, with a mean BMI for age score of between -1 <BAZ< +1, children from both groups were categorized as having a normal nutritional status according to the NCHS/WHO (2007) growth reference (WHO, 2007). See table 4.21.

Table 13: Mean Body Mass Index (BMI) for age Z-score (BAZ)Comparison Between Children Aged 6-12 From the Exposed and unexposed Population

Characteristics	**Kibera)**	**Korogocho**	**Independent t-test P-value**
	N =70 (34M/35F)	**N=70 (37M/33F)**	
BMI for age Z-score (Female) (BAZ)	Mean (SD)	Mean (SD)	
	-0.15 (0.9)	**-0.31 (0.9)**	0.474
BMI for age_z score (Male) (BAZ)	**-0.23 (1.1)**	**-0.75 (1.3)**	**0.07**

CHAPTER FIVE

5.0 DISCUSSION

5.1 Introduction

There is a strong interrelation between the environment we live in and our health. Environmental pollution resulting from unregulated dumping contributes significantly to causation of a wide range of both communicable and non-communicable diseases resulting from contamination of the water, soil and the air. Developing countries account for almost 90% of deaths related to pollution, with air and water pollution being the commonest form of pollution (Osseiran & Chriscaden, 2016).

The objectives of this study were to determine the relationship between open dumpsite related pollution and the physical growth of children aged between 6 years to 12 years as well as the pregnancy and birth outcomes of women residing in Korogocho (exposed group) and Kibera (unexposed group).

5.2 Social Demographic Characteristics of Study Population

5.2.1 Literacy

The literacy levels between the two groups did not differ significantly, Korogocho had higher literacy level compared to Kibera at 100% and 88.9% respectively. According to UNESCO (UNESCO Institute for Statistics, 2020) literacy levels in Kenya in the year 2020 were at 81.5%, however, this is lower than the literacy levels recorded among our two study groups.

5.2.2 Income

The household income between the two communities varied significantly with Korogocho (exposed) having twice the number of households 15 (42.86%) with an income of less than USD 2 per day compared to Kibera 7 (20%).

According to a 2015-word bank report (World Bank, 2015), an average 37.1% of people in Kenya were living below the poverty line, earning less than 2$ per day, however this is slightly lower than the average poverty levels recorded in our study population - Korogocho.

5.3 Birth Outcomes.

5.3.1 Miscarriage:

The birth outcomes of the study population varied between the exposed and the non-exposed population; although not statistically significant, the number of miscarriages that were reported in Korogocho (exposed study group) was higher at 7 (19%) compared to those reported in Kibera (unexposed study group) at 1 (2.9%).

The findings of our study are in keeping with previous metanalysis of 43 studies by (Grippo et al., 2018) on the effects of environmental pollution on the fetus, which noted an increased susceptibility of the fetus during pregnancy to environmental pollution with adverse outcomes including miscarriage and low birth weight.

In another recent study by Silva et al., 2022 in Brazil looking at the effects of environmental pollution exposure and pregnancy outcome.

The study had findings that were in agreement to our study, noting that with women living in areas exposed to traffic related pollution had a higher prevalence of miscarriage at

25.56% compared to women in less traffic pollution exposed areas whose miscarriage prevalence was low at 6.83%.

Additionally, a study carried out by Oyedele & Oyedele, 2017 among residents within the environs of Olusosun waste dumpsite in Nigeria, reported findings that were in agreement with our study findings.

The study noted that an average of 52% of residents within less that 100 meters to the dumpsite reported having had a miscarriage compared to only 20% among residents far (more than 500meters) from the dumpsite.

5.3.2 Complications During Pregnancy and Delivery

Our study noted that there was a significantly higher number of pregnancy and birth related complications among mothers in the exposed population (Korogocho) compared to those from the unexposed population (Kibera). The birth related complications reported in Korogocho were postpartum hemorrhage 3(8.14%), Eclampsia (pregnancy induced hypertension) 2(5.4%), postpartum infection (puerperal sepsis), 1(2.7%) and cervical tear 2(5.9%) with 2 (5.9%) cases of postpartum hemorrhage reported in mothers drawn from Kibera (Chi-square P-Value=0.024<0.05).

These study findings were in agreement with several studies looking at the effects of environmental pollution on maternal outcomes. In one of the studies carried out in Niger Delta,(Oghenetega et al., 2022) noted that exposure to hydrocarbons related environmental pollution was associated with high levels of maternal related complications such as postpartum hemorrhage and Premature Rupture of Membranes (PROM) in addition, a systematic review and meta-analyses of 17 studies by (Pedersen et al., 2014) on the effects of exposure to ambient air related environmental pollution on maternal outcomes. Noted that, for every 5mcg/m^3 increase in PM 2.5. (particulate matter) there was a 1.57 (95% confidence interval, 1.26–1.96) odds of increase in the number of pregnancy-induced hypertensive disorders and a 1.31 (95% confidence interval, 1.14–1.50) odds of an increase in the number of preeclampsia cases. Simply put, for every 5mcg/m^3 increase in the levels of air pollution, a pregnant women had a 57% increase in the odds of having pregnancy-induced hypertensive disorders and a 31% increase in the odds of having pre-eclampsia.

5.3.3 Foetal Birth Weight

In our study, the exposed population Korogocho reported fewer low birth weight outcomes with 1 (2.78) low birth weight recorded compared to Kibera (unexposed) with 2 (8.89%). The results obtained in our study were however in contrast to similar studies which noted significant association between exposure to environmental pollution and low fetal birth weight.

In one multi-African countries study by Bachwenkizi et al., (2022b) , exposure high levels of outdoor pollution quantified by measuring the levels of fine particulate matter ($PM_{2.5}$), was associated with increased odds of low birth weight and preterm birth, odds ratio (OR) of 1.28 (95% CI: 1.23, 1.34) and 1.08 (95% CI: 1.01, 1.16) respectively.

In several other studies carried out in high income countries, (Y. Liu et al., 2019) in Guangdong China, looking at the association between air pollution, preterm birth and low birth weight, the study noted that there was an increased odds ratio for low birth weight of 1.028 (95% CI 1.00–1.06) and 1.018 (95% CI 1.01–1.04) for every 10mcg/m3 increase in PM2.5 and PM10 levels respectively. The study in concluding noted that, significant levels of air pollution were associated with adverse birth outcomes such as preterm birth and low birth weight.

(Ha et al., 2001) also looking at the association between air pollution and low birth weight in Seoul Korea noted that, exposure to various air pollutants such as carbon monoxide, nitrogen dioxide, Sulphur dioxide and total suspended particles in the first trimester of pregnancy was a risk factor for low birth weight. Further noting that, for each interquartile increase in the concentration of carbon dioxide in the first trimester there was a 1.08 relative risk of low birth weight. Similarly, every interquartile increase in the concentration of nitrogen dioxide, Sulphur dioxide and total suspended particles was associated with a relative risk of 1.07, 1.06, 1.04 respectively for a low-birth-weight outcome.

5.4 Clinical Symptoms.

The results of the clinical symptoms experienced by the population indicated that coughing, eye irritation and stomach-ache were the most common symptoms experienced with an average 100%, 81% and 61% of the population being affected respectively. However, the spectrum of symptom complaints was found to be 50% less in the unexposed population as compared to the exposed population. These findings were in agreement with studies carried out at the Dandora dumpsite and Olusosun Waste Dumpsite in Nigeria which recorded similar findings.

In one of the studies carried out by (Njoroge G. Kimani, 2007) at the Dandora Dumpsite, looking at the impact of the Dandora dumpsite on public health.

The results were in agreement with our results noting a high number of children examined at the select clinic, presenting with respiratory symptoms (46.9%), gastrointestinal problems such as stomachache and diarrhea (17.9%), as well as skin disorders and eye irritation (14.5%) and (9.8%) respectively.

In another study carried out by (Oyedele & Oyedele, 2017) at the Olusosun waste dumpsite in Nigeria, looking at the effects of the dumpsite on the neighbors. The study findings were also similar to our findings with the population closest (within 100 meters) to the waste dumpsite reporting higher cases of respiratory related symptoms (68%) compared to (32%), stomach complications (diarrhea 52% compared to 36% and nausea72% compared 44%) among the population more than 100 meters from the dumpsite.

5.5 Anthropometry

The study noted that children in the unexposed population were 1.2 kgs heavier in mean Weight and 0.2 cm taller than children in the unexposed population.

The mean WHZ, HAZ and BAZ scores which categorize children depending on their nutritional status in comparison to the median of a WHO reference population, noted that both the exposed and unexposed population had normal weight for height, normal height for age and normal nutritional status with reference to their WHZ, HAZ and BAZ mean scores respectively, with no significant statistical difference in the anthropometric means between the two population.

Our study, although noting marginal differences in the growth status of the children from the exposed population in relation to the children from the unexposed population (1.2 kg difference in Weight and 0.2cm difference in height) the differences did not reflect any level of statistical significance, which is in contrast to similar studies.

One of the studies carried out in Pakistan by (Awan R et al., 2016) among children aged 5-7 years looked at the impact of domestic waste on their health and nutritional status. In this study, children exposed to the waste dumpsite were found to have significantly lower anthropometric scores compared to the unexposed children group.

The exposed children had a mean weight for age Z score of 16 kg (SD 5.6) compared to 22.5 kg (SD 2.0) for unexposed and a P-Value = 0.000<0.05, with exposed children mean height for age Z-score of 41 inches (SD 3.7) compared to 43 inches (SD 2.4) for the unexposed population at a significant P-Value =0.010<0.05. The mean BMI for age for the exposed was also significantly lower than the unexposed at 14 kg/m2 (SD 3.3) compared to 19 kg/m2 (SD 2.1) P-Value= 0.000<0.05, respectively.

A study by (Steegmann, 2015) among children residing near the hazardous waste site in love canal also recorded similar results to those of Awan R et al., 2016 study. In the study, exposed children were found to have significantly short stature for their age compared to the unexposed children, with a mean height for age percentile of 46.6 (SE2.2) and 53.3 (SE1.4), respectively and P-value = 0.004<0.05. However, the difference in the mean weight for age was not significantly different.

Several reasons that could explain the variability in the anthropometric findings between our study and the two related studies:

Introduction of the school feeding program:

The introduction of the school feeding program by the Ministry of Health targeting school going children in the arid and semiarid areas and informal settlements in Kenya (*Nutrition Portal | Nutrition in Education*, n.d.) has been shown to positively impact on the health and nutrition status of school age children in informal settlements. In a study by (Neervoort et al., 2013) on the effects of school feeding program on nutrition and anemia in an urban slum in Kenya. The study noted that school fed children were less stunted (P=0.02) and less wasted (P=0.02) than the unexposed group.

In a metanalysis study of 45 articles in low- and middle-income countries (Wang et al., 2021), noted that school feeding programs improved the height and weight of school fed children by a mean difference of 0.32 cm; CI=0.032; P-Value 0.032 and 0.58kg; CI 0.22; P value=0.001 respectively.

Parental Height Consideration and Adjustment:

Our study did not adjust for parental height. Several studies have shown that parental height is strongly associated with a child's nutritional status. Santos Felisbino-Mendes et al., 2014 in his study noted that maternal height was positively associated with the child's HAZ scores, in the study, mothers whose height was less than 145 cm, their children had a HAZ score 1.2 lower than children whose mothers height was 160 cm. Addo et al., 2013 drawing findings from 5 pooled birth cohorts, observed that, maternal height was strongly associated with birth weight and conditional height at 2 years, noting that, short mothers (<150cm) were more likely to have stunted children at 2years of age.

Improved nutrition coupled with reduced exposure time when children are in school away from exposure to the dumpsite may have significantly contributed to improved growth status in our exposed study population. However, the irreversible harm caused by the unsolicited waste dumpsite cannot be underestimated and urgent action is needed to address this concern.

5.6 Strengths and Limitations of The Study

5.6.1 The Key Strengths of the Study

In our setting, this is the first study to the best of my knowledge that attempts to quantify the physical disability as well as the adverse maternal health outcomes associated with longstanding exposure to open dumpsite-related environmental pollution.

The study was able to use measurements that are reproducible and not compromised by recall bias to comprehensively assess the physical growth of children exposed to the Dandora waste landfill and compare it to an unexposed population.

The measurement of growth was an efficient and highly effective way to determine the health status of children in the population compared to more complex health surveys and laboratory-based testing.

The study used systematic sampling (we had a sampling frame) in determining the study population hence reducingthe selection bias and ensured a representative sample was drawn from the study population. In addition, a pilot study was carried out before commencing the study, this allowed us to refine our study design and process as well as test and refine the questionnaire and familiarize the research team and assistants with the research instruments.

5.6.2 Limitations of the Study

The study design used in the research–cross-sectional study design, was limited in that it could only present associations, which does not imply causality, noting that other factors present in the study areas could also be responsible for the differences noted between the two populations such factors include: household size, family income and maternal level of education.

The use of non-probability convenience sampling of the women study population means that the results can be generalized to only similar sub-populations

In addition, the study also employed a research assistant who administered a questionnaire which required recall of specific medical history details spanning five years; this could have led to the introduction of recall bias in the study.

Moreover, the selection of study participants was based on five years history of exposure to the dumpsite; however, other factors, such as a history of chronic disease prior to the exposure, were not considered. The study did not also statistically adjust for possible confounders such as parental height, family size and birth weight.

5.7 Summary

In our setting, this is the first study to the best of my knowledge that attempts to quantify the physical disability as well as the adverse reproductive health outcomes associated with longstanding exposure to open dumpsite-related environmental pollution.

The study notes that maternal exposure to pollution poses health consequences to the fetus, with an increased likelihood of miscarriage and maternal-related birth complications such as convulsions, postpartum haemorrhage and infection. In addition, the study observes that children living near unregulated waste dumpsite are more often likely to miss school and attend hospital more often as a result of the clinical symptoms observed in a majority of these children.

The costs associated with healthcare and the implications of missing school too often for these children further compromise their only chance of pulling away from the cycle of poverty and life in the slum. Therefore, this study provides an essential basis for championing public health policies geared towards addressing environmental protection and waste management.

Further, the study exposes the challenges that most developing countries such as ours face in addressing environmental pollution and the consequent health effects on its population, noting that most developing countries lack necessary legislations to address solid waste management and in countries where these legislations are available the ability to enforce these legislations is mainly lacking (Ferronato & Torretta, 2019). This has allowed for unsolicited waste dumping in heavily populated areas such as the slums.

These, coupled with a lack of monitoring facilities such as particulate matter monitors to monitor air quality and a lack of water quality monitoring facilities, have allowed for continued exposure of the population to hazardous pollutants gravely affecting their health with no legal recourse for the populations that are exposed to these hazards.

By comparing standard anthropometric indices used for monitoring children's growth, the study notes health threats to children and women residing in Korogocho (Exposed population), which are precursors to diseases and disabilities, as well as present long-term financial implications for an already impoverished population.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

Environmental pollution associated with the Dandora dumpsite presents significant health risks to populations living within the environs of the dumpsite. The study results noted that children and expectant women exposed to the dumpsite experienced varying adverse health effects ranging from increased clinical symptoms that would warrant frequent hospital visits and impaired linear growth in children to increased maternal complications and miscarriage in women.

6.1 Recommendations

Lack of facilities to monitor the environment, especially in urban areas in our country, presents a significant challenge in ensuring compliance to set measures aimed at safeguarding the environment and minimizing human exposure to various health risks that result from environmental pollution caused by unsolicited household, industrial and hospital waste dumping and burning. Carrying out environmental monitoring evaluation and reporting on the same by relevant authorities will ensure compliance and accountability by the organizations and the policy makers thus safeguarding the environment.

The Nairobi County government should urgently take steps and enact environmental protection policies addressing household and industrial waste management. In addition, while considering high-impact interventions and policies to reduce the burden of childhood diseases in the country, the Ministry of Health and policymakers should prioritize tackling environmental pollution as one of its key strategies.

Public health programs and environmental protection policies also need to be urgently implemented to address air pollution because of the adverse health effects on mothers and their children. Suffice it to say that the county government of Nairobi should strongly consider relocating the Dandora dumpsite.

Further to this, the government should plan to have well-managed solid waste landfills which, apart from ensuring safe disposal of waste generated from the growing population, can also be used as an alternative energy source, generating electricity from harnessing methane gas that's a byproduct of organic matter decomposition in the landfills (Banaget et al., 2020).

In conclusion, having used a cross-sectional study design, it is not possible to infer causality, there being other possible pausal explanations for the observed results in our study.

Therefore, recommend that future studies consider prospective cohort studies, which ideally explore children's mobility from the exposure area and account for acute morbidity experienced in the follow-up period. The study should track children's movement from exposure areas and include assessments of acute morbidity during the follow-up period, providing valuable insights into the relationship environmental exposure, and health outcomes observed.

We also recommend a prospective cohort study that will focus on exploring the effects of pollution exposure on women’s reproductive health and utilize statistical analysis to identify associations between the health outcomes and pollution.

6.2 Dissemination plan

The study findings will also be shared with the Nairobi County government and NEMA. In addition, the study findings will be presented to the Moi university school of public health. As well as published in a leading medical or public health journal in order to disseminate the knowledge gained.

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APPENDICES

APPENDIX I: ASSENT FORM FOR RESEARCH

Serial Number (Code)Parent /Guardian ....
…………………………..

Serial number (Code) of the Child...

Class......................................

Date...

Michael Karanu of Moi University has requested me and my child to participate in a study to find out the growth status of my child and about my previous pregnancies and birth outcomes.

Having understood what the study involves, I agree that my child and I takes part in the study.

Serial Number (Code) …………………………………

Sign/Left Thumbprint ....

Date ....

Witness (Parent/Guardian) ....

APPENDIX II: QUESTIONNAIRE

Introduction :

My name is -I am a school of public health student at Moi University. I am conducting a study to assess the effects the environment our children are living in is having on their growth, as well as on the birth outcomes of women with the aim of informing and developing mitigating factors.

HOUSEHOLD NO: -- -- -- -- -- -- -- -- -- -- -- -- -- --- -- -- --- -- -- -- -- -- --

DATE: -- -- -- -- -- -- -- -- -- -- -- -- -- --- -- -- --- -- -- -- -- -- --

STREET: -- -- -- -- -- -- -- -- -- -- -- -- -- --- -- -- --- -- -- -- -- -- --

ESTIMATED DISTANCE FROM THE LAND FILL: -- -- -- -- -- -- --- --- --- --- --- --- --- ---

1. Less than 50m
2. 50m - 500m
3. 501km -1km
4. 1km - 2km
5. More than 2km

MAIN BUILDING MATERIAL FOR THE HOUSE: -- -- -- --- --- --- ---- --- --- --- --- -- --- -- - --

1. Concrete
2. Brick
3. Corrugated iron
4. Soil
5. Others- - - - - - - -

SERIAL NUMBER (CODE) OF RESPONDENT- -

RELATIONSHIP TO HOUSEHOLD HEAD: -

DATE OF BIRTH: - AGE: - - - - - - - - - - - - - - - - -

GENDER: -

1. Female

A1. HOW LONG HAS THE HOUSEHOLD LIVED HERE?

1. Less than 1 year
2. 1 to 2 years
3. 3 to 4 years
4. More than 5 years

A. SOCIO DEMOGRAPHIC CHARACTERISTICS:

A2. Do you have any children (<12years) residing with you?	**A3. Why did you choose to reside here? (Tick as much as relevant)**	**A4. Literacy**	**A5. Highest level of education:**
1. Yes 2. No If YES How many?............	1. Bought the land /plot 2. I was born here 3. Cost of housing is affordable 4. Schooling of children 5. Closeness to my place of work 6. Look for work 7. Other (specify).................	1. None 2. Literate	1. No formal schooling 2. Primary School graduate 3. High school 4. Vocational School training 5. College graduate 6. University graduate 7. Postgraduate

A6. In the last 3 months have you been working	**A7. If not working why?**	**A8. What is your occupation?**	**A9. What is your average monthly income?**	**A10. What is the status of your housing?**
1. Yes 2. No	1. Laid off 2. Retired 3. Sick 4. Looking after children	1. Driver 2. Conductor 3. Civil servant 4. Small scale trader 5. Farmer	1. <5,000ksh/month 2. 5,000Ksh to 15,000ksh	1. I own the house 2. Rent the house (how much):………… 3. Employer provided housing

	5. Cannot find a job 6. Pregnant 7. Others	6. Jua-kali artisan 7. Healthcare worker 8. Teacher 9. House wife 10. Others……………..	3. 16,000ksh to 25,000ksh 4. 26,000ksh to 35,000ksh 5. > 36,000ksh	4. Not paying rent Other ……………	
A11.Which fuel do you mainly use for cooking? (Tick one)	**A12. How many rooms does the house have?**	**A13. What is your main water source?**	**A14. Does anyone in your house smoke?**		
1. Wood/Charcoal 2. Gas 3. Kerosene 4. Electricity 5. Other................	6. (1) 7. (2) 8. (3) 9. (4) 10. (5) 11. Others …….	12. 1.House plumbing (local water authority Nairobi. 3. Well 4. Water vendor 5. Community water point	**1. Yes** If yes how long...…… No of Sticks/day………. **2. Ex-smoker** How long have you quit smoking? …… **No**		

B. SYMPTOMS:

B1. Does the location of the dumpsite pose any health problem on you and your child?

(a) Yes (b) No

B2. What health symptoms has your child experienced/complained about in the last 3 months?

SYMPTOMS:		IF YES HOW OFTEN
Itching or irritation in the eyes	☐	☐
Skin rashes	☐	☐
Itching or irritation of nose	☐	☐
Headache	☐	☐
Excessive tiredness of doing daily chores	☐	☐

Excessive day time sleepiness	☐	☐
Sore throat	☐	☐
Diarrhea	☐	☐
Stomach-ache	☐	☐
Coughing	☐	☐

C. MATERNAL AND CHILD HEALTH - BIRTH OUTCOME HISTORY:

C1. No of children: ________ No of living children_______

C2. Have you had any Miscarriage in the last 5 years (December 2015 to now):

1. Yes □

2. No □

C3. If yes, state when……………………. number of miscarriage (s) …………………

C4. No of child death in last 5 years (December 2016 to December 2021) ________

Please provide details of children born in last 5 years (December 2016 to December 2021) to the present (or have been living in the area for at least a year).

(See the antenatal card).

Birth Date	Sex M/F	Birth Weight (Kg)	Gestation (Weeks)	Parity	Mother's Age	Complication During Pregnancy (Yes/No) State Details	Congenital Abnormalities (Yes/No) State Details	Death <5y (Yes/No) State Detail

APPENDIX III: ANTHROPOMETRIC MEASUREMENT RECORDING SHEET

S.no: ______________________ Age: ______________ Gender ……………. Date: _________

Weight (Kgs): …………………………….

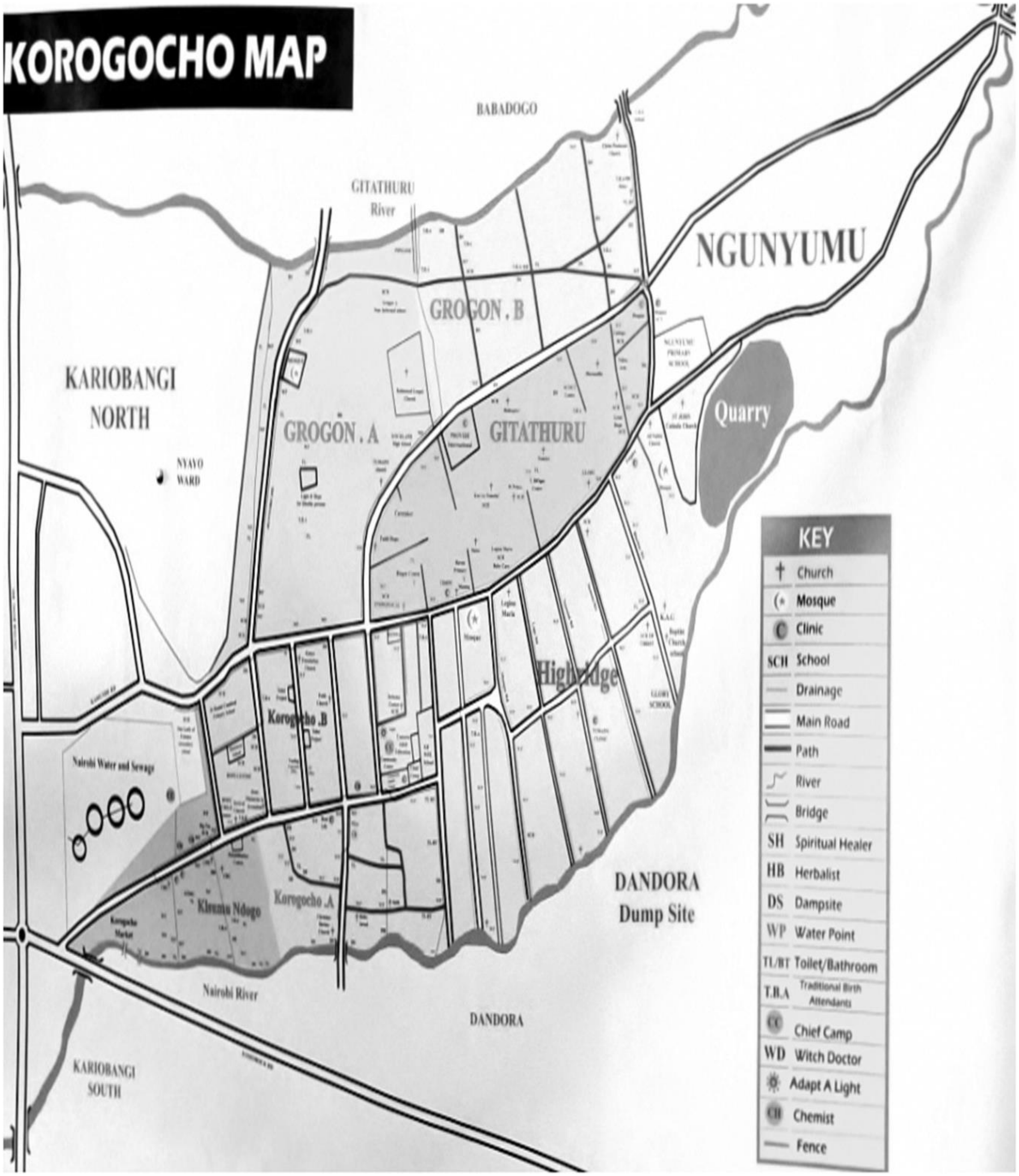
Height (Meters): ………………………………

BMI (kg/m^2): …………………………….

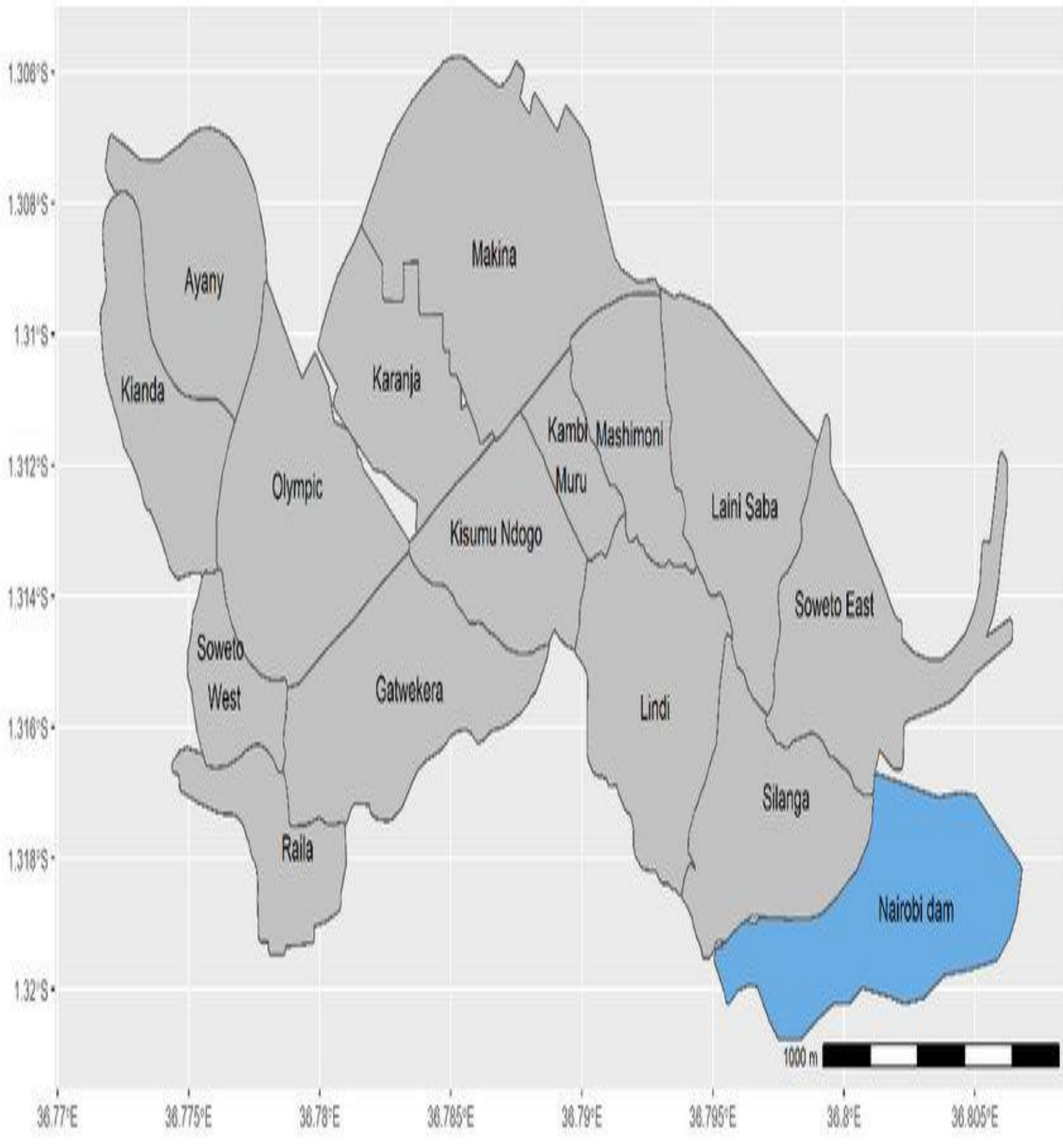
BMI for age Z-Score: …………………

Weight for Height Z- Score (WHZ): ………………………

APPENDIX IV: KOROGOCHO AND KIBERA MAPS



KIBERA MAP


1.306°S
1.308°S
1.31°S
1.312°S
1.314°S
1.316°S
1.318°S
1.32°S
36.77°E
36.775°E
36.78°E
36.785°E
36.79°E
36.795°E
36.8°E
36.805°E
Makina
Ayany
Karanja
Kianda
Kambi Muru
Mashimoni
Olympic
Laini Saba
Kisumu Ndogo
Soweto East
Soweto West
Gatwekera
Lindi
Silanga
Raila
Nairobi dam
1000 m

APPENDIX V: IREC STUDY APPROVAL

INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471/2/3

MOI UNIVERSITY
COLLEGE OF HEALTH SCIENCES
P.O. BOX 4606
ELDORET
Tel: 33471/2/3

Reference: IREC/042/2021
Approval Number: 0003960

26th August, 2021

Dr. Michael Karanu,
Moi University,
School of Public Health,
P.O. Box 4606-30100,
ELDORET-KENYA.

Dear Dr. Karanu,

GROWTH STATUS AMONG CHILDREN AGED 6-12 YEARS RESIDING NEAR DANDORA OPEN DUMPSITE AND KIBERA SLUM: A CROSS-SECTIONAL COMPARATIVE STUDY

This is to inform you that ***MTRH/MU-IREC*** has reviewed and approved your above research proposal. Your application approval number is ***FAN: 0003960.*** The approval period is **26th August, *2021- 25th August, 2022.***

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, Material Transfer Agreements (MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***MTRH/MU-IREC***.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ***MTRH/MU-IREC*** within 72 hours of notification.
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to ***MTRH/MU-IREC*** within 72 hours.
v. Clearance for export of biological specimens must be obtained from ***MOH at the recommendation of NACOSTI*** for each batch of shipment.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to ***MTRH/ MU-IREC.***

Prior to commencing your study; you will be required to obtain a research license from the National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and other relevant clearances from study sites including a written approval from the CEO-MTRH which is mandatory for studies to be undertaken within the jurisdiction of Moi Teaching & Referral Hospital (MTRH) and its satellites sites.

Sincerely,

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
26 AUG 2021
APPROVED
P. O. Box 4606-30100 ELDORET

PROF. E. WERE
CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc	CEO	-	MTRH	Dean	-	SOP	Dean	-	SOM
	Principal	-	CHS	Dean	-	SON	Dean	-	SOD

APPENDIX VI: NACOSTI STUDY APPROVAL

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **100694**

Date of Issue: **06/September/2021**

RESEARCH LICENSE

This is to Certify that Dr.. michael karuingi karanu of Moi University, has been licensed to conduct research in Nairobi on the topic: Growth Status Among Children Aged 6-12years Residing Near Dandora Open Dumpsite and Kibera Slum: A Cross-Sectional Comparative Study. for the period ending : 06/September/2022.

License No: **NACOSTI/P/21/12759**

100694

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

APPENDIX VII: SIMILARITY INDEX REPORT

SR170

THESIS WRITING COURSE

PLAGIARISM AWARENESS CERTIFICATE

This certificate is awarded to

MICHAEL KARUINGI JORAM KARANU

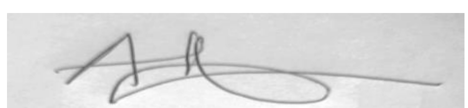
SPH/PGH/NC/1004/17

In recognition for passing the University's plagiarism

Awareness test with a similarity index of 0% and

Striving to maintain academic integrity.

Awarded by:



Prof. Anne Syomwene Kisilu , CERM-ESA Project Leader

18th /04/2023

SIMILARITY INDEX REPORT - MICHAEL KARUINGI JORAM KARANU

By MICHAEL KARUINGI JORAM KARANU

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