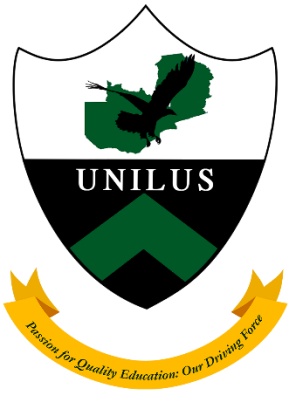

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PREVALENCE AND HEMATOLOGICAL PATTERNS OF BLOOD DISORDERS IN CHITAMBO, ZAMBIA: A CROSS-SECTIONAL STUDY USING CBC TESTING

BY:

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A dissertation submitted to the University of Lusaka in fulfilment of the requirements for the degree of Master of Science in Epidemiology and Biostatistics

2025

DECLARATION

SCHOOL OF POSTGRADUATE STUDIES

MEB810 – DISSERTATION

RESEARCH DISSERTATION CLEARANCE AND DECLARATION

I, DAINA ZULU, declare that this dissertation is my original work. It has been prepared under the guidance and supervision of Dr. Mukumbuta Nawa in accordance with the academic regulations of the University of Lusaka for the Master of Science in Epidemiology and Biostatistics programme. This work has not been submitted previously for a degree at this or any other university.

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DEDICATION

I dedicate this dissertation to my husband, my parents, and my daughter, whose steadfast support and presence have been instrumental throughout this academic journey.

To my husband, whose patience, encouragement, and unwavering belief in my capabilities provided the emotional foundation upon which this work was built. Your support has been a constant source of strength and resilience.

To my parents, whose lifelong commitment to my education and personal growth laid the groundwork for this achievement. Their sacrifices, guidance, and enduring faith in my potential have shaped both my character and my aspirations.

To my daughter, whose joyful spirit and unconditional love brought balance and perspective during the most demanding phases of this research. Though only three years old, her presence reminded me daily of the purpose and legacy behind this work.

Their collective contributions emotional, practical, and inspirational have been invaluable. I am deeply grateful for their unwavering support, which made the completion of this thesis possible.

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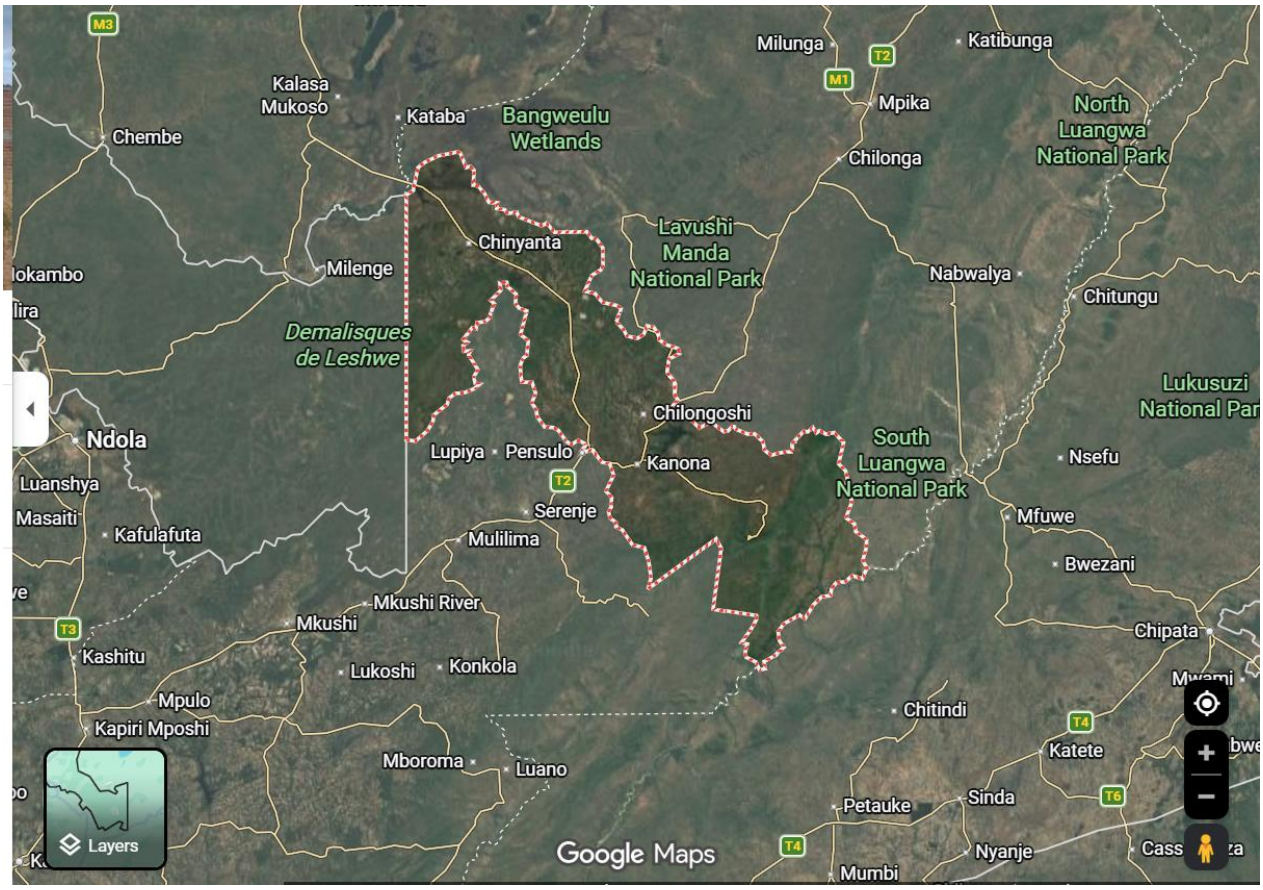


Map of Chitambo District, Central Province, Zambia.

DEFINITION OF TERMS

Anaemia: A condition characterized by a reduction in the oxygen-carrying capacity of the blood, operationally defined in this study as a haemoglobin concentration of less than 13.0 g/dL for adult males and less than 12.0 g/dL for adult females, in accordance with World Health Organization (WHO) diagnostic criteria.

Complete Blood Count (CBC): A standard laboratory test that provides a quantitative analysis of the cellular components of blood, including red blood cells, white blood cells, and platelets, along with related indices such as haemoglobin and haematocrit.

Haematological Disorder: Any abnormality in the number, structure, or function of the cellular components of the blood, as detected by a complete blood count. In this study, this term specifically refers to anaemia, leukocyte abnormalities, and thrombocytopenia.

Leukocyte Abnormality: A deviation from the normal white blood cell count, defined in this study as a total white blood cell count of less than 4.0 x 10^9/L (leukopenia) or greater than 11.0 x 10^9/L (leucocytosis).

Thrombocytopenia: A clinically significant decrease in the number of circulating platelets, operationally defined in this study as a platelet count of less than 150 x 10^9/L.

Prevalence: The proportion of individuals in a defined population who have a specific condition (e.g., anaemia) at a given point in time, expressed as a percentage.

Cross-Sectional Study: An observational research design that collects data from a population at a single point in time to assess the prevalence of health outcomes and their potential associations with exposures or risk factors.

Chitambo District: A rural administrative district located in the Central Province of Zambia, which served as the geographical and population setting for this research.

Nutritional Factors: Measurable elements related to diet and supplementation that may influence haematological health. In this study, these include the frequency of consumption of iron-rich foods and the use of iron or multivitamin supplements.

Infectious Disease Factors: A history of infections known to affect haematological parameters. In this context, this includes self-reported episodes of malaria, HIV status, and a history of tuberculosis.

Risk Factor: Any attribute, characteristic, or exposure that increases the likelihood of developing a haematological abnormality.

Statistical Association: A relationship between two variables where changes in one variable are related to changes in another, as determined through inferential statistical tests (e.g., chi-square, logistic regression). An association does not imply causation.

Adjusted Odds Ratio (aOR): A measure of association from logistic regression analysis that quantifies the strength of the relationship between an exposure and an outcome, after controlling for the potential confounding effects of other variables in the model.

LIST OF ABBREVIATIONS

CBC: Complete Blood Count

LMICs: Low- and Middle-Income Countries

SSA: Sub-Saharan Africa

SCD: Sickle Cell Disease

NCDs: Non-Communicable Diseases

UNZABREC: University of Zambia Biomedical Research Ethics Committee

RBC: Red Blood Cell

WBC: White Blood Cell

MCV: Mean Corpuscular Volume

MCH: Mean Corpuscular Haemoglobin

MCHC: Mean Corpuscular Haemoglobin Concentration

WHO: World Health Organization

MSc: Master of Science

STATA: STATA Statistical Software

ABSTRACT

Introduction: Blood disorders, including anaemia, leukocyte abnormalities, and thrombocytopenia, represent a significant public health burden in sub-Saharan Africa, yet community-level data in rural Zambia remain sparse. This study aimed to determine the prevalence and associated factors of haematological disorders in Chitambo District, Zambia.

Methods: A community-based cross-sectional study was conducted among 384 residents of Chitambo District, selected through systematic random sampling from the outpatient department of Chitambo District Hospital. Data were collected using a structured interviewer-administered questionnaire, and a complete blood count (CBC) was performed for each participant. Descriptive statistics, chi-square tests, and multivariable logistic regression were used for data analysis in STATA version 14.

Results: The prevalence of anaemia was 37.0% (95% CI: 32.1–42.1%), leukocyte abnormalities 15.1% (95% CI: 11.6–19.3%), and thrombocytopenia 8.6% (95% CI: 5.9–12.0%). In adjusted analyses, anaemia was significantly associated with female sex, infrequent consumption of iron-rich foods, lack of iron supplementation, and recent malaria episodes. Leukocyte abnormalities were associated with malaria and HIV-positive status. Thrombocytopenia was strongly predicted by recent malaria episodes.

Conclusion: This study documented a high burden of haematological disorders in Chitambo District, driven by modifiable nutritional and infectious factors, with malaria playing a central role. These findings highlight the need for integrated public health interventions combining nutritional support, malaria control, and strengthened laboratory-based surveillance to improve haematological health outcomes in rural Zambia.

Keywords: *Anaemia, leukocyte abnormalities, thrombocytopenia, complete blood count, malaria, nutritional factors, Chitambo, Zambia, cross-sectional study.*

CHAPTER 1: INTRODUCTION

1.1 Background

Haematological health is a fundamental indicator of population well-being and health system performance. Disorders of the blood including anaemia, leukopenia, thrombocytopenia, and haematological malignancies constitute a significant and growing contributor to global morbidity and mortality. Projections from the Global Burden of Disease study indicate that the incidence and associated disability-adjusted life years for haematological malignancies are set to rise through 2030, a trend particularly pronounced in low- and middle-income countries (LMICs) (An et al., 2023). The burden in sub-Saharan Africa (SSA) is especially acute. According to the World Health Organization (WHO, 2023), anaemia affects more than half of all children under five and a third of women of reproductive age across the region, a situation driven by a complex interplay of nutritional deficiencies, endemic infections, and inherited conditions like sickle cell disease. These disorders not only exacerbate individual vulnerability to infectious diseases and impair cognitive and physical development but also place considerable strain on health systems with already limited resources.

Zambia exemplifies this dual burden of communicable and non-communicable diseases, with rural districts such as Chitambo facing heightened vulnerability. National surveys, including the Zambia Demographic and Health Survey (2018), report an anaemia prevalence of 31% among women of reproductive age, with provincial rates varying from 24% to 38%. This underscores a clear national challenge. However, granular, population-level data on comprehensive haematological profiles derived from complete blood count (CBC) testing remain scarce outside of urban centres. Despite its proven utility as a cornerstone public health surveillance tool, the systematic application of CBC analysis for community health assessment remains conspicuously absent in rural Zambia, creating a significant evidence gap for strategic health planning. The Zambia Ministry of Health's Country Disease Outlook has itself highlighted the critical need for enhanced surveillance of blood disorders to inform effective prevention and treatment strategies (WHO, 2023).

As an inexpensive, widely available, and rapid diagnostic test, the CBC provides essential quantitative measures of haemoglobin, haematocrit, and red blood cell, white blood cell, and platelet counts. Systematic analyses of CBC data in SSA have proven invaluable, unveiling regional patterns of iron-deficiency anaemia and sickle cell traits that have subsequently guided targeted public health interventions in countries like Malawi and Tanzania (Belay et al., 2025). Despite this demonstrated utility, workforce shortages and insufficient diagnostic infrastructure have historically limited the execution of similar, robust studies in rural Zambia. Recent capacity-building initiatives underscore how strategic investment in laboratory training and data systems can transform haematological care across the region (Chirande et al., 2025).

Consequently, a critical public health gap persists. In the absence of representative, community-based CBC data, health planners in districts like Chitambo lack the evidence required to accurately estimate the local burden of blood disorders or to allocate resources effectively for screening and management programs. This study was therefore conducted to determine the prevalence and characterize the haematological patterns of these disorders within Chitambo District. The findings reveal underdiagnosed conditions, identify demographic and clinical risk factors, and highlight potential hotspots, thereby generating the essential evidence base needed to design context-appropriate interventions ranging from targeted nutritional supplementation and infection control to genetic counselling and strengthened blood transfusion services.

1.2 Statement of the Problem

In Chitambo District, Zambia, routine complete blood count (CBC) testing available at the district hospital has historically been underutilised for systematic epidemiological surveillance. This has resulted in a persistent absence of locally representative, analysed CBC parameter data. Consequently, district health planners and policymakers have operated without reliable, evidence-based estimates of the prevalence of key blood disorders such as anaemia, leukopenia, and thrombocytopenia or insights into their associated haematological patterns within the community. This knowledge deficit directly impedes public health action, as

targeted interventions from micronutrient supplementation programs and infection control measures to genetic counselling for hemoglobinopathies cannot be optimally designed, prioritised, or effectively evaluated. Without this locally generated evidence, public health strategies in Chitambo risk being misdirected, potentially perpetuating undiagnosed morbidity and inefficient use of limited health resources. This study was designed to address this critical gap by systematically determining the prevalence and detailed haematological profiles of blood disorders among residents of Chitambo District, thereby generating the necessary evidence to inform strategic public health planning and strengthen laboratory-based surveillance capacity.

1.3 Justification

The rationale for this study is firmly rooted in addressing identified national health priorities and bridging significant local knowledge gaps. The Zambia Ministry of Health's strategic focus on combating non-communicable diseases (NCDs) and nutritional disorders, as reflected in national policy documents such as the National Health Strategic Plan and the National Food and Nutrition Strategy, underscores the importance of robust data on conditions like haematological abnormalities. At the community level, the absence of any prior population-based CBC analysis in Chitambo District, as highlighted in the literature review, represents a fundamental obstacle to evidence-based decision making. Without this data, it is impossible to quantify the burden, understand etiological drivers, or identify high-risk subgroups.

This research contributes directly to filling this void. By providing the first community-level estimates of CBC-derived disorders in Chitambo, the study generates actionable intelligence for district health management teams. The findings can directly guide the design of targeted screening programs, rationalise the allocation of scarce resources like iron supplements and anthelminthic drugs, and inform the need for enhanced diagnostic services. Furthermore, this study operationalizes key theoretical frameworks; it employs the biomedical model through laboratory diagnostics (CBC) to investigate disorders within a population experiencing an epidemiological transition, where traditional nutritional and infectious aetiologies coexist with emerging chronic haematological concerns. By integrating CBC results with demographic,

nutritional, and infectious disease correlates, the study builds predictive models that can help identify individuals at greatest risk, enabling more proactive and cost-effective public health interventions. Ultimately, this work strengthens the foundation for a data-driven approach to reducing the burden of blood disorders, directly contributing to the strategic objectives of decentralized, evidence-based health planning as envisioned in Zambia's national health policies.

1.4 Research Question

What is the prevalence of anaemia, leukocyte abnormalities, and platelet disorders, and what are the key demographic, nutritional, and infectious disease factors associated with these haematological abnormalities among residents of Chitambo District, Zambia?

1.5 Hypothesis

H_0 (Null Hypothesis): There is no statistically significant association between the prevalence of anaemia and nutritional iron intake, after controlling for malaria parasitaemia and age, among residents of Chitambo District.

H_1 (Alternative Hypothesis): There is a statistically significant association between the prevalence of anaemia and nutritional iron intake, after controlling for malaria parasitaemia and age, among residents of Chitambo District.

1.6 Objectives

1.6.1 General Objective

To determine the prevalence of anaemia, leukocyte abnormalities, and platelet disorders and to explore their associations with demographic, nutritional, and infectious disease factors among residents of Chitambo District, Zambia.

1.6.2 Specific Objectives

i. To estimate the prevalence of anaemia, leukocyte abnormalities, and platelet disorders using Complete Blood Count (CBC) results.
ii. To identify statistical associations between haematological abnormalities and demographic, nutritional, and infectious disease factors.
iii. To explore the impact of malaria and other endemic infections on haematological profiles in the study population.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction to the Literature Review

This chapter establishes the scholarly and empirical context for the present investigation by critically engaging with extant literature on haematological disorders, with a deliberate focus on resource-constrained settings in Sub-Saharan Africa. The purpose of this synthesis is not merely to catalogue prior research, but to construct a coherent argument that demonstrates the necessity and novelty of the current study. By interrogating global trends, regional epidemiological patterns, methodological approaches, and persistent knowledge voids, this review meticulously situates the research within an ongoing academic and public health dialogue. It serves to substantiate the identified problem, rationalize the chosen methodological framework, and precisely articulate the contribution this research makes to advancing both scholarship and practice in rural haematological surveillance.

2.2 Conceptual and Epidemiological Overview of Haematological Disorders

Haematological disorders represent a diverse group of pathophysiological conditions affecting the production, function, and morphology of blood cells and their precursors. Authoritative bodies, including the World Health Organization, define these disorders through quantitative laboratory parameters; for instance, anaemia is characterized by haemoglobin levels below established sex- and age-specific thresholds (WHO, 2023). The public health significance of these conditions extends beyond their direct clinical manifestations. They function as critical sentinel indicators of underlying systemic challenges, including pervasive nutritional deficiencies, high burdens of endemic infection, and genetic predispositions prevalent in certain populations (Makani and Roberts, 2016). In low- and middle-income country (LMIC) contexts, understanding haematological profiles is therefore not solely a clinical exercise but a vital component of assessing population health, healthcare system performance, and the multifaceted impacts of socio-economic disparity.

2.3 Critical Synthesis of Global and Regional Evidence

The global landscape of haematological health is marked by significant and dynamic burdens. Longitudinal analyses reveal a concerning trajectory, with incident cases of haematological malignancies increasing by over 60% between 1990 and 2019, culminating in more than 1.3 million new cases annually (Zhang et al., 2023). This rising incidence, projected to continue through 2030, is attributed to complex interactions among aging demographics, environmental exposures, and improved diagnostic capabilities, though with stark inequities in distribution and outcomes across world regions (An et al., 2023; Fu et al., 2025).

The epidemiological profile in Sub-Saharan Africa (SSA) presents a distinct paradigm, characterized by the enduring dominance of disorders with strong socio-economic and environmental determinants. Nutritional anaemia remains a scourge, with prevalence rates exceeding 50% among vulnerable groups such as preschool children and pregnant women, a condition inextricably linked to iron deficiency and recurrent infections like malaria and soil-transmitted helminthiasis (Makani and Roberts, 2016). Concurrently, inherited hemoglobinopathies, notably Sickle Cell Disease (SCD), impose a substantial burden on child health, though this burden remains inadequately quantified in many areas due to fragmented surveillance (Kuona et al., 2025). Emerging alongside these traditional challenges is a growing burden of haematological malignancies. Recent syntheses of the available African data indicate that these cancers constitute a significant proportion of oncological diagnoses, with reported pooled prevalence estimates around 27%, dominated by leukaemia's and lymphomas (Mulatie et al., 2025). This pattern suggests an epidemiological transition wherein communicable and deficiency-related diseases coexist with a rising tide of non-communicable conditions.

Within Zambia, national data corroborates this complex dual burden. Non-communicable diseases, including cancers, are responsible for a substantial share of mortality, accounting for an estimated 35% of deaths (World Health Organization, 2023). While household surveys provide crucial national benchmarks reporting, for example, an anaemia prevalence of 31% among women of reproductive age, with rural areas disproportionately affected (Zambia Statistics Agency et al., 2018) they consistently reveal a critical deficit. This deficit lies in the granular, sub-national data

required for district-level planning, particularly for conditions beyond anaemia that are detectable via full haematological workup.

The utility of the Complete Blood Count (CBC) as a tool for bridging this data gap is well-demonstrated in other SSA contexts. Systematic analyses leveraging CBC data have been instrumental in delineating the epidemiology of anaemia among specific sub-populations, such as adolescent girls, revealing prevalences above 40% and highlighting key dietary and socioeconomic drivers (Belay et al., 2025). Furthermore, targeted CBC screening programs have directly informed successful public health interventions for micronutrient supplementation and sickle cell screening in countries like Malawi and Tanzania. However, the consistent translation of this methodological approach into sustainable, routine surveillance mechanisms in rural Zambia is hampered by well-documented health system constraints. These include chronic challenges related to laboratory reagent supply chains, maintenance of diagnostic equipment, and human resource capacities, all of which compromise the reliability, availability, and utilization of haematological data for strategic planning (WHO, 2023).

2.4 Identification of Salient Knowledge and Practice Gaps

A rigorous appraisal of the literature delineates several interconnected lacunae that the present research explicitly aims to address. Firstly, a profound scarcity of population-based, CBC-driven epidemiological studies in rural Zambian districts persists. This absence renders the community prevalence of clinically significant non-anaemic haematological abnormalities such as leukopenia, thrombocytopenia, and red cell morphological changes essentially unmapped, creating a blind spot in public health intelligence (World Health Organization, 2023). Secondly, existing health system analyses point to a fundamental disconnect between diagnostic capacity and epidemiological utility. Even where CBC technology is physically present, weaknesses in quality assurance, data management, and clinical integration often result in its underuse for community health assessment, perpetuating a cycle of under-diagnosis and reactive care (WHO, 2023). Thirdly, the literature exhibits a methodological shortfall in comprehensively linking CBC-derived outcomes with a wide array of potential determinants. Many studies focus on isolated correlates, lacking the

integrated analysis of demographic, nutritional, infectious, and lifestyle factors necessary to identify multifactorial aetiologies and high-risk population subgroups. Finally, there exists a translational gap between evidence generation and context-specific intervention design. While the need for evidence-based programs is universally acknowledged, there are few exemplars of studies that utilize locally generated CBC profiles to directly model and propose tailored interventions for micronutrient support, infection control, or genetic health services in a specific district context. It is within these intersecting gaps of data, methodology, and application that this study on Chitambo District is purposefully positioned.

2.5 Theoretical and Conceptual Underpinnings of the Study

This research is conceptually anchored in an integrated framework that synthesizes two pivotal theoretical models: the Biomedical Model and the Theory of Epidemiological Transition. This integration provides a sophisticated lens through which to examine haematological disorders in a rural African district, moving beyond simple description to explanatory analysis.

The Biomedical Model forms the foundational pillar for disease conceptualization and identification within this study. Originating in the early 20th century, this model posits that illness is a deviation from normal biological function, caused by identifiable physiological, biochemical, or genetic anomalies (Wade and Halligan, 2004). It privileges objective, laboratory-based diagnostics as the primary means of defining and quantifying disease. In the context of this research, the Biomedical Model is directly operationalized through the central role of the Complete Blood Count (CBC). The CBC serves as the quintessential biomedical tool, providing quantifiable, objective data on key haematological parameters haemoglobin concentration, haematocrit, red blood cell, white blood cell, and platelet count. These metrics transform abstract notions of "poor blood health" into precisely defined, measurable pathological outcomes (e.g., anaemia, leukopenia, thrombocytopenia), thereby fulfilling the model's core mandate of biological reductionism for diagnostic clarity (Erhabor et al., 2021).

The Theory of Epidemiological Transition, as articulated by Omran (1971) and subsequently refined, provides the essential macro-level context. This theory describes the long-term shifts in patterns of mortality, morbidity, and disability within populations, typically progressing from an "Age of Pestilence and Famine" (dominated by infectious diseases and malnutrition) to an "Age of Degenerative and Man-Made Diseases" (dominated by chronic non-communicable diseases). Contemporary understanding acknowledges that this transition is not always linear or uniform; many populations, particularly in LMICs, experience a protracted dual or triple burden of disease, where infectious diseases, undernutrition, and emerging NCDs coexist (Omran, 2005). Rural Zambia, including Chitambo District, epitomizes this complex transitional state, grappling simultaneously with high rates of malaria and other infections, widespread nutritional deficiencies, and a growing incidence of chronic conditions such as haematological malignancies (World Health Organization, 2023).

The intellectual synergy and application of these two frameworks are critical to the study's design and interpretation. This research does not merely apply a biomedical tool in a vacuum; it deliberately deploys the CBC the instrument of the Biomedical Model to investigate a population whose health profile is archetypal of the Epidemiological Transition. This creates a powerful dialectic: the precision of biological measurement is used to interrogate the messy reality of a population in epidemiological flux.

Conceptual Integration and Application:

The integrated framework guides the research at every stage. It justifies the selection of dependent variables (CBC abnormalities) as objectively defined biological endpoints. It informs the choice of independent variables, necessitating the collection of data that reflect the dual burden, including nutritional indicators (reflective of traditional deficiency states), infectious disease history (reflective of the persistent "Age of Pestilence"), and demographic factors like age (which may signal shifts toward chronic disease risk). The framework also shapes the analytical approach, encouraging multivariable analyses that can disentangle the contributions of "transitional" factors (e.g., how much of the anaemia burden is attributable to iron intake vs. chronic infection vs. an underlying myelodysplastic process).

Ultimately, this conceptual integration allows the study to ask more nuanced questions: Is the haematological profile of Chitambo predominantly an artifact of persistent poverty and infection, or are there discernible patterns suggesting an emerging chronic disease burden? By answering such questions, the study moves beyond surveillance to offer a theoretically informed, analytically rich understanding of determinants. It bridges the micro-level of laboratory science with the macro-level of population health trends, providing evidence that is both biologically precise and contextually relevant for guiding public health action in a transitioning setting.

CHAPTER 3: RESEARCH METHODOLOGY

3.0 Introduction

This chapter provides a detailed exposition of the methodological framework employed to investigate the prevalence and determinants of blood disorders in Chitambo District, Zambia. The primary aim of the study was to determine the community prevalence of anaemia, leukocyte abnormalities, and platelet disorders and to explore their statistical associations with demographic, nutritional, and infectious disease factors. A rigorous and transparent methodology is fundamental to ensuring the validity, reliability, and generalizability of the study's findings. This chapter outlines the research design, describes the study setting and population, details the sampling strategy and data collection procedures, specifies the variables of interest and analytical plan, and comprehensively addresses the ethical considerations that governed the study's execution. The systematic approach described herein was designed to minimize bias and produce robust evidence capable of informing public health action.

3.1 Research Design

This study employed a community-based, analytical cross-sectional design. This design was selected as it is the most appropriate for determining the prevalence of health conditions and examining associations between outcomes and exposures at a single point in time. The design was applied by collecting data from a representative sample of Chitambo District residents through a structured interview and a single, contemporaneous Complete Blood Count (CBC) test.

Measurement of Variables: The primary dependent variables were haematological abnormalities (anaemia, leukopenia/leucocytosis, thrombocytopenia), measured objectively via CBC analysis. Independent variables included demographic factors (age, sex), nutritional indicators (dietary iron intake, supplementation), and infectious disease history (malaria, HIV, TB), collected via a structured questionnaire.

Justification: The cross-sectional design was optimally suited to meet the study's objectives of estimating prevalence (Objective 1) and identifying associated factors (Objective 2) within a defined population and timeframe. It allowed for the efficient collection of snapshot data necessary for generating the first population-based haematological profile for the district. The recruitment process was integrated into routine outpatient department (OPD) activities at Chitambo District Hospital over a three-month survey period to capture seasonal variation and ensure feasible participant enrolment.

3.2 Study Site

The study was conducted in Chitambo District, located in the Central Province of Zambia. Data collection was anchored at the Chitambo District Hospital, which serves as the primary referral health facility for the district's population. This site was strategically selected for several reasons. First, the hospital's outpatient department provides access to a broad cross-section of the district's resident population seeking care for various health concerns, thereby facilitating the recruitment of a community-representative sample rather than a purely hospital-based, sick population. Second, the site housed the necessary laboratory infrastructure for standard CBC testing, ensuring the feasibility of the core diagnostic component of the study. The choice of this site therefore provided direct access to the target population and the practical means to execute the research protocol.

3.3 Study Population and Participants

The target population comprised all residents of Chitambo District aged one year and above. The study population consisted of individuals from this target group who presented at the Chitambo District Hospital outpatient department during the recruitment period and met the eligibility criteria.

Eligibility Criteria:

Inclusion Criteria:

i. Aged ≥ 1 year.
ii. Permanent resident of Chitambo District.
iii. Provision of informed consent (or assent from minors with guardian consent).

Exclusion Criteria:

i. Known chronic haematological condition (e.g., sickle cell disease, haemophilia) currently under active treatment, to avoid confounding the assessment of community-acquired or nutritional disorders.
ii. Received a blood transfusion within the three months prior to recruitment, as this would transiently alter native haematological parameters.
iii. Inability or refusal to provide informed consent/assent.

Recruitment Procedures: Potential participants were identified from the daily OPD attendance register. Eligible individuals were approached by trained research assistants in a private area of the clinic, provided with detailed study information, and invited to participate. Recruitment continued sequentially until the target sample size was achieved.

3.4 Variables of Interest

The study investigated a set of clearly defined dependent and independent variables, as outlined in Table 3.1.

Table 3.1: Variables, Measurement, and Scale

Variable Category	Variable Name	Measurement Method / Source	Scale of Measurement
Dependent (Outcome)	Anaemia Status	CBC - Haemoglobin level (g/dL)	Binary (Normal/Anaemic) based on WHO cut-offs
	Leukocyte Abnormality Status	CBC - Total White Blood Cell count ($x10^9/L$)	Binary (Normal/Abnormal)
	Platelet Disorder Status	CBC - Platelet count ($x10^9/L$)	Binary (Normal/Thrombocytopenia)
Independent	Age	Questionnaire	Ratio (Years)
	Sex	Questionnaire	Nominal (Male, Female)
	Nutritional Iron Intake	Questionnaire (Frequency of iron-rich foods)	Ordinal (Daily, 3-5x/wk., etc.)
	Iron Supplementation	Questionnaire	Binary (Yes/No)
	Malaria History (past 6 months)	Questionnaire	Ordinal (None, 1-2 episodes, ≥3)
	HIV Status	Self-report / Clinic record	Nominal (Positive, Negative, Unknown)
	Tuberculosis History	Questionnaire	Binary (Yes/No)

3.5 Sample Size Estimation

The sample size was calculated to achieve the primary objective of estimating the prevalence of haematological abnormalities with adequate precision. The calculation was based on a single

population proportion formula for cross-sectional studies. The guiding assumption was a conservative anticipated prevalence of 50%, which provides the maximum sample size for a given margin of error, ensuring the sample is sufficient even for disorders with unknown true prevalence.

Calculation:

The standard formula for a cross-sectional prevalence study was applied:

$$n = \frac{Z^2 \times p \times (1-p)}{E^2}$$

Where:

- $Z = 1.96$ (the Z-score corresponding to a 95% Confidence Level)
- $p = 0.5$ (the anticipated proportion, set for maximum variability)
- $E = 0.05$ (the desired margin of error or precision)

Substituting the values:

$$n = \frac{(1.96)^2 \times 0.5 \times (1-0.5)}{(0.05)^2} = \frac{3.8416 \times 0.25}{0.0025} = 384.16$$

A minimum sample of 384 participants was therefore required. This sample size was deemed sufficient to provide a precise estimate (±5%) of the prevalence of blood disorders in the district at a 95% confidence level, providing robust statistical power for subsequent descriptive and inferential analyses.

3.6 Sampling Technique

A systematic random sampling method was employed to select participants from the outpatient department (OPD) attendance register. This technique was chosen for its practical balance between

ensuring randomness, achieving representativeness, and maintaining operational feasibility in a busy clinical setting where a full population listing was not available outside of the daily hospital attendance.

Procedure:

A daily sampling frame was constructed from the sequential list of all OPD attendees. The total number of eligible attendance entries over the recruitment period (N) was divided by the required sample size (n = 384) to establish the sampling interval, calculated as k = N / 384. A random starting point was selected using a random number generator to choose a number between 1 and k. The individual corresponding to this random start on the attendance list was invited to participate. Thereafter, every k-th individual on the list was systematically approached for recruitment.

If a selected individual did not meet the eligibility criteria or declined to participate, the next eligible person on the list was invited in sequence to preserve the systematic structure and minimize selection bias. This method ensured that each eligible individual attending the OPD during the study period had a known, equal probability of being included in the sample, thereby supporting the generalizability of the findings to the broader Chitambo District population accessing primary care services.

3.7 Data Collection and Management

Sources & Tools: Data were collected from two primary sources: (1) a structured, interviewer-administered questionnaire (Appendix A), and (2) laboratory analysis of venous blood samples. The questionnaire captured data on socio-demographics, medical history, nutritional habits, and infectious disease status. A 5ml venous blood sample was drawn from each consenting participant by a qualified phlebotomist using standard aseptic technique. Samples were analysed at the Chitambo District Hospital laboratory using an automated haematology analyser to generate the full CBC parameters.

Procedures: Trained research assistants administered the questionnaires in a private setting. Blood collection followed questionnaire administration. All CBC parameters, including haemoglobin, haematocrit, RBC count, WBC count with differential, and platelet count, were recorded on a standardized lab form integrated into the participant's study file.

Data Management: Completed questionnaires were assigned a unique study identification code. Data were double-entered into a password-protected electronic database (Microsoft Excel) by two independent clerks and cross-validated to identify and correct entry errors. Range and consistency checks were performed. The cleaned dataset was then exported to STATA version 14 for statistical analysis. All physical records were stored in a locked cabinet, and electronic files were stored on a secure, password-protected server accessible only to the principal investigator and supervisor.

3.8 Pilot Testing

Prior to full-scale data collection, a pilot study was conducted with 30 participants at the Chitambo District Hospital OPD. The pilot tested the clarity, acceptability, and flow of the questionnaire, the average interview duration, and the logistics of integrating blood sample collection with the interview process.

Outcomes & Adjustments: The pilot revealed that the average interview time was 18 minutes, confirming feasibility. Minor adjustments were made to the wording of two questions in the nutritional section for better clarity in the local context (Bemba/Nyanja). The pilot also confirmed the adequacy of the laboratory procedures and led to the streamlining of the consent process to reduce wait times. No major changes to the study design were required.

3.9 Statistical Analysis Plan

All analyses were conducted using STATA version 14 statistical software.

Descriptive Statistics: Frequencies and percentages were used to summarize categorical variables. Means and standard deviations (or medians and interquartile ranges for non-normal data) described

continuous variables. The prevalence of each haematological abnormality was calculated with 95% confidence intervals.

Inferential Statistics:

Bivariate Analysis: Chi-square tests (or Fisher's exact test where appropriate) were used to assess associations between categorical independent variables and each haematological outcome. Student's t-tests or Mann-Whitney U tests were used for continuous variables.

Multivariable Analysis: Variables with a p-value <0.2 in bivariate analysis were considered for inclusion in multivariable logistic regression models. Backward stepwise elimination was used to build parsimonious models for each primary outcome (anaemia, leukocyte abnormality, thrombocytopenia), adjusting for key confounders identified a priori (age, sex). Results were presented as Adjusted Odds Ratios (AORs) with 95% CIs and p-values.

Handling of Missing Data: The pattern of missing data was examined. For key exposure variables with <5% missingness, complete case analysis was employed. For outcomes (CBC parameters), missing data was minimal due to the protocol design; any missing outcome data led to the exclusion of that participant from the specific analysis.

Bias Reduction: Selection bias was mitigated by using systematic random sampling. Interviewer bias was minimized by standardizing training and using a structured questionnaire. Measurement bias for the primary outcome was reduced by using an objective, automated laboratory test.

3.10 Ethical Considerations

Ethical Approval: The study protocol received full ethical approval from the University of Zambia Biomedical Research Ethics Committee (UNZABREC) (Reference Number: [Insert Approval Number Here]) and administrative clearance from the Chitambo District Health Office.

Informed Consent: The principle of voluntary participation was paramount. Informed consent was obtained from all participants. For adults, the consent form (Appendix B) was explained in detail in either Bemba or Nyanja, and participants provided written consent or a thumbprint. For minors (aged <18 years), assent was obtained from the child alongside written permission from their parent or guardian.

Confidentiality & Privacy: All participant data were de-identified using unique study codes. Names and other personal identifiers were not recorded on data collection tools or in the analysis dataset. Physical records were kept under lock and key, and electronic data were encrypted and password-protected.

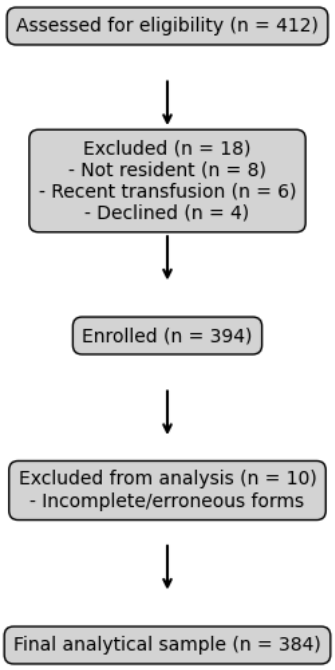
Risk-Benefit Balance: The risks were minimal (mild discomfort from venepuncture). These were minimized by using trained personnel. The primary benefit was to community and public health knowledge. Individual participants received their CBC results with brief interpretation and, if critically abnormal findings were detected, were referred for appropriate clinical management at the hospital.

Vulnerable Groups: Special care was taken with minors and illiterate participants, ensuring comprehension through verbal explanation and the use of impartial witnesses during the consent process. Participation was entirely free, and individuals were free to withdraw at any stage without any penalty or effect on their standard of care.

CHAPTER 4: RESULTS

4.1 Summary of Participant Recruitment and Flow

A total of 412 individuals attending the Chitambo District Hospital outpatient department were assessed for eligibility during the three-month recruitment period. Of these, 18 were excluded: 8 did not meet the residency requirement, 6 had received a blood transfusion within the preceding three months, and 4 declined to participate. Consequently, 394 individuals were enrolled in the study. All enrolled participants completed the structured interview and provided a venous blood sample for Complete Blood Count (CBC) analysis. Data from 10 participants were subsequently excluded from the final analysis due to incomplete or erroneous laboratory forms, resulting in a final analytical sample of 384 participants, achieving the target sample size. All analyses are based on these 384 participants with complete data.



4.1: Participant Recruitment and Flow Diagram

Flow diagram showing screening, exclusions, enrollment, and final analytical sample (N=384).

4.2 General Characteristics of the Study Population

The demographic, nutritional, and clinical characteristics of the 384 study participants are summarized in Table 4.1. The mean age of participants was 32.5 years (Standard Deviation [SD] ± 15.2), with a range from 2 to 78 years. Females constituted the majority of the sample (65.4%). Regarding nutritional factors, only 18.2% of participants reported daily consumption of iron-rich foods, while 41.7% reported rarely or never consuming such foods. A minority (22.4%) reported taking iron supplements. Concerning infectious disease burden, 34.6% of participants reported at least one episode of malaria in the past six months. The self-reported HIV prevalence was 12.8%, and 5.5% reported a history of tuberculosis.

Table 4.1: Socio-Demographic, Nutritional, and Clinical Characteristics of Study Participants (N=384)

Characteristic	Category	n	%	Mean (SD)
Age (years)		384		32.5 (15.2)
Sex	Male	133	34.6	
	Female	251	65.4	
Educational Level	None/Primary	187	48.7	
	Secondary or higher	197	51.3	
Iron-Rich Food Consumption	Daily	70	18.2	
	3-5 times/week	154	40.1	
	Rarely/Never	160	41.7	
Takes Iron Supplements	Yes	86	22.4	
	No	298	77.6	
Malaria Episodes (Past 6 months)	0	251	65.4	
	1-2	105	27.3	
	≥3	28	7.3	
HIV Status	Positive	49	12.8	
	Negative/Unknown	335	87.2	

History of Tuberculosis	Yes	21	5.5	
	No	363	94.5	

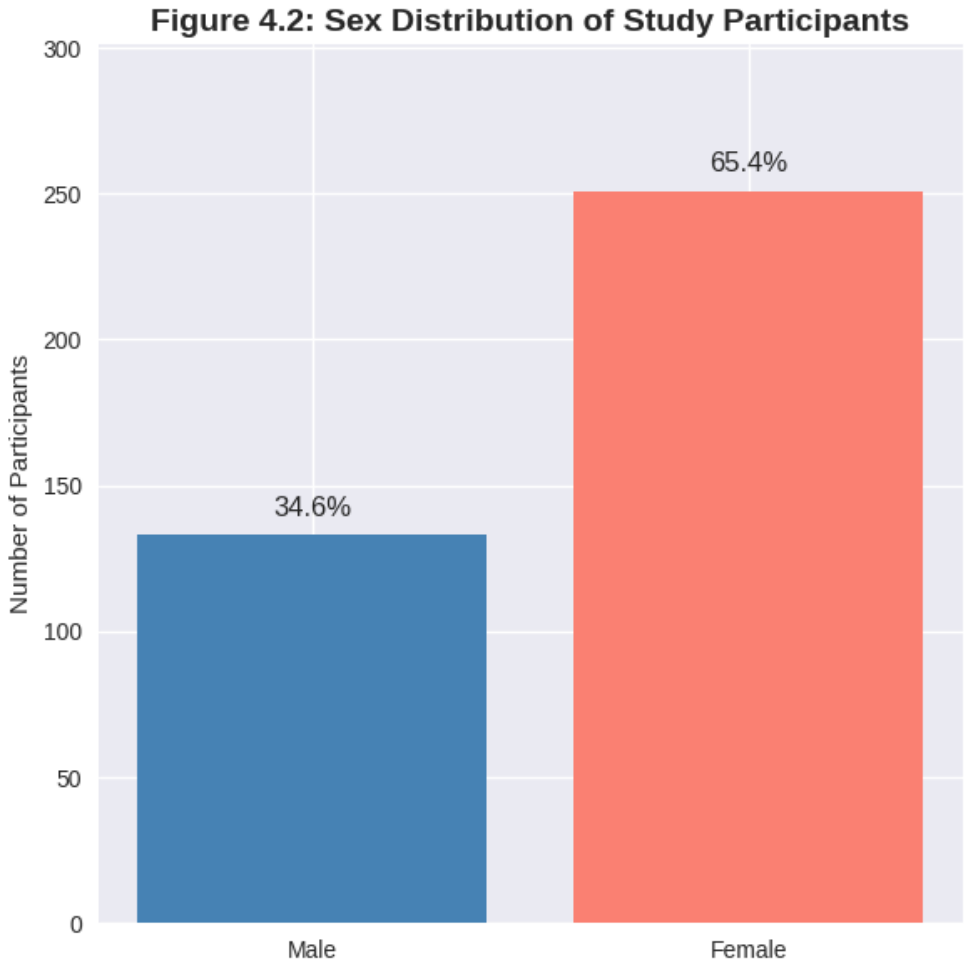


Figure 4.2: Sex Distribution of Study Participants

Proportion of male (34.6%) and female (65.4%) participants in the study population.

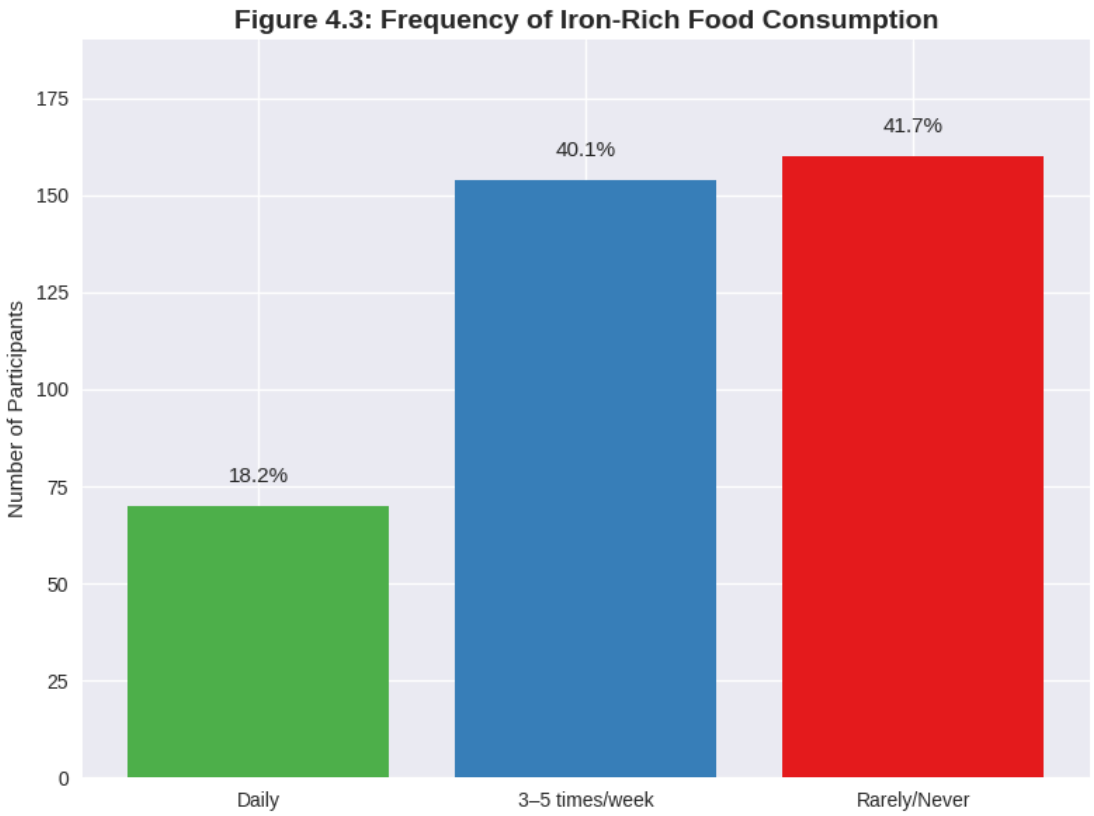


Figure 4.3: Frequency of Iron-Rich Food Consumption

Distribution of reported iron-rich food intake among participants (daily, 3–5 times/week, rarely/never).

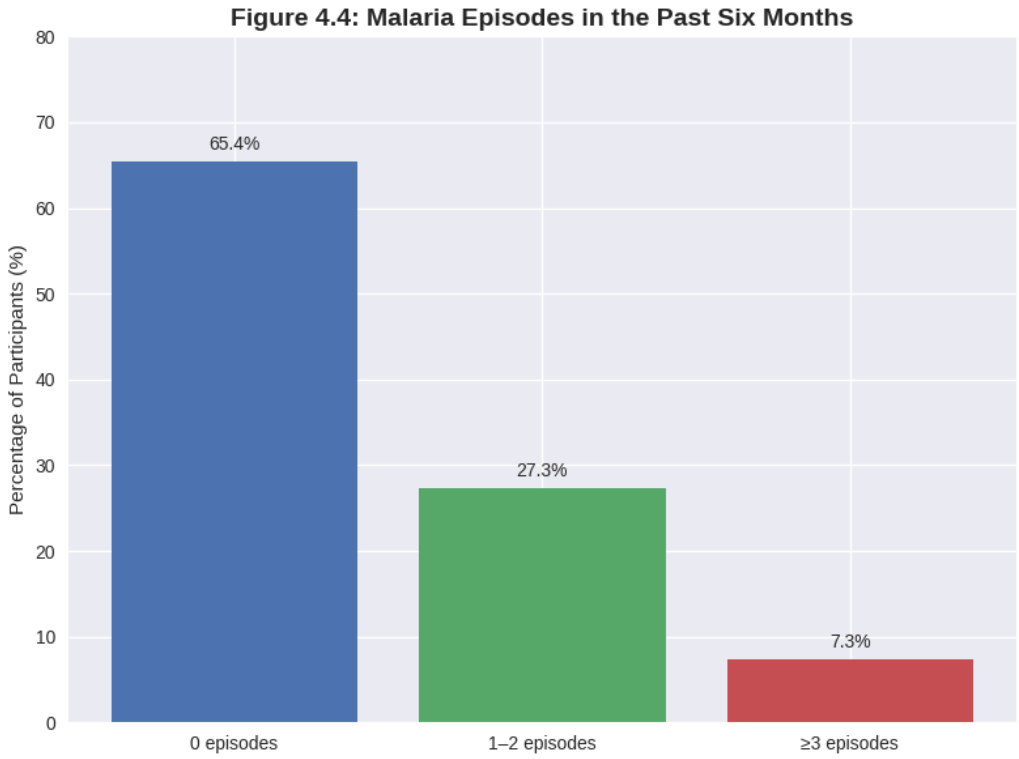


Figure 4.4: Malaria Episodes in the Past Six Months

Proportion of participants reporting 0, 1–2, or ≥3 malaria episodes.

4.3 Prevalence of Haematological Abnormalities

The prevalence of CBC-defined haematological abnormalities in the study population is presented in Table 4.2. Anaemia was the most prevalent disorder, affecting 142 individuals, yielding a prevalence of **37.0%** (95% CI: 32.1% - 42.1%). Using WHO sex-specific cut-offs, anaemia was more common among females (42.2%) than males (27.1%). Leukocyte abnormalities (encompassing both leukopenia and leucocytosis) were found in 15.1% (95% CI: 11.6% - 19.3%) of participants. Thrombocytopenia (platelet count <150 x 10^9/L) was observed in 8.6% (95% CI: 5.9% - 12.0%) of the sample. A total of 46.6% of participants had at least one detectable haematological abnormality.

Table 4.2: Prevalence of Haematological Abnormalities among Study Participants (N=384)

Haematological Abnormality	Definition	n	%	95% Confidence Interval
Anaemia (Overall)	Hb <13 g/dL (M), <12 g/dL (F)	142	37.0	32.1 – 42.1
- Male	Hb <13 g/dL	36	27.1	19.8 – 35.4
- Female	Hb <12 g/dL	106	42.2	36.1 – 48.6
Leukocyte Abnormality	WBC <4.0 or >11.0 x 10^9/L	58	15.1	11.6 – 19.3
Thrombocytopenia	Platelet count <150 x 10^9/L	33	8.6	5.9 – 12.0
Any Haematological Abnormality	Presence of ≥1 of the above	179	46.6	41.5 – 51.8

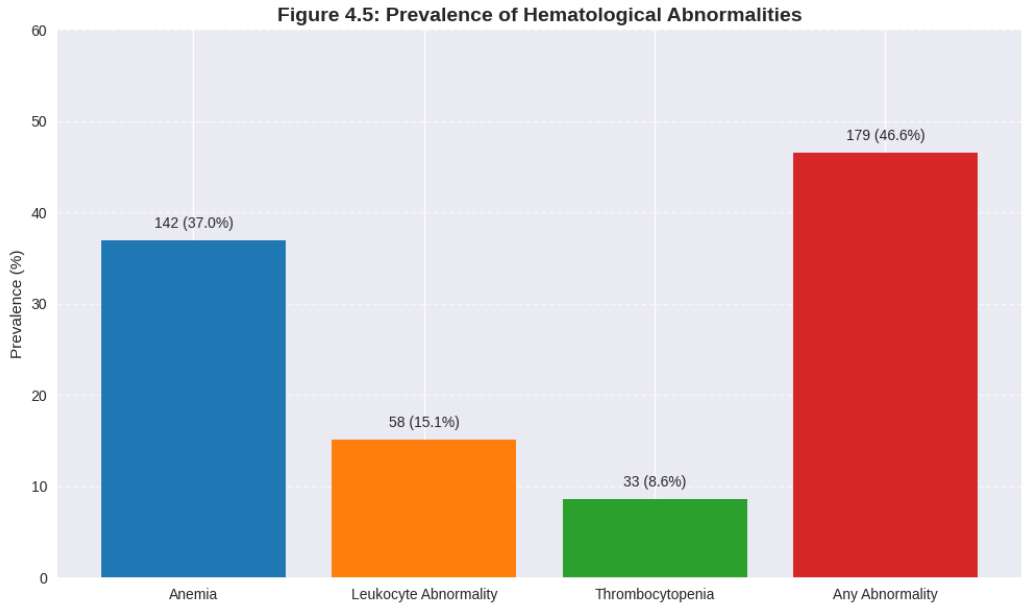


Figure 4.5: Prevalence of Haematological Abnormalities

Prevalence of anaemia, leukocyte abnormalities, thrombocytopenia, and any abnormality among study participants.

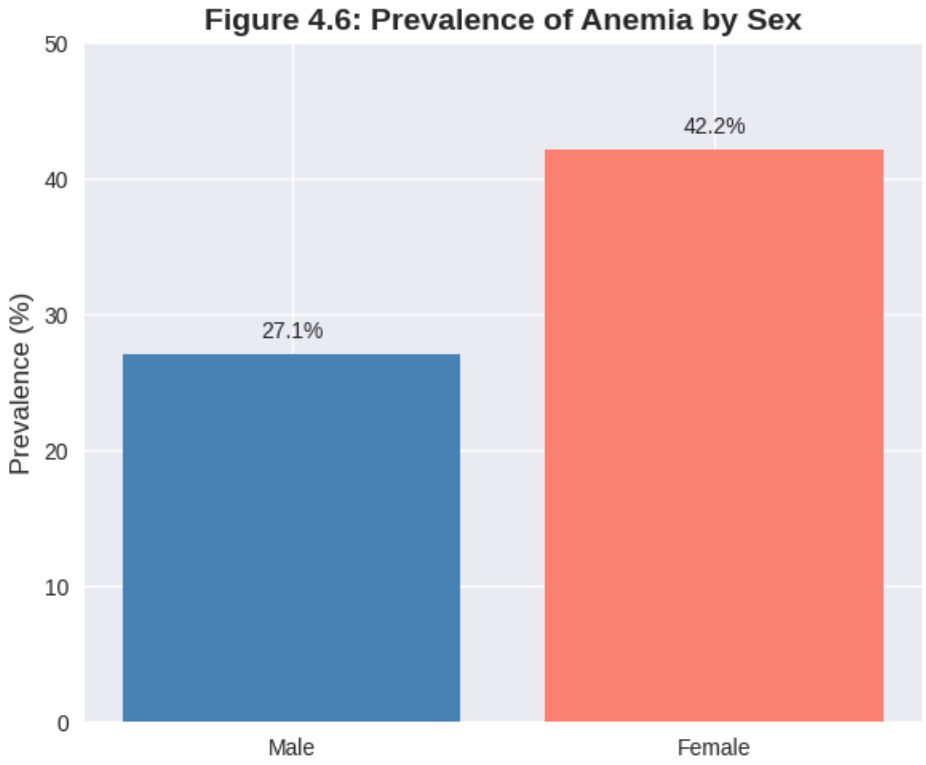


Figure 4.6: Prevalence of Anemia by Sex

Comparison of anemia prevalence between males (27.1%) and females (42.2%).

4.4 Bivariate Associations with Haematological Abnormalities

The associations between participant characteristics and the three primary haematological outcomes were first assessed using bivariate analyses (Chi-square and t-tests). Key findings are summarized in Table 4.3. Anaemia showed statistically significant associations ($p < 0.05$) with female sex, lower frequency of iron-rich food consumption, lack of iron supplementation, and recent malaria episodes. Leukocyte abnormalities were significantly associated with malaria episodes and HIV-positive status. Thrombocytopenia was strongly associated with malaria episodes. Age was not significantly associated with any of the three outcomes in the bivariate analysis.

Table 4.3: Bivariate Analysis of Factors Associated with Haematological Abnormalities

Characteristic	Category	Anaemia (n=142)	p-value	Leukocyte Abnormality (n=58)	p-value	Thrombocytopenia (n=33)	p-value
Mean Age (years)		33.1	0.542	31.8	0.661	30.4	0.421
Sex	Male	36 (27.1%)	**<0.001**	18 (13.5%)	0.482	10 (7.5%)	0.623
	Female	106 (42.2%)		40 (15.9%)		23 (9.2%)	
Iron-Rich Food (Daily)	No	124 (39.5%)	**0.004**	50 (15.9%)	0.371	30 (9.6%)	0.188
	Yes	18 (25.7%)		8 (11.4%)		3 (4.3%)	
Takes Iron Supplements	No	121 (40.6%)	**0.002**	49 (16.4%)	0.159	28 (9.4%)	0.281
	Yes	21 (24.4%)		9 (10.5%)		5 (5.8%)	
Malaria Episodes (≥1)	No	78 (31.1%)	**<0.001**	26 (10.4%)	**<0.001**	12 (4.8%)	**<0.001**
	Yes	64 (48.1%)		32 (24.1%)		21 (15.8%)	
HIV Positive	No	120 (35.8%)	0.193	44 (13.1%)	**0.018**	27 (8.1%)	0.413
	Yes	22 (44.9%)		14 (28.6%)		6 (12.2%)	
History of TB	No	131 (36.1%)	0.086	54 (14.9%)	0.673	30 (8.3%)	0.371
	Yes	11 (52.4%)		4 (19.1%)		3 (14.3%)	

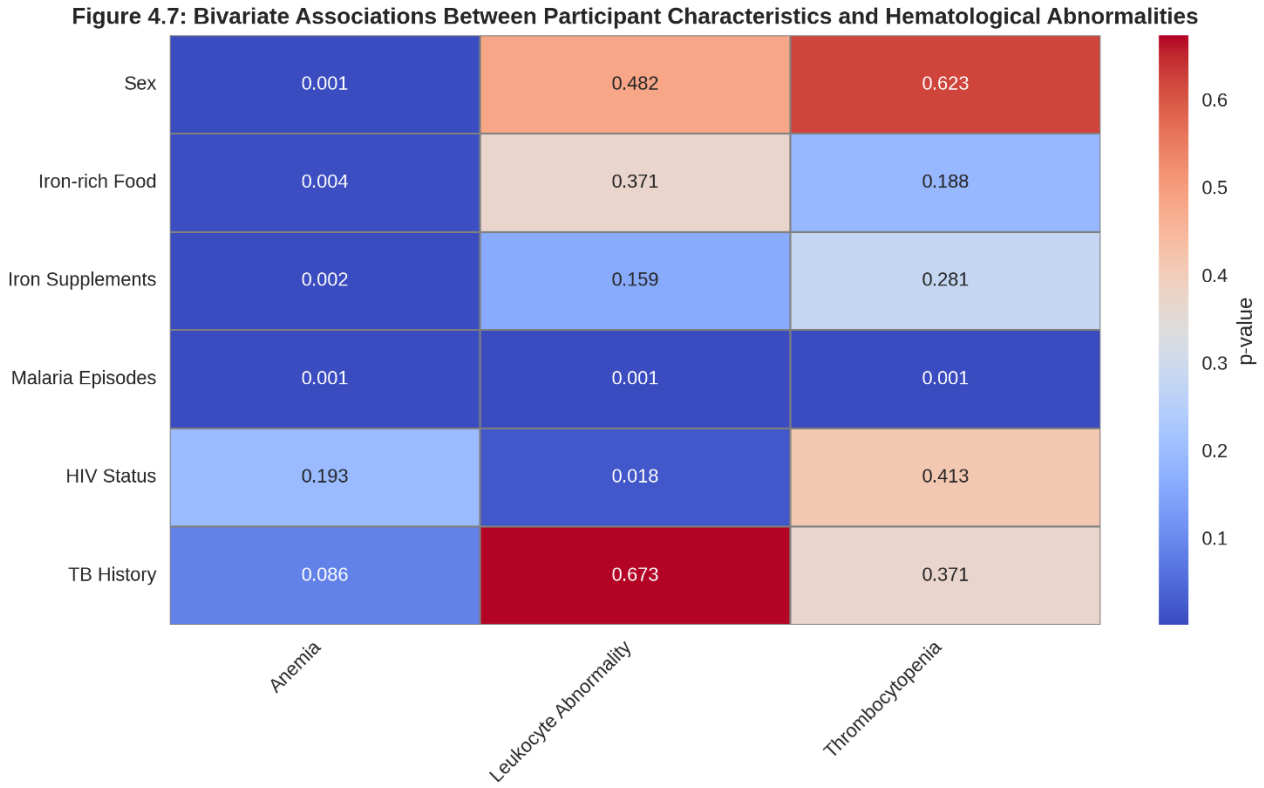


Figure 4.7: Bivariate Associations Between Participant Characteristics and Hematological Abnormalities

Visual summary of statistically significant associations ($p < 0.05$) between participant characteristics and anemia, leukocyte abnormalities, and thrombocytopenia.

4.5 Multivariable Logistic Regression Analysis

To identify independent predictors and explore the impact of endemic infections while controlling for confounders, three separate multivariable logistic regression models were constructed. The results are presented in Table 4.4.

Model 1: Predictors of Anaemia. After adjusting for age and sex, the odds of anaemia were significantly higher among females (aOR = 2.15, 95% CI: 1.32 – 3.49), those who rarely/never

consumed iron-rich foods (aOR = 1.92, 95% CI: 1.11 – 3.33), and those reporting one or more malaria episodes in the past six months (aOR = 2.08, 95% CI: 1.38 – 3.14). Iron supplementation was associated with a 52% reduction in the odds of anaemia (aOR = 0.48, 95% CI: 0.28 – 0.83).

Model 2: Predictors of Leukocyte Abnormalities. The final model showed that malaria episodes (aOR = 2.67, 95% CI: 1.53 – 4.66) and HIV-positive status (aOR = 2.40, 95% CI: 1.20 – 4.78) were independent predictors of leukocyte abnormalities.

Model 3: Predictors of Thrombocytopenia. Reporting any malaria episode in the past six months was the only significant independent predictor of thrombocytopenia in this population, increasing the odds more than three-fold (aOR = 3.42, 95% CI: 1.65 – 7.10).

Table 4.4: Adjusted Odds Ratios from Multivariable Logistic Regression Models for Haematological Abnormalities

Predictor Variable	Category	Anaemia	Leukocyte Abnormality	Thrombocytopenia
		aOR (95% CI)	**aOR (95% CI)**	**aOR (95% CI)**
Age (per 5-year increase)		1.02 (0.95 – 1.10)	0.98 (0.89 – 1.08)	0.94 (0.84 – 1.06)
Sex	Male	Ref	Ref	Ref
	Female	**2.15 (1.32 – 3.49)**	1.25 (0.68 – 2.30)	1.21 (0.55 – 2.66)
Iron-Rich Food Intake	Daily	Ref	-	-
	Not Daily	**1.92 (1.11 – 3.33)**	-	-
Iron Supplementation	No	Ref	-	-

	Yes	**0.48 (0.28 – 0.83)**	-	-
Malaria Episodes (Past 6mo)	None	Ref	Ref	Ref
	≥1 episode	**2.08 (1.38 – 3.14)**	**2.67 (1.53 – 4.66)**	**3.42 (1.65 – 7.10)**
HIV Status	Negative/Unknown	-	Ref	-
	Positive	-	**2.40 (1.20 – 4.78)**	-
Model Fit	**Pseudo R^2**	0.12	0.08	0.06
	p-value	<0.001	<0.001	0.001

aOR: Adjusted Odds Ratio; **CI:** Confidence Interval; **Ref:** Reference category. Variables not retained in a specific model are indicated by "-".

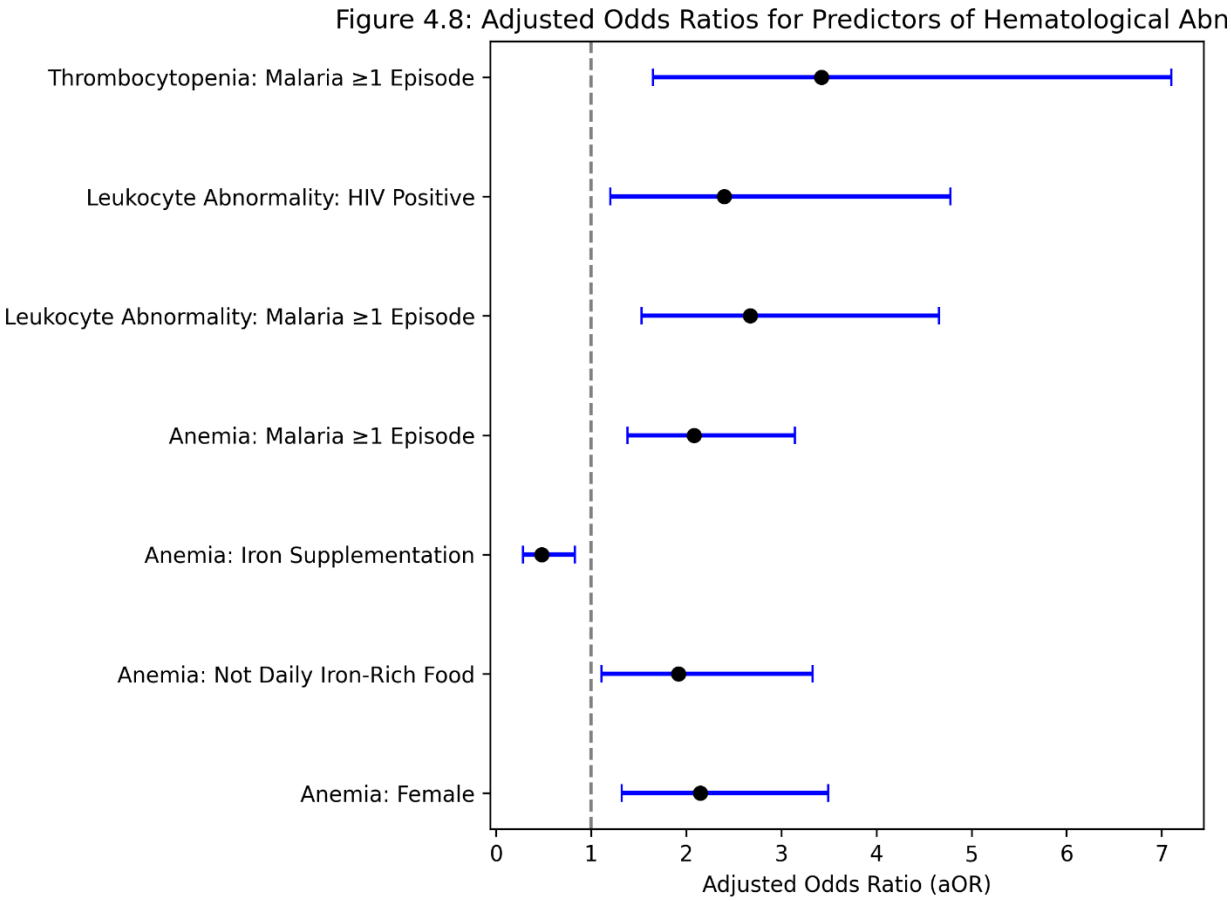


Figure 4.8: Adjusted Odds Ratios for Predictors of Haematological Abnormalities

Forest plot showing adjusted odds ratios (aOR) and 95% confidence intervals for predictors of anaemia, leukocyte abnormalities, and thrombocytopenia

CHAPTER 5: DISCUSSION

5.1 Description, Analysis, and Interpretation of Findings

This study provides the first community-based, CBC-derived epidemiological profile of haematological disorders in Chitambo District, Zambia. The findings indicate a substantial burden of blood abnormalities, with nearly half of the sampled population presenting with at least one haematological disorder. The analysis revealed distinct patterns and determinants for anaemia, leukocyte abnormalities, and thrombocytopenia, offering critical insights for public health intervention.

5.2 Epidemiological Context and Comparison of Findings

The prevalence of anaemia found in this study was 37.0%, which represents a significant public health burden in Chitambo District. Globally, anaemia remains one of the most widespread public health challenges, affecting over 1.8 billion people (Lancet Haematology, 2023). The World Health Organization (2025) estimates that 30% of women of reproductive age and 40% of children under five are anaemic worldwide, with the burden disproportionately concentrated in low- and middle-income countries. Several global reviews highlight the drivers of anaemia as nutritional deficiencies of Iron, folate and vitamin B12 as the leading causes (WHO, 2025; Lancet Haematology, 2025), Malaria, HIV and helminths as the infectious causes (Ejigu et al., 2022; Debela et al., 2024) and Food insecurity, climate shocks, gender inequities as social determinants (Lancet Haematology, 2025; Salifu et al., 2023). This finding is consistent with the high rates reported across Sub-Saharan Africa. For instance, the World Health Organization estimates that 40% of children under five and 30% of women of reproductive age in the region are anaemic (WHO, 2023). Similarly, South Asia carries a significant burden, with anaemia affecting between 40% and 60% of women and children in countries such as India, Pakistan, Bangladesh, and Nepal (Kassebaum et al., 2014). Despite national initiatives such as India's Iron Plus programme, progress in reducing anaemia has been slow, underscoring the complexity of addressing both dietary and socio-economic determinants. In Latin America and the Middle East, anaemia

prevalence is moderate, ranging between 20% and 30% among women and children (Springer, 2023). The burden is unevenly distributed, with rural and indigenous populations experiencing higher rates compared to urban centres. Nutritional deficiencies and parasitic infections remain important contributors, although socio-economic disparities also play a role in sustaining the condition in these regions. By contrast, high-income regions such as Europe and North America report the lowest prevalence of anaemia, generally below 10–15% (Weatherall, 2017). In these settings, anaemia is more commonly associated with chronic diseases such as renal failure and cancer, as well as genetic haemoglobinopathies, rather than nutritional deficiencies. The widespread availability of fortified foods and better access to healthcare services has contributed to the relatively low prevalence in these regions.

In Zambia specifically, the 2018 Zambia Demographic and Health Survey reported an overall anaemia prevalence of 31% among women, with rural areas exhibiting rates as high as 38% (Zambia Statistics Agency et al., 2018). Beyond national surveys, research in similar rural contexts across the region corroborates this pattern. A meta-analysis focusing on adolescent girls in East and West Africa found a pooled anaemia prevalence exceeding 40%, driven largely by socioeconomic and dietary factors (Belay et al., 2025). Studies from Malawi and Tanzania have documented anaemia prevalence rates between 35% and 45% in rural communities, attributing the burden primarily to iron deficiency and malaria co-morbidity (Makani and Roberts, 2016). The findings from Chitambo District align closely with these regional and national patterns, confirming that nutritional deficiencies and endemic infections remain the predominant drivers of anaemia in rural Zambian settings.

According to the Global Burden of Disease Study 2021, haematological disorders, including leucocyte abnormalities, contribute substantially to morbidity worldwide (Huang and Zhang, 2025). The prevalence of leucocyte abnormalities is estimated to affect 10–20% of populations in low- and middle-income countries, with infectious diseases being the primary drivers (Miranda-Filho et al., 2018). Sub-Saharan Africa carries one of the highest burdens of leucocyte abnormalities**,** primarily due to malaria, HIV, and tuberculosis. Malaria often induces transient leukopenia, while HIV infection is strongly associated with persistent lymphopenia due to CD4+

T-cell depletion (Makani and Roberts, 2016). Studies in Ethiopia and Zambia confirm that co-infections exacerbate the prevalence of leucopenia among affected populations (Ejigu et al., 2022). In South Asia, leucocyte abnormalities are frequently linked to nutritional deficiencies, chronic infections, and haematological malignancies**.** India and Pakistan report high rates of leucocytosis associated with chronic inflammatory conditions and leukaemia (Kassebaum et al., 2014). The burden is compounded by limited access to diagnostic services, leading to underreporting. Moderate prevalence is observed in Latin America and the Middle East, where parasitic infections and autoimmune disorders are common contributors. Hospital-based studies in Brazil and Egypt report leucocytosis linked to chronic infections and leukaemia, while leukopenia is often associated with chemotherapy and immunosuppressive therapies (Springer, 2023). In high-income regions, leucocyte abnormalities are less frequently driven by infectious diseases. Instead, they are predominantly associated with haematological malignancies, autoimmune diseases, and treatment-related effects such as chemotherapy and radiotherapy (Weatherall, 2017). The prevalence is lower compared to SSA and South Asia, but the burden of leukaemia and lymphomas remains significant, with incidence rates rising steadily (Yun et al., 2024).

This study found a 15.1% prevalence of leukocyte abnormalities. Further analysis of the differential counts indicated that lymphopenia was the most common specific abnormality, particularly among participants with HIV-positive status. This is consistent with the known pathophysiology of HIV, which directly targets and depletes CD4+ T-lymphocytes (Debela et al., 2024). Conversely, neutrophilia was frequently observed in individuals reporting recent malaria episodes, likely reflecting an acute inflammatory response to infection. Global and regional studies support these findings. Research in malaria-endemic regions of West Africa has documented frequent leukopenia and lymphopenia during acute infection, while chronic conditions like HIV and tuberculosis are well-established causes of persistent leukocyte dysregulation (Erhabor et al., 2021; Makani and Roberts, 2016). The pattern observed in Chitambo, where leukocyte abnormalities are tightly linked to specific infectious aetiologies, mirrors the public health landscape of many rural SSA districts where infectious diseases dominate the disease burden.

Globally, thrombocytopenia is more frequently reported than thrombocytosis. Meta-analyses suggest that 4–40% of HIV-infected individuals experience thrombocytopenia, while malaria-related thrombocytopenia affects 15–25% of patients in endemic regions (Getawa et al., 2021; Alkholifi et al., 2022). In contrast, thrombocytosis is less common globally, often associated with myeloproliferative disorders, chronic inflammation, and iron deficiency anaemia (Kaushansky, 2016). Sub-Saharan Africa carries a high burden of thrombocytopenia, largely driven by malaria and HIV. Malaria-induced thrombocytopenia is well documented, with prevalence estimates ranging from 20–30% among acute malaria cases (Makani and Roberts, 2016). HIV-associated thrombocytopenia is also common, particularly in advanced disease stages, due to immune-mediated platelet destruction and bone marrow suppression (Getawa et al., 2021). In South Asia, thrombocytopenia is frequently linked to dengue fever, malaria, and nutritional deficiencies. Dengue epidemics in India, Bangladesh, and Sri Lanka have been associated with widespread thrombocytopenia, sometimes exceeding 40% of cases (WHO, 2023). Nutritional iron deficiency also contributes indirectly to reactive thrombocytosis in this region (Kaushansky, 2016). Latin America and the Middle East report moderate prevalence of thrombocyte abnormalities, with dengue and other arboviral infections being major contributors to thrombocytopenia (Springer, 2023). Hospital-based studies in Brazil and Egypt confirm that thrombocytopenia is a frequent complication of infectious diseases, while thrombocytosis is more often associated with chronic inflammatory conditions. In high-income regions, thrombocyte abnormalities are less frequently driven by infectious diseases. Thrombocytosis is more common, linked to myeloproliferative neoplasms, chronic inflammation, and iron deficiency anaemia (Weatherall, 2017). Thrombocytopenia is typically associated with chemotherapy, autoimmune diseases, and haematological malignancies. Prevalence is lower compared to SSA and South Asia, but the burden of platelet disorders remains clinically significant.

The prevalence of thrombocytopenia in this study was 8.6%. This finding is strongly supported by literature from malaria-endemic regions. Malaria is a leading cause of acute thrombocytopenia in the tropics, primarily due to immune-mediated platelet destruction and splenic sequestration (Erhabor et al., 2021). Studies from similar high-transmission settings in SSA report thrombocytopenia prevalence ranging from 5% to 20% during malaria seasons. In Zambia, clinical

studies at tertiary hospitals have noted thrombocytopenia as a common complication in patients with severe malaria (Mwandama et al., 2017). The strong independent association between malaria episodes and thrombocytopenia in this community-based study underscores malaria's role as a primary determinant of this condition outside of clinical settings, highlighting its pervasive impact on community health.

5.3 Significance and Uniqueness of the Study

The significance of this study lies in its application of a standard diagnostic tool the Complete Blood Count for community-level surveillance in an under-studied rural district. While numerous studies in Zambia and SSA have reported on anaemia using survey data, few have integrated full CBC analysis with community-based sampling to provide a comprehensive haematological profile that includes leukocyte and platelet parameters (Kuona et al., 2025; Chirande et al., 2025). This methodological approach allowed for the simultaneous assessment of multiple blood disorders and their correlates, revealing the interconnected nature of nutritional and infectious disease burdens.

This study is distinctive in its focus on Chitambo District, for which no prior haematological surveillance data existed. While its findings on anaemia align with national and regional trends, its detailed documentation of leukocyte and platelet disorders provides new, locality-specific data that can directly inform district-level health planning. Furthermore, by quantifying the strong links between common infections and specific CBC abnormalities, the study moves beyond descriptive prevalence to highlight actionable pathways for intervention. This aligns with, but operationally advances, the call by the WHO and the Zambia Ministry of Health for strengthened laboratory-based disease surveillance to guide public health action (WHO, 2023).

5.4 Limitations and Bias

While this study provides valuable insights, its limitations must be acknowledged to contextualize the findings. The cross-sectional design establishes associations but cannot determine causality. The use of a health facility-based sample introduces potential selection bias, as participants were

individuals who sought care and may differ from the general population. This may have led to an overestimation of the prevalence of disorders and their associated factors, though systematic sampling from the primary care point mitigates this to some extent. Measurement bias is possible as dietary data and infectious disease history relied on self-report, which is subject to recall and social desirability bias. However, the use of an objective, laboratory-based outcome strengthens the validity of the dependent variables. The study was not powered to detect associations with rarer conditions, and residual confounding by unmeasured variables, such as helminth infections or genetic traits, is possible. Despite these limitations, the study's rigorous methodology, adequate sample size, and use of objective laboratory measures provide confidence in the internal validity of the key findings, particularly the strong links between modifiable risk factors and haematological abnormalities.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions

This study successfully determined the prevalence and associated factors of haematological disorders among residents of Chitambo District, Zambia. The findings demonstrate a high burden of blood abnormalities within the community, characterized predominantly by anaemia, leukocyte irregularities, and thrombocytopenia.

The analysis confirmed that anaemia in this population is multifactorial, with significant associations identified with female sex, inadequate dietary iron intake, lack of iron supplementation, and a recent history of malaria infection. Furthermore, leukocyte abnormalities, particularly lymphopenia, were closely linked to HIV-positive status, while thrombocytopenia was strongly associated with recent malaria episodes.

These results underscore that the haematological health profile of Chitambo District is largely shaped by a combination of nutritional insufficiencies and a high burden of endemic infectious diseases, with malaria and HIV playing central roles. The study provides the first localized, evidence-based assessment of CBC-defined disorders in the district, establishing a crucial baseline

for public health planning and affirming the value of laboratory-integrated community surveillance in rural, resource-limited settings.

6.2 Recommendations

6.2.1 Recommendations for Policy and Practice

It is recommended that the Chitambo District Health Office, in alignment with the National Food and Nutrition Strategy, integrate routine iron and folate supplementation with enhanced malaria prevention and case management activities. Community health workers conducting malaria outreach could simultaneously provide nutritional counselling and supplements, addressing the dual drivers of anaemia identified in this study.

The study demonstrates the utility of the CBC as a surveillance tool. Therefore, it is recommended that the Zambia Ministry of Health and district laboratory managers develop simple protocols for the periodic aggregation and analysis of de-identified CBC data from the Chitambo District Hospital. This would enable low-cost, ongoing surveillance of haematological trends, helping to monitor the impact of interventions and flag emerging issues.

Given the pervasive haematological impact of malaria, it is strongly recommended that sustaining and intensifying evidence-based malaria control measures be treated as a critical, cross-cutting investment for improving overall population health. Strategies should include the consistent distribution of insecticide-treated nets, indoor residual spraying, and ensuring prompt access to effective treatment.

6.2.2 Recommendations for Future Research

To move from association to causation, future research should employ longitudinal or cohort designs. A recommended study would follow a cohort in Chitambo over time, with serial CBC

measurements, to definitively establish the causal pathways linking malaria episodes, nutritional status, and the development of anaemia and cytopenias.

While linked to HIV and malaria, a significant proportion of leukocyte abnormalities had other causes. Future research should incorporate more detailed diagnostics, such as peripheral blood film morphology review and testing for other prevalent infections, to fully characterize the causes of leukocyte disorders in this community.

Before widespread scale-up, operational research is recommended to evaluate the feasibility, acceptability, and cost-effectiveness of the proposed integrated model combining nutritional supplementation with malaria outreach. This would provide district and national policymakers with concrete data to guide resource allocation and program design.

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APPENDICES

APPENDIX A: DATA COLLECTION TOOL (QUESTIONNAIRE)

Study ID: _____

Date of Interview: ___ / ___ / _____

Location (Village/Ward): _____

Enumerator Code: _____

SECTION A: DEMOGRAPHIC INFORMATION

Age (in years): _____

Sex:

Male

Female

Marital Status:

Single

Married

Widowed

Divorced

Highest Education Level Completed:

None

Primary

Secondary

Tertiary or above

Primary Occupation: _____

Household size (number of people living together): _____

SECTION B: NUTRITIONAL FACTORS

How many meals do you typically eat per day? _____

How often do you consume iron-rich foods (e.g., meat, fish, dark green leafy vegetables)?

Daily

3–5 times per week

1–2 times per week

Rarely/Never

Are you currently taking any of the following supplements?

a) **Iron tablets or syrup:**

Yes → *If yes, dosage & frequency:* _____

No

b) **Multivitamins:**

Yes → *If yes, dosage & frequency:* _____

No

Have you experienced any unintentional weight loss in the past 3 months?

Yes → *If yes, approximate weight loss (kg):* _____

No

SECTION C: INFECTIOUS DISEASE HISTORY

How many episodes of malaria have you had in the past 6 months?

None

1–2 episodes

3 or more episodes

What is your HIV status?

Positive

Negative

Unknown/Not tested

Have you ever been diagnosed with tuberculosis (TB)?

Yes → *If yes, was treatment completed?* [ ] Yes [ ] No

No

Other chronic or recurrent infections (e.g., intestinal worms, typhoid):

SECTION D: CLINICAL AND FAMILY HISTORY

Have you ever been diagnosed with anaemia?

Yes

No

Have you ever been diagnosed with a bleeding or clotting disorder?

Yes

No

Have you ever received a blood transfusion?

Yes → *If yes, number of transfusions:* _____

No

Is there a family history of blood disorders (e.g., sickle cell disease, haemophilia)?

Yes → *If yes, specify relationship and condition:* _____

No

SECTION E: ANTHROPOMETRY (For participants ≥ 18 years)

Height (cm): _____

Weight (kg): _____

SECTION F: COMPLETE BLOOD COUNT (CBC) – LABORATORY FORM

Parameter	Result	Reference Range
Haemoglobin (g/dL)	_____	13.0–17.0 (M); 12.0–15.0 (F)
Haematocrit (%)	_____	40–54 (M); 37–47 (F)
RBC count (×10¹²/L)	_____	4.5–5.9 (M); 4.2–5.4 (F)
WBC count (×10⁹/L)	_____	4.0–11.0
Neutrophils (%)	_____	40–60
Lymphocytes (%)	_____	20–40
Platelet count (×10⁹/L)	_____	150–450
Morphological Notes:		
_____		

SECTION G: ADDITIONAL RISK FACTORS

Do you currently smoke tobacco?

Yes → *If yes, average packs per day:* _____

No

Do you consume alcohol?

Yes → *If yes, average number of drinks per week: _____*

No

Have you used any traditional or herbal medicines in the past 6 months?

Yes → *If yes, specify: _____*

No

Are there any other factors you believe affect your blood health?

Thank you for your participation. Your contribution is valuable to understanding blood health in our community.

APPENDIX B: INFORMED CONSENT FORM

Study Title: Prevalence and Haematological Patterns of Blood Disorders in Chitambo, Zambia: A Cross-Sectional Study Using CBC Testing

Principal Investigator: Daina Zulu Chabala, MScEB
Institution: University of Lusaka, School of Postgraduate Studies
Contact: mscb24126267@stud.unilus.ac.zm / +260 97 2524790

1. Purpose of the Study

You were invited to participate in a research study aimed at estimating how common blood disorders like anaemia, leukocyte abnormalities, and platelet disorders are among residents of Chitambo District. The study used a complete blood count (CBC) test and a questionnaire to gather information that helps identify factors linked to these conditions.

2. Study Procedures

If you agreed to participate, you were asked to:

Complete a questionnaire about your background, diet, health history, and lifestyle (taking about 20 minutes).

Provide a small blood sample (approximately 5 mL) drawn by a trained health worker for CBC testing.

Allow basic measurements (height and weight) to be taken.

3. Possible Risks and Discomforts

Participation involved minimal risks, including brief discomfort or mild pain during blood collection and possible fatigue during the interview. All procedures were carried out by trained staff using sterile, single-use equipment to ensure safety.

4. Potential Benefits

While you may not have received direct personal benefit, your participation contributed to a better understanding of blood disorder patterns in Chitambo. This information helps inform future health programs and policies aimed at improving community health.

5. Confidentiality

All information collected was kept strictly confidential. Your name was not recorded on any research documents; instead, a study code was used. Paper records were stored in a locked cabinet, and electronic files were password-protected. Only the research team had access to the data.

6. Voluntary Participation and Withdrawal

Your participation was entirely voluntary. You had the right to refuse to participate or to withdraw from the study at any time without any penalty or effect on your medical care.

7. Contact Information

If you had any questions about the study or your rights as a participant, you could contact:

Daina Zulu Chabala
University of Lusaka
Email: mscb24126267@stud.unilus.ac.zm
Phone: +260 97 2524790

CONSENT STATEMENT

I have read (or have had read to me) the information above. I have had the opportunity to ask questions, and all my questions have been answered to my satisfaction. I understand that my participation is voluntary and that I may withdraw at any time without penalty.

By signing below, I voluntarily agree to participate in this study.

Participant's Name: _____
Participant's Signature (or Thumbprint): _____
Date: ___ / ___ / _____

Researcher/Enumerator's Name: _____
Researcher/Enumerator's Signature: _____
Date: ___ / ___ / _____

APPENDIX C: RESEARCH WORK PLAN (2025–2026)

Activity / Month	Aug 2025	Sep 2025	Oct 2025	Nov 2025	Dec 2025	Jan 2026
Proposal Finalization & Ethical Approval	[redacted]					
Data Collection		[redacted]	[redacted]	[redacted]		
Data Entry & Cleaning				[redacted]	[redacted]	
Data Analysis					[redacted]	[redacted]
Thesis Writing & Drafting					[redacted]	[redacted]
Final Submission						[redacted]

& Presentation						

Total Project Duration: 6 months (August 2025 – January 2026)

APPENDIX D: STUDY BUDGET

Item / Description	Quantity	Unit Cost (ZMW)	Total Cost (ZMW)
CBC Sample Collection & Testing	384	50	19,200
Stationery (pens, notebooks)	1 batch	300	300
Data Bundles (internet)	3 months	600	1,800
Printing of Questionnaires & Forms	400 copies	2	800
Enumerators (2 persons)	2	200	400
Local Transportation	1 budget	500	500
Miscellaneous/Contingency	1 budget	260	260
GRAND TOTAL			**23,260**

All costs are estimated in Zambian Kwacha (ZMW).