ENSIGN GLOBAL COLLEGE – KPONG

EASTERN REGION, GHANA

FACULTY OF PUBLIC HEALTH

DEPARTMENT OF COMMUNITY HEALTH

EPIDEMIOLOGICAL ANALYSIS OF YAWS IN GHANA- A SCOPING REVIEW

BY

VERA XOESE NYAMATA

(237100255)

AUGUST, 2024

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A THESIS SUBMITTED TO THE DEPARTMENT OF COMMUNITY HEALTH, FACULTY OF PUBLIC HEALTH ENSIGN GLOBAL COLLEGE IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE MASTER OF PUBLIC HEALTH DEGREE

AUGUST, 2024

DECLARATION

I hereby certify that except for references duly cited for other people's work, this project submitted to the faculty of Public Health, Ensign Global College, Kpong is the result of my investigation has not been presented for any other degree elsewhere.

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Dr Sandra Boatemaa Kushitor	……..	01/10/2024 ……..
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Certified by

Dr Stephen Manortey	……..	……..
(Head of Academic Program)	Signature	Date

DEDICATION

This thesis is dedicated to God Almighty for His unfailing love in my life throughout this journey. I also dedicate this work to my children, Stanley and Jerry who had to deal with my absence from home every weekend. And finally, to all those who strive for knowledge and contribute to the betterment of society through research and education.

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DEFINITION OF TERMS

Neglected Tropical Diseases	Neglected tropical diseases (NTDs) are a collection of bacterial, parasitic, viral, and fungal infections that are common in tropical and subtropical developing nations, where poverty is widespread. Beyond their health impact, NTDs impose a significant social and economic burden, leading to social stigma, physical disabilities, disfigurement, blindness, discrimination, loss of social standing, malnutrition, stunted growth, and impaired cognitive development.
Suspected case	A case showing typical features of an illness and missing a laboratory and epidemiological information.
Probable case	A case showing clinical features of illness and a partial laboratory results (pending confirmation) or epidemiological link to a lab-confirmed case.
Confirmed case	A case with a lab confirmation of the causative agent.

ABBREVIATION /ACRONYMS

BU	Buruli Ulcer
CL	Cutaneous Leishmaniasis
DHIMS	District Health Information Management System
DNA	Deoxyribonucleic acid
DPP	Dual Path Platform
MDA	Mass Drug Administration
MDT	Mechanical Diagnosis and Therapy
NBUYEP	National Buruli Ulcer/Yaws Eradication Program
NYEP	National Yaws Eradication Program
NTDs	Neglected Tropical Diseases
PCR	Polymerase Chain Reaction
RDT	Rapid Diagnostic Test
TCT	Total Community Treatment
TTT	Total Targeted Treatment
UHC	Universal Health Coverage
UNICEF	United Nations Children's Fund
WHO	World Health Organization

ABSTRACT

Background: Yaws is a neglected tropical disease (NTD) that affects children less than 15 years old in disadvantaged communities. It is caused by *Treponema Pallidum Pertenue,* which affects the skin, bones and cartilage which, if left untreated results, in permanent disfigurements and disabilities. This study assessed the prevalence and distribution of yaws, explore its geographic spread, and identify challenges within the surveillance and reporting systems.

Methodology: Data was gathered from electronic databases such as PubMed and Google Scholar, and the District Health Information Management System (DHIMS) in Ghana, utilizing a descriptive study and scoping review technique. The study examined the prevalence of yaws across different regions, evaluated geographic patterns, and identified gaps in surveillance and reporting.

Results/Findings: Yaws remains endemic, particularly in rural and impoverished areas, with notable variability in prevalence across Ghana. The geographic distribution was uneven, with the highest concentration of cases in the Western North (n= 152), Central (n=63), and Eastern regions (n=41) in 2023, influenced by socio-economic and environmental factors. The study identified significant challenges in the surveillance and reporting systems, including insufficient resources, incomplete data reporting, and delays in data submission.

Conclusion: The findings underscore the urgent need for targeted public health interventions in high-prevalence regions, improved surveillance, and enhanced reporting systems. Addressing these challenges requires increased resource allocation, better diagnostic tools, and stronger community engagement. The study highlights the importance of ongoing research and policy support to advance yaws eradication efforts and achieve the World Health Organization's targets.

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CHAPTER 1

1.0 INTRODUCTION

1.1 Background

Yaws, a treponematosis, is one of the skin neglected tropical diseases (NTDs) earmarked for eradication by the World Health Organization (WHO) in March 2012 (WHO, 2012). Bejel, pinta, and yaws are caused by *Treponema pallidum endemicum, Treponema pallidum carateum, and Treponema pallidum pertenue,* respectively. Yaws is the most common among these three diseases and is primarily found in impoverished rural communities, affecting mostly children 2 to 15 years of age in tropical forest regions of Africa, Asia, Latin America, and the Pacific (Kazadi *et al.*, 2014; Asiedu *et al*., 2020). The disease is recently known to be endemic in three countries, including Ghana, Solomon Islands and Papua New Guinea which have each reported over 15,000 cases between 2011 and 2013 (Marks *et al*., 2015).

Yaws is highly contagious and is primarily spread through direct skin-to-skin contact with individuals who have active lesions. These infections, while not deadly, result in painful and occasionally disfiguring sores on the skin, cartilage, face, lips, and bones. Approximately 10% of cases not treated over a long period may lead to stigmatized outcomes and permanent impairment of the face, arms and legs (Asiedu *et al*., 2020). Currently, no vaccine is available for preventing yaws (Asiedu et al., 2020; Okine *et al.*, 2020).

In the 1950s and 1960s, the World Health Organization (WHO) and UNICEF launched a mass campaign to combat yaws, primarily through the administration of penicillin benzathine injections. Despite these large-scale efforts, the disease persisted in many regions. In January 2012, WHO introduced a new initiative aimed at accelerating progress against neglected tropical diseases, with a specific goal of eradicating yaws by 2020 (Ghana Public Health Division, 2020). Unfortunately, even with these renewed efforts, yaws continues to be endemic in at least twelve countries (Kazadi *et al.*, 2014). Yaws remains

endemic in regions such as the Pacific, Southeast Asia, and Central and West Africa. Between 2010 and 2013, Ghana, the Solomon Islands, and Papua New Guinea accounted for 84% of the more than 250,000 cases of yaws reported to WHO from countries where the disease is prevalent (Okine *et al.*, 2020).

In Africa, a significant area for yaws prevalence is found within the humid forested zone along the borders Cameroon, the Central African Republic, the Democratic Republic of the Congo, and the Republic of the Congo. This region is home to native communities residing in impoverished areas with limited healthcare access (Kazadi *et al.*, 2014). Recent serological studies have revealed yaws prevalence rates ranging from 20% to 86% among these populations (Kazadi *et al.*, 2014).

Though yaws is widely spread across the regions of Ghana, there is not enough data on the prevalence since there are gaps in collecting surveillance data to determine the actual prevalence of yaws in Ghana (Kazadi *et al.*, 2014). This study will hence explore the prevalence and distribution of yaws in Ghana.

1.2 Problem Statement

Yaws prevalence is high in rural communities due to insufficient water and sanitation, as well as poor personal hygiene. All districts in Ghana, except for nine in the Grater Accra Region, have reported cases of yaws (NYEP Annual Report, 2008). The disease primarily affects rural, underprivileged areas in the Eastern, Volta, Central, Ashanti, Brong Ahafo, and Western Regions (Kazadi *et al.*, 2014; Okine *et al.*, 2020). According to the National Yaws Eradication Program (NYEP) annual report (2018), pilot studies conducted in the Eastern region found that the prevalence in some schools was between 10% and 20% with 75% of the cases under 15 years. Despite previous efforts to control yaws globally, its prevalence and trends in Ghana remain poorly understood. The National Yaws Elimination Program's 2008 strategic plan policy document reiterated Ghana's commitment to eradicating yaws. This is in line with the elimination and ultimate eradication strategy of WHO/UNICEF, which was implemented in 1950 and was extended in Geneva in 1978 and 2007.

The current state of yaws in Ghana, including its prevalence, regional distribution, and the effectiveness of surveillance and reporting systems, remains poorly understood despite recent advancements (Ghinai *et al.*, 2015). Although yaws is acknowledged as a significant health issue in Ghana, comprehensive epidemiological analyses detailing its prevalence, distribution, and trends over time are notably lacking. This gap in research hinders the formulation of effective intervention strategies and complicates the monitoring and control efforts necessary for disease eradication. An in-depth understanding of yaws epidemiology is crucial for addressing this neglected tropical disease and ensuring successful eradication.

In spite of WHO-led attempts to eradicate yaws, Ghana-specific contemporary epidemiological data are scarce. This knowledge gap impedes efforts to create focused therapies and threatens the advancement of the global eradication aim (Marks *et al.*, 2015). Furthermore, the dynamics of yaws transmission in Ghana may be influenced by variables like socioeconomic level, access to healthcare, and environmental circumstances, making control efforts even more challenging (Ghinai *et al.*, 2015).

To fill this vacuum, a comprehensive epidemiological analysis is needed to determine the high-risk groups and geographic hotspots, explain the existing yaws burden in Ghana, and define temporal trends. For the purpose of controlling and eliminating yaws in Ghana, these findings are essential in directing policy choices, resource allocation, and implementation tactics.

1.3 Rationale of the study

Though yaws was targeted for eradication by WHO by the year 2020, the disease remains endemic in several countries, including Ghana (Mitjà *et al.*, 2015). Understanding the determinants, distribution, and trends of yaws in Ghana is crucial for designing effective control and eradication strategies (Kazadi *et al.*, 2014). Since yaws is mainly seen among populations with poverty, inadequate health infrastructure, and limited access to health care, Ghana with its diverse socio-economic landscape and geographical features

provides an ideal setting for investigating the prevalence and trends of yaws. Despite some control measures carried out, the disease remains prevalent in some regions, suggesting the need for a comprehensive epidemiological analysis to inform a targeted intervention (Ghinai *et al.*, 2015). Also, because WHO has renewed its commitment to eradicating yaws by 2030 through the implementation of the Morges strategy, it is imperative to have country-specific data on the prevalence and trends of the disease to inform evidence-based interventions contributing to achieving a global yaws eradication target.

Examining the geographical distribution of yaws cases throughout Ghana's many districts and regions can shed light on the diseases' spatial epidemiology (Kazadi *et al.*, 2014). Analyzing spatial patterns and mapping the distribution of yaws cases might assist to pinpoint high-transmission areas, enable focused interventions, and more efficiently distribute resources to the places most in need (Mitjà *et al.*, 2015).

To strengthen yaws surveillance efforts and enhance data quality, gaps and limitations in Ghana's yaws monitoring and reporting systems must be identified through document review analysis. This study will examine policy papers, guidelines, and surveillance reports identify and suggest solutions for obstacles to efficient monitoring and reporting, such as inadequate resources, incomplete reporting, and late data submission.

In effect, this research seeks to augment the previous knowledge, on the epidemiology of yaws in Ghana and provide substantiation to facilitate well-informed decision-making and policy formulation concerning yaws control and eradication initiatives. This study can produce important insights that will direct efforts towards accomplishing yaws elimination targets in Ghana and eventually support international efforts to eradicate yaws as a public health issue by integrating current research and analyzing yaws data from Ghana.

1.4 Conceptual framework

The conceptual framework for this research combines aspects of social-ecological model and the health belief model to examine the epidemiology of yaws in Ghana. It considers individual, interpersonal, community, and systemic factors influencing the disease's prevalence, distribution, and surveillance of yaws in the Ghanaian population. At the individual level, the study focuses on knowledge and awareness of yaws, perceived risk, perceived severity, and health-seeking behaviors. Interpersonal factors include the influence of family, peers, as well as social support networks. Community-level factors encompass socioeconomic status, geographical location, and health infrastructure. Systemic factors involve public health policies, surveillance systems, and resource allocation. This study specifically emphasizes community-level factors, highlighting the relevance of health infrastructure and local resources in managing yaws. By addressing these interconnected layers, the framework provides a comprehensive approach to understanding and combating yaws in Ghana, underscoring the need for an integrated strategy that includes individual behaviors, social support, community resources, and systemic policies.

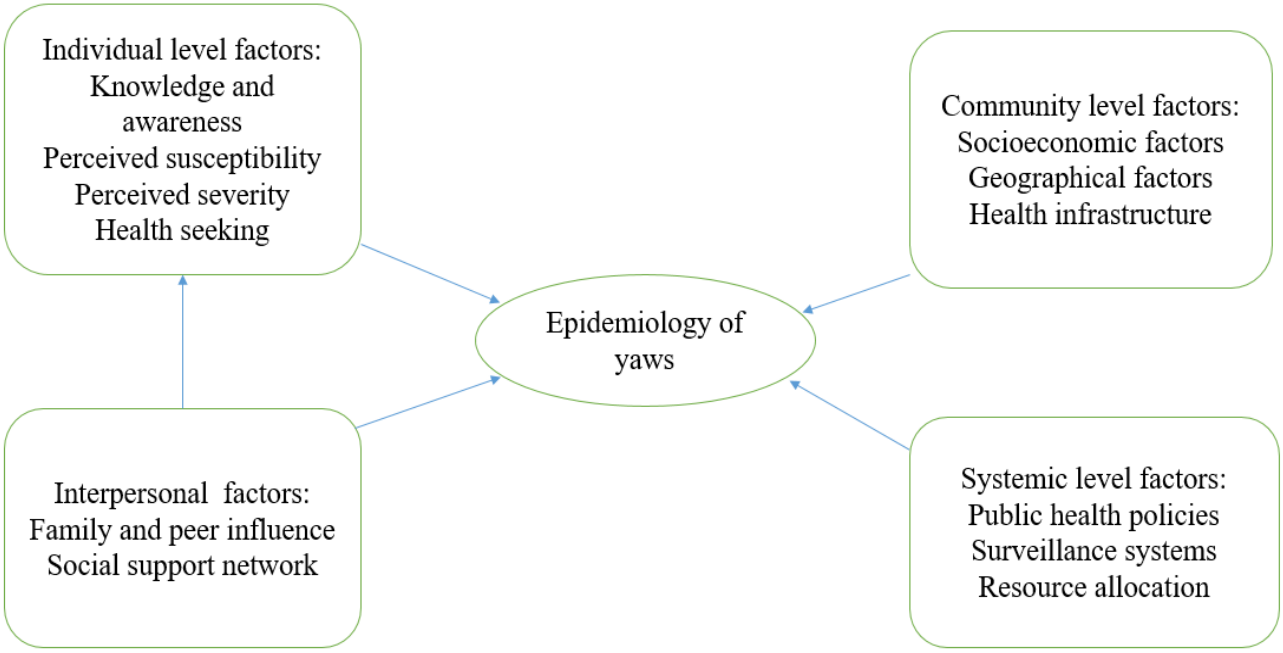


Figure 1: Conceptual Framework

Source: Adapted from Asiedu, K., Frizpatrick, C., & Jannin, J.(2020). Eradication of Yaws: Historical Efforts and Achieving WHO's 2020 Target.

1.5 Research Questions:

1. What is the reported prevalence of yaws in Ghana from available literature between 2014 and 2024?
2. What do the existing data reveal about the geographical distribution of yaws cases across the regions and districts in Ghana?
3. What gaps and challenges are identified in yaws surveillance and reporting systems in Ghana from a review of the available studies and reports?

1.6 General Objective:

To examine and integrate existing data on the prevalence and geographic distribution of yaws in Ghana.

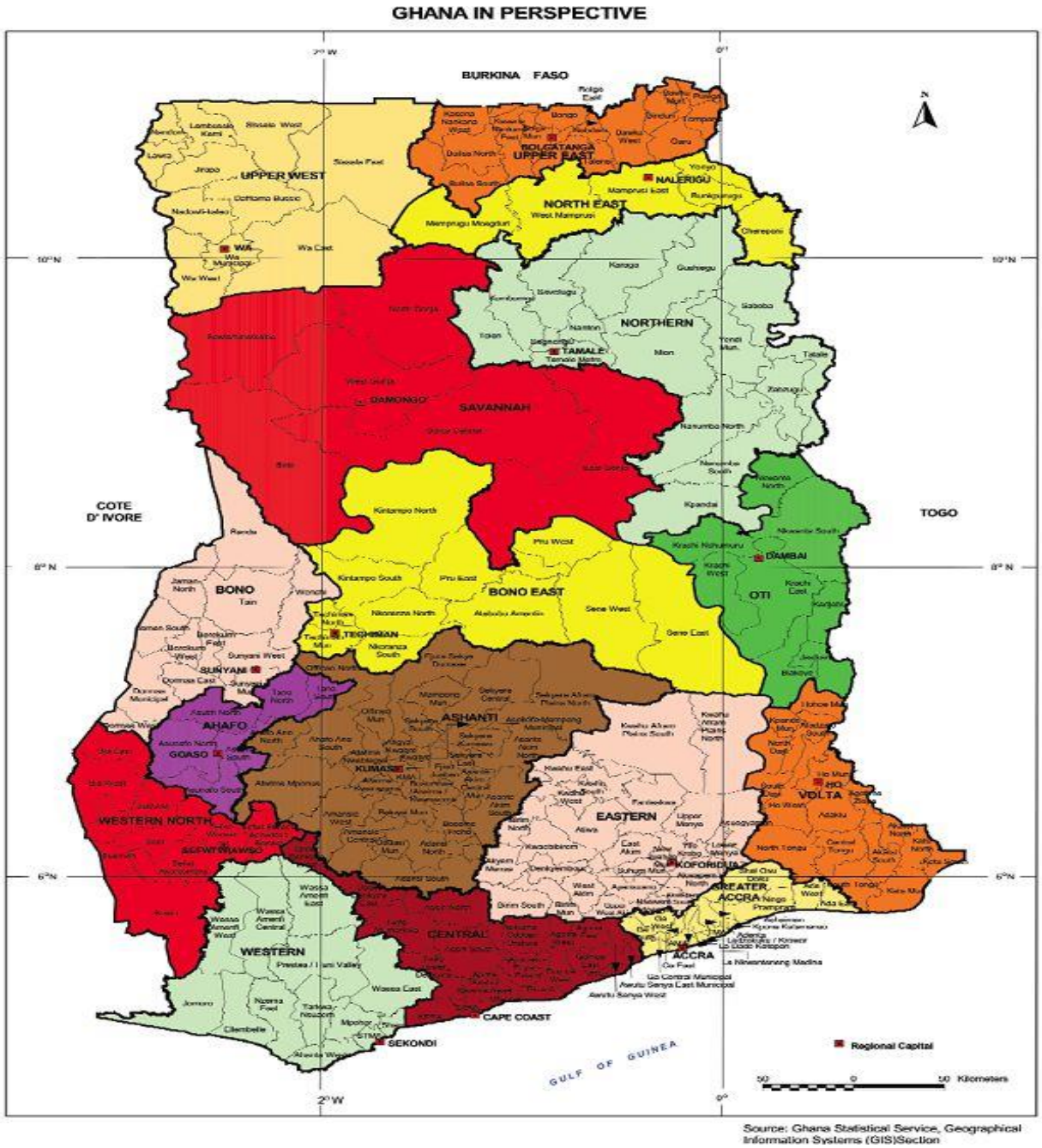
1.7 Specific Objectives:

1. To explore documented reports on the prevalence of yaws in Ghana between 2014 and 2024 by reviewing published studies and grey literature.
2. To analyze geographic patterns of yaws distribution across Ghana, based on findings from literature and reports available during the study period.
3. To identify gaps and challenges in yaws surveillance and reporting systems in Ghana, as described in relevant studies and documents.

1.8 Profile of Study Area

Ghana is bordered by Burkina Faso to the north, Togo to the east, and Cote d'Ivoire to the west. To the south, its coastline stretches approximately 550km along the Gulf of Guinea, extending about 675km inland. The land area is 238,533km^2 in total (Ghana Statistical Service, 2021). Ghana is made up of 16 regions and 261 metropolitan, municipal and districts. According to the 2021 National Population and Housing Census, Ghana's total population stands at 30,832,019, with an average growth rate of 2.1% (Ghana Statistical Service, 2021). Rural areas are home to 43.3% of the population. Among children aged 5-14 years, 82% of males and 71% of females participate in agricultural activities across various regions. Additionally, 92% of households have access to improved drinking water sources, with urban households having higher access (97.8%) compared to rural households (83%). However, 79.9% of households using unimproved water sources depend on surface water, which is prevalent in 10 out of Ghana's 16 regions (Ghana Statistical Service, 2021). Poor access to improved water sources impacts negatively on personal and environmental hygiene practices among household members.

Map of Ghana



Map 1: *Administrative Map of Ghana*

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Introduction

Gaining insight into the epidemiology of yaws is vital for developing successful strategies for its control and eradication. This literature review aims to provide a detailed overview of the current understanding of yaws epidemiology in Ghana, with a focus on its prevalence, associated risk factors, and the challenges in surveillance and control. By synthesizing findings from multiple studies, this review seeks to identify research gaps and propose future areas of study to support ongoing efforts to eliminate yaws in Ghana.

2.2 Clinical presentation of yaws

Yaws is an infectious disease caused by *Treponema pallidum* subspecies *pertenue*. It is one of four treponemal diseases that affect humans (Marks *et al.*, 2015). Yaws has re-emerged as an endemic infection resulting from *Treponema pallidum* subspecies *pertenue* (Marks *et al.*, 2015). The disease manifests as papillomatous and ulcerative skin lesions in its early stages. In its later stages, it can lead to more severe skin lesions, bone involvement, and, in rare instances, destructive lesions of the nasopharynx (Ghinai *et al.*, 2015).

Similar to other treponemal diseases, yaws can be categorized into primary, secondary, and tertiary stages for clinical purposes. However, it is important to note that patients may exhibit a combination of symptoms from different stages. The initial sign of primary yaws is a papule that appears at the inoculation site around 21 days after infection (with a range of 9–90 days). The lower limbs are the most common location for primary lesions, although other areas of the body can also be affected. Unlike syphilis, genital lesions are exceedingly rare. I left untreated, these lesions generally heal on their own, leaving scars, within 3 to 6 months (Marks *et al.*, 2015).

Yaws is transmitted via direct skin contact, mainly affecting children under 15, particularly in areas with poor socioeconomic conditions and inadequate sanitation. It persists as endemic in low- to middle-income countries, with a resurgence seen in the Pacific, West and Central Africa, and Southeast Asia (Okine *et al.*, 2020). The disease affect males more frequently than females, often contracted through cuts or abrasions on the lower legs. This higher incidence in boys is attributed to their increased physical activity, making them more prone to injuries. Transmission takes place when an individual comes into contact with fluids from lesions of an infected person. Yaws predominantly impact rural communities which have poor economic conditions and low hygiene standards. The incidence of the disease decreases as social and economic conditions improve. Additionally, rural areas with extensive vegetation heighten the risk of leg and foot injuries, leading to subsequent infections (Kazadi *et al.*, 2014).

2.3 Epidemiology of yaws

Neglected Tropical Diseases (NTDs) disproportionately affect low- and middle-income nations (Stolk *et al.*, 2016). These diseases are not only prevalent across different countries but also tend to be more concentrated within the poorest segments of the population (Houweling *et al.*, 2016). Poverty is frequently recognized as a key driver of neglected tropical diseases (NTDs), as it is associated with inadequate living and working conditions and restricted access to preventive and curative healthcare services (Aagaard-Hansen and Chaignat, 2010). Additionally, NTDs worsen poverty, as many developing countries lack social protection systems, such as health insurance for catastrophic medical costs and disability or sickness insurance to offset income loss during illness or disability (Lenk *et al.*, 2016).

Neglected tropical diseases (NTDs) are often associated with the most impoverished populations and are used as indicators of progress toward achieving Universal Health Coverage (UHC) (Fitzpatrick and Engels, 2016; Houweling *et al.*, 2016). Among these, skin NTDs characterized by prominent cutaneous symptoms include conditions such as leprosy, yaws, cutaneous leishmaniasis (CL), and Buruli ulcer (BU),

all of which remain significant public health issues in various countries (Mawson, 2020; Yakupu *et al.*, 2023). India and Ecuador are two countries that have successfully eliminated yaws. In Ecuador, after the implementation of a yaws surveillance and treatment program, serological surveys in 1998 showed a low reactive serology rate of 3.54%. Similarly, a 2005 survey in India found no sero-reactors among 3,821 children under five years old (Mitjà *et al.*, 2015). This study focuses specifically on Yaws in Ghana.

Yaws is believed to be endemic in at least 12 countries (Kazadi *et al.*, 2014; Okine *et al.*, 2020). The reported cases of yaws likely underestimates the true incidence of the disease. The prevalence of yaws in warm, humid climates is attributed to the sensitivity of *T. pallidum* subspecies *Pertenue* to cooler, drier conditions, which may also explain the higher occurrence of skin lesions during the rainy season (Marks *et al.*, 2015). In the 1950s, approximately 50 million people were infected with yaws. The World Health Organization (WHO) initiated a mass treatment campaign using benzathine benzylpenicillin, which led to a significant global reduction in infections (Marks, 2018; Okine *et al.*, 2020). However, yaws eventually fell off the public health agenda, leading to a resurgence of cases over the next 30 years. Yaws has resurfaced as a public health concern in South America (Santos *et al.*, 2010) the Pacific, South-East Asia, (Fegan *et al.*, 2010), and Africa (Manirakiza *et al.*, 2011), The WHO currently estimates that approximately 2.5 million people may be infected (Okine *et al.*, 2020).

While the full scope of yaws in Africa remains uncertain, seven countries reported cases to the WHO in 2012: Cameroon, Central African Republic, Benin, Congo, Togo, Côte d'Ivoire, and Ghana, with the Democratic Republic of the Congo reporting earlier in 2008. Ghana appears to be the most affected, documenting over 20,000 cases annually from 2007 to 2010 (Kazadi *et al.*, 2014). Another key yaws hotspot in Africa is the tropical forest region along the borders of Cameroon, Congo, and the Central African Republic, where indigenous Pygmy populations reside. Ghana, Cameroon, and Congo are the countries currently implementing national initiatives to address yaws and track cases through their

respective health information systems (Kazadi *et al.*, 2014). Recent research in Papua New Guinea indicates that the prevalence of yaws lesions has varied, with rates ranging from 4% in the Karkar Islands in 1990 to 15% in the peri-urban areas of Port Moresby in 2001 (Manning and Ogle, 2002). The country has some of the highest hospital-based incidence estimates globally, at 2.5% annually.

In Cameroon, the mass-treatment campaigns of the 1950s led to the assumption that yaws had been eliminated from the country. Nevertheless, outbreaks reappeared among indigenous groups in the Lomié health district in 2007 and 2008. These populations usually inhabit impoverished areas with limited or no access to healthcare and education, often migrating through forested regions (Kazadi *et al.*, 2014). Further activities in 2010 identified 789 suspected yaws cases. All the health districts are still considered endemic for yaws in Cameroon, with the most of the cases occurring in the East Region. A survey conducted in the Lomié health district in 2012 revealed that yaws remain prevalent among the indigenous residents of Baka and Bantu communities, with a 9% prevalence rate of for yaws lesions (World Health Organization, 2024).

The regions of Likouala, Sangha, and Lékoumou, are endemic for yaws in the Republic of the Congo with at least 16 of the 84 districts reporting cases annually. The indigenous Babengas living in the humid forested region of Likouala, sharing borders with endemic areas in Cameroon are the most affected. A screening and treatment program conducted by Coldiron et al. in 2013, in the Likouala region's Bétou and Enyellé districts, reached around 6,000 children and identified 485 clinical cases with yaws-like ulcers. One hundred and eighty-three (183) of these subjects had a confirmed reactive serology, representing a clinical yaws prevalence of 2.9% (Kazadi *et al.*, 2014).

In 2012, a yaws control program was reestablished in the Central African Republic. Surveys carried out recently revealed a high prevalence of *Treponema Pallidum* infection in the southwestern regions of Lobaye and Sangha, with 11% of school-going children exhibiting yaws skin lesions and 85% showing reactive serological results (active and latent). There are also indigenous populations living in this area

close to the borders of the Democratic Republic of the Congo and the Republic of the Congo (Manirakiza *et al.*, 2011).

According to surveys carried out in Ghana in 2008, 0.68% of the country's population had clinically prevalent yaws lesions. However, in certain rural communities, the prevalence reached as high as 20%

(World Health Organization, 2022). Over time, Ghana's case-reporting trend has significantly decreased, with cases falling from 35,200 in 2009 to 9,300 in 2012, respectively (Kazadi *et al.*, 2014). All ten regions of Ghana report yaws annually, but the Western, Ashanti, Eastern, Central, and Volta, regions are the most affected. Approximately 11% of the 170 districts failed to report any yaws cases via routine reporting between 2008 and 2011.

2.4 Geographical Distribution of Yaws in Ghana

Out of the 12 nations that are known to be endemic for yaws, Ghana reports more than 20,000 cases each year between 2007 and 2010. To coordinate eradication efforts, the nation started a nationwide yaws eradication campaign in 2008. Nearly all 216 districts in the nation are endemic for the disease, with the southern forested parts being the most affected. According to Kazadi et al. (2014), out of the 9,356 instances of yaws documented in 2012, 534 were from the West Akim Municipality.

In West Akim Municipality, where three Mechanical Diagnosis and Therapy (MDT) exercises have been conducted, the disease has shown signs of return despite prior mass drug treatment strategies. Over the past eight years, an average of 111 cases per 100,000 population per year were reported nationwide (Dzotsi et al., 2017). Rural settlements in Ghana keep reporting new cases in spite of several strategies implemented over the years. A national school-based survey indicated a prevalence of 20% among school children (Agana-Nsiire et al., 2014). The Eastern, Volta Central, and Regions remain endemic, reporting between 5 and 338 cases per 100,000 population over four years (Okine et al., 2020).

Most yaws-endemic communities were found to be near the borders of other districts and regions, according to a study by Basing et al. (2020) in four districts of Ghana: Ayensuanor, Upper West Akim, Nkwanta South, and Nkwanta North. In the Nkwanta North District, patients surveyed were from both Nkwanta North and Nkwanta South Districts; a total of ten communities were surveyed, and DPP positive cases were observed in all of the communities.

A total of 10 communities were assessed, and DPP-positive cases were discovered in all of them. In Nkwanta South District, Sibi Central, Sibi Hilltop, and Lamina, and Nkwanta North District's Krachi Akura, were the communities with the greatest number of DPP positive cases. Participants came from 30 localities in the Upper West Akim District; 29 of those communities—across 5 districts in 3 regions—reported having DPP positive cases (Basing *et al.*, 2020). The communities of Brofuyedu, Obinimda, Esusu, Okurase, and Siwunkyemu were notable for having a high number of DPP positive cases. The majority of DPP positive cases in the West Akim Municipality came from people who didn't live there. In total, 28 out of the 29 communities surveyed in the four districts had DPP positive individuals. DPP positive instances were found in Teacher Mante, Achiansah, Apau Wawase, and the adjacent communities in the Ayensuanor District. But a few cases also came out of Upper West Akim District's Alaafia (Basing *et al.*, 2020).

2.5 Challenges in the Yaws surveillance system

In Ghana, yaws surveillance and reporting face several significant challenges, particularly in rural areas. According to a 2008 survey, 0.68% of people nationwide had yaws lesions, with a prevalence of 20% or higher in certain rural areas (Kazadi et al., 2014). In spite of this, Ghana has seen a decrease in the number of yaws cases reported, dropping from 35,200 in 2009 to 9,300 in 2012. Every one of the ten former regions filed a yearly report every year, however between 2008 and 2011, 17 of the 170 districts did not provide any reports.

Reporting issues are particularly prevalent in the Northern Region and metropolitan areas like Accra and Kumasi, where failure to submit data is a significant barrier (Kazadi *et al.*, 2014).

Surveillance is hampered by the fact that diagnosis is often based solely on clinical manifestations, which can lead to misdiagnoses. The chancroid-causing agent, Haemophilus ducreyi, has been implicated in the development of non-genital skin lesions in yaws-endemic areas, according to recent investigations, complicating the clinical diagnosis of yaws (Agana-nsiire *et al.*, 2014; Ghinai *et al.*, 2015; Basing *et al.*, 2020). As a result, surveillance data that rely on clinical signs alone may be inaccurate, emphasizing the need for confirmatory serological and molecular testing. However, access to diagnostic tools remains limited due to lack of funding and resources, further impeding accurate prevalence estimation and disease reporting (Marks *et al.*, 2015; Okine *et al.*, 2020). Surveillance is a crucial element in planning, implementing, and evaluating public health responses. The process involves the systematic collection, analysis, and dissemination of health data to stakeholders (Adokiya *et al.*, 2015). However, despite global efforts, many developing countries, including Ghana, struggle to establish fully functional health surveillance systems. The International Health Regulations (IHR 2005) call for enhanced capacity in disease surveillance through the Integrated Disease Surveillance and Response (IDSR) strategy. However, this initiative has been inadequately implemented in many countries, leading to poor-quality data that hinder effective planning and decision-making (Chretien and Lewis, 2008; Kasolo *et al.*, 2013; Adokiya *et al.*, 2016).

Specifically for yaws, Ghana's NTDs (Neglected Tropical Diseases) Master plan for 2021–2025 highlights ongoing challenges. These include inadequate funding, lack of stakeholder collaboration, and human resource gaps that undermine the sustainability of NTD programs, including yaws surveillance. Furthermore, there is minimal integration with the Water, Sanitation, and Hygiene (WASH) sector, an essential component for controlling NTDs like yaws (Ghana Public Health Division, 2020). The country's

reliance on external funding, lack of national policies for NTD control, and absence of country-specific procedures have also been cited as key obstacles.

Human resource issues, such as insufficient training and misalignment of staff with programmatic needs, further complicate efforts to strengthen the surveillance system. The absence of a Monitoring and Evaluation (M&E) plan for NTDs, inadequate training for health workers, and reliance on the WHO's general guidelines, which are not tailored to local contexts, hinder effective service delivery. Moreover, the health information systems are inadequate, lacking standardization in data collection and proper training for health personnel (Ghana Public Health Division, 2020).

In West Africa, yaws prevalence based on clinical diagnosis ranges between 3% and 10%. However, clinical diagnosis alone is unreliable and contributes to inaccurate reporting. The absence of active surveillance systems may have contributed to Ghana missing the ambitious 2020 eradication target set by WHO (Tchatchouang, 2022). Furthermore, a study by Handley et al. (2022) identified funding and logistics as major barriers to improving molecular testing capacity and surveillance, including insufficient resources to establish diagnostic laboratories in yaws-endemic districts.

Despite efforts to report yaws cases in Ghana through the electronic DHIMS2 system, less than 5% of suspected cases are confirmed due to the shortage of diagnostic tools like rapid diagnostic tests (RDT) and Dual Path Platform (DPP) kits. Community health surveillance volunteers report suspected cases, but confirmation often depends on the availability of these limited test kits (Handley *et al.*, 2022).

Ultimately, effective yaws surveillance in Ghana faces a myriad of challenges, including the need for improved diagnostic tools, sustainable funding, and better integration of health and non-health sectors to address the complexity of NTD control comprehensively.

CHAPTER 3

3.0 METHODOLOGY

3.1 Introduction

This chapter explains how the research topic was explored and why specific designs and procedures were employed. The chapter also discusses the context in which the study was conducted, the sampling technique, the data collecting instrument, the data collection protocol, the analysis, the validity, and ethical considerations in the study.

3.2 Study Design

Descriptive statistics was employed to explore the prevalence and distribution of yaws in Ghana over the past decade using data from the DHIMS. Microsoft Excel was primarily employed in this analysis to visually describe the prevalence and trends of yaws data from DHIMS. QGIS Desktop software version 3.28.8 was however used to describe the geographical distribution of yaws cases in Ghana.

Additionally, a scoping review of the literature related to gaps and challenges that exist in yaws surveillance and reporting systems in Ghana was conducted. A scoping review is a form of knowledge synthesis that locates and synthesizes an existing or developing body of literature on a particular subject using an organized and iterative process (Mak and Thomas, 2022).

3.2.1 District Health Information Management System (DHIMS2)

The study used data retrieved from the DHIMS 2 database. The District Health Information Management System (DHIMS2) is a robust web-based program used to remotely gather data from various levels of a health system and store in a central location. DHIMS2 is used to collect and analyze health system routine data, which are automatically aggregated by districts and regions (Odei-Lartey *et al.*, 2020). Also, a program report of the Ghana Health Service's Yaws Eradication Program data from 2018 and 2019 was

retrieved. Data on yaws surveillance, including suspected and confirmed cases according to the age groups of under 15 years and above 15 years, was analyzed and classified according to gender.

Yaws data from DHIMS and a program report of the Ghana Health Service's Yaws Eradication Program were imported into Microsoft Excel for analysis. Using an Excel data extraction form, pertinent information from the other sources was also retrieved. This information included study characteristics (such as authors, publication year, study design, and study population).

3.2.2 Variables

The variables analyzed during this study included suspected cases, suspected cases tested with RDT, RTD-positive cases, confirmed cases with DPP, the age distribution of the suspected and confirmed cases, and the sex distributions according to the various regions of Ghana.

3.3 Statistical Analysis

Microsoft Excel was employed in this analysis. Descriptive statistics was used to describe the prevalence and trends of yaws data from DHIMS, as well as data from the National Yaws Eradication Program, using percentages and proportions. Data was presented using bar graphs and maps.

3.3.1 Scoping Review Framework

This scoping review followed the framework outlined by (Mak and Thomas, 2022). The methodology consisted of five stages: (1) identifying the research question, (2) identifying relevant studies, (3) selecting studies, (4) charting the data, and (5) collating, summarizing, and reporting the results. This study followed the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews) guidelines to ensure methodological rigor.

Stage 1: Identifying the research question

The primary research questions guiding this scoping review was what is the reported prevalence of yaws in Ghana from available literature between 2014 and 2024? The study also sought to answer the question "What is the geographical distribution patterns of yaws cases across regions and districts in Ghana" and "What gaps and challenges are identified in yaws surveillance and reporting systems in Ghana from a review of the available studies and reports"?

Stage 2: Identifying Relevant Studies

A comprehensive literature search was conducted across several electronic databases, including PubMed, Scopus, Web of Science, and Google Scholar. Additional sources included grey literature such as government reports, WHO publications, and conference proceedings. The search strategy incorporated keywords and MeSH terms related to yaws, epidemiology, Ghana, surveillance, and public health. The search terms were adjusted as necessary for each database to optimize retrieval and was restricted to articles published between the periods of 2014 to 2024. An excel sheet was used to extract information on included study characteristics (authors, publication year, study design, study population, geographic location, and key findings).

Table 1: Search results

Search Details	**Results**
PubMed ((yaws) OR (yaws[MeSH Terms])) AND (Ghana)	50
Google Scholar "Yaws" AND "Ghana"	1,510
Science Direct "Yaws" AND "Ghana"	95
Total	1655

Stage 3: Study Selection & Eligibility

The selection process for this study on yaws in Ghana involved two main stages: initial screening and full-text review. Two reviewers independently examined the titles and abstracts of the identified articles in the first stage to determine eligibility based on the inclusion and exclusion criteria. The inclusion criteria specifically targeted English-language research that examined the epidemiology of yaws in Ghana and were published between 2014 and 2024. The full texts of possibly pertinent research were examined in the second step before being finally included. Any differences or arguments amongst reviewers were settled by conversation and, if required, by seeking advice from a third reviewer. Additionally, the inclusion criteria were refined as needed during this process to ensure relevance and accuracy in the selection of studies.

Inclusion and Exclusion Criteria

Inclusion Criteria:

The inclusion criteria for the studies considered in this review were as follows: only studies published in English were included. The focus was specifically on studies addressing the epidemiology of yaws in Ghana. Various types of documents were considered, including research articles, reviews, reports, and conference abstracts. Additionally, only studies published from 2014 to the present were included in the review.

Exclusion Criteria:

The exclusion criteria for the studies in this review were as follows: studies not related to yaws or not focused on Ghana were excluded. Non-epidemiological studies, such as clinical trials on treatment without an epidemiological context, were also not considered. Articles without available full texts were excluded, as were studies published before 2014 or after 2024.

Stage 4: Charting the Data

A data extraction form was developed collaboratively by the research team, including categories such as author, year, study design, study population, yaws prevalence or incidence rates, geographic location, and key findings. The form was pilot tested and refined through a calibration exercise. Two reviewers independently extracted data from a small sample of papers, discussing discrepancies to ensure consistency in the extraction process.

Stage 5: Collating, Summarizing, and Reporting the Results

After data extraction, both numerical and thematic analyses were conducted. Numerical analysis results were presented in tables and charts to showcase key aspects of yaws epidemiology in Ghana, including prevalence trends, geographic distribution, and demographic patterns. Thematic analysis involved examining text excerpts to identify recurring themes related to yaws surveillance challenges, risk factors, and control strategies.

The research team engaged in reflexive discussions throughout the analysis process, using memos to capture insights and interpretations. Codes were developed and refined iteratively, leading to the creation of categories and themes that provided a comprehensive overview of yaws epidemiology and related challenges in Ghana. The final report aligned findings with the study objectives, presenting a nuanced understanding of the yaws situation in the country.

3.4 Study Population

The study population of this study included all peer-reviewed literature on yaws published in Ghana between 2014 and 2024. This includes research articles, reviews, reports, and conference abstracts that focus on the epidemiology of yaws in Ghana.

3.5 Data Source

We researched electronic databases, including PubMed, Science Direct and Google Scholar, to identify relevant studies on yaws epidemiology in Ghana published over the past decade (2014-2024). Additional sources of literature were searched, including grey literature, government reports, and organizational websites, to ensure the inclusion of all relevant studies and reports. The study selection process for this scoping review followed a systematic approach, as illustrated in the PRISMA flow diagram. The initial identification phase involved searching multiple electronic databases, yielding a total of 1,655 records: 1,510 from Google Scholar, 50 from PubMed, and 95 from Science Direct. No additional records were identified through registers.

Prior to screening, 816 records were removed. This included 685 duplicate records, 125 records marked as ineligible, and 6 records removed for other reasons. This preliminary filtering resulted in 840 records proceeding to the screening phase. During the screening process, 682 records were excluded based on initial criteria, leaving 158 reports to be sought for retrieval. All 158 of these reports were successfully retrieved and subsequently assessed for eligibility.

The eligibility assessment led to further exclusions based on three primary reasons: studies unrelated to the review objectives, incorrect study type, and inappropriate study setting. In the end, the thorough selection process led to the inclusion of three studies in the final review.

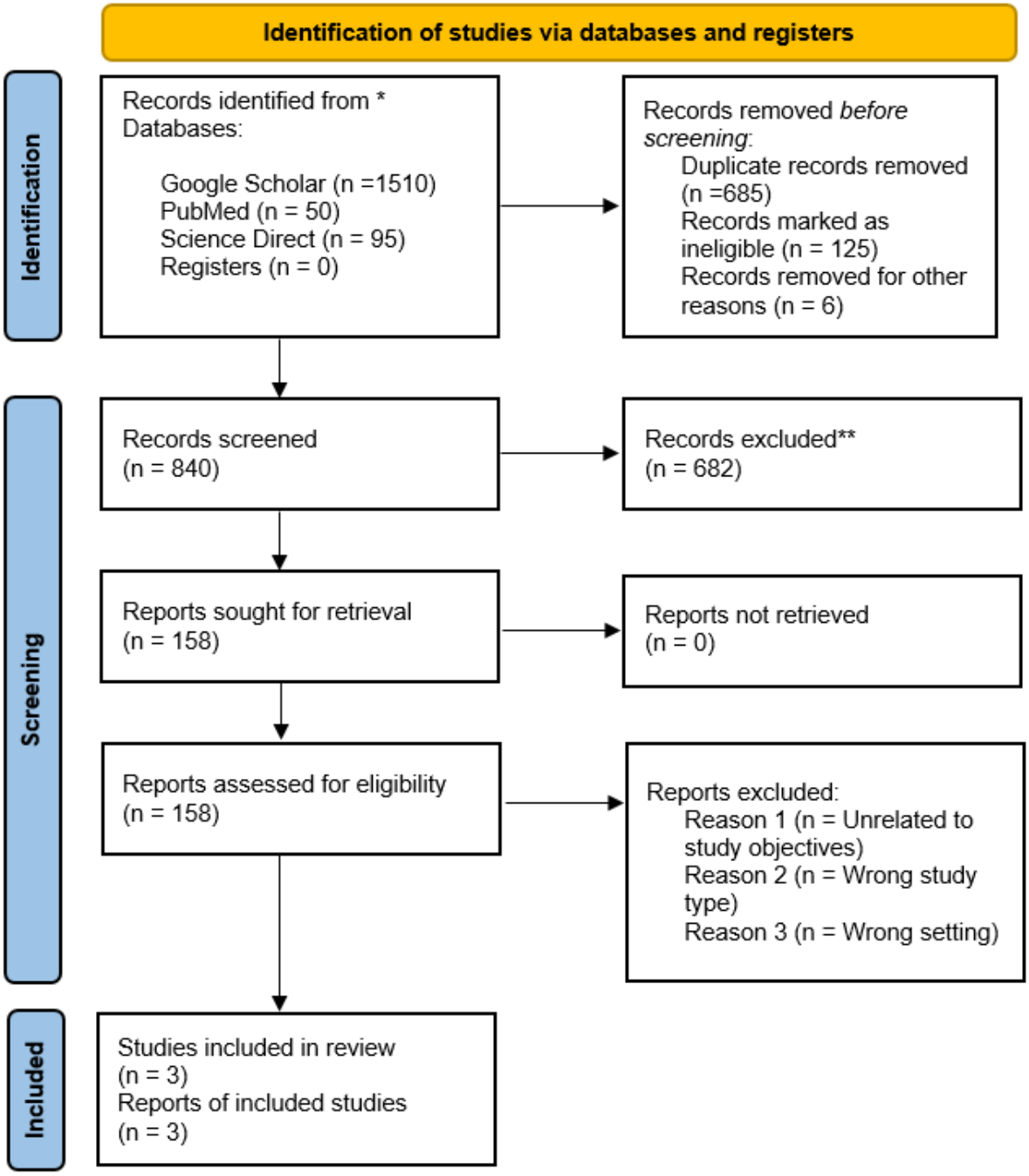


Figure 2: *PRISMA flow chart describing the study selection process*

3.6 Quality Assessment

While formal quality appraisal is not typically conducted in scoping reviews, this study employed a modified credibility assessment to ensure the reliability of included sources. This process involved evaluating key aspects of each study without the rigorous scoring associated with traditional quality appraisal methods. The assessment focused on three main criteria: 1) Relevance to the research question, 2) Methodological transparency, and 3) Source credibility.

For each included study, reviewers noted the study design, data collection methods, and any obvious limitations reported by the authors. Particular attention was paid to the alignment between the study's objectives and the current review's aims. Additionally, the credibility of the publication source was considered, with preference given to peer-reviewed journals and reputable health organizations.

This streamlined approach allowed for a basic evaluation of the evidence base without the time-intensive process of full quality appraisal, maintaining the rapid and comprehensive nature of the scoping review while still providing context for interpreting the findings.

3.7 Data Extraction

Using predefined data extraction forms, pertinent information was taken out of every chosen article. Study features, including authors, publication year, study design, study population, yaws prevalence or incidence rates, geographic location, and major findings, were all included in the retrieved data.

3.8 Data Synthesis

The main technique used to combine data from the included documents about Ghana's yaws surveillance and reporting systems was thematic analysis. This method made it possible to thoroughly and methodically examine the recurrent themes and patterns in the literature on the epidemiology of yaws in Ghana.

Themes were categorized under broad headings such as epidemiological status, risk factors, surveillance challenges, and control strategies. The coding and theme creation processes were streamlined by the usage

of Microsoft Excel. In order to increase credibility, certain portions of the data was separately coded by two researchers, who then compared their results and addressed any differences. This process ensured consistency in the interpretation and categorization of the data.

A narrative summary was provided for each theme, supplemented by tables and figures to illustrate key findings. The purpose of the review was to present a thorough summary of the status of our understanding on yaws epidemiology in Ghana, highlighting trends, gaps, and areas for future research. This method made it possible to comprehend the many variables influencing yaws prevalence, distribution, and control efforts in the country.

3.9 Reporting

The findings were displayed in tables, figures, and narrative summaries to facilitate interpretation and dissemination.

3.10 Ethical Issues

This study involved secondary analysis of existing data, and no primary data collection was conducted. Ethical approval was sought from the Ensign Global College Institutional Review Board (IRB) (Appendix 1). Additionally, permission was obtained from the Ghana National Yaws Eradication Program to use their data. All data obtained are stored securely for five years and archived thereafter (Appendix 2).

3.11 Limitations of Study

The study’s limitations largely arose from its dependence on secondary data sources, particularly the reports of the District Health Information Management System (DHIMS2) and the Ghana Health Service's Yaws Eradication Program. While these sources provide valuable information, they may suffer from data collection and reporting inconsistencies across different regions and periods. The potential for underreporting is a significant concern, especially in rural areas with limited access to healthcare, which could result in an underestimation of yaws prevalence. Furthermore, the study's focus on the past decade

(2014-2024) may not capture long-term epidemiological trends, potentially overlooking historical patterns of yaws distribution in Ghana.

Geographic variations in surveillance capacity and reporting practices across different regions of Ghana pose another limitation. These disparities may skew the analysis of geographic distribution, potentially over representing areas with more robust surveillance systems. The reliance on secondary data analysis and literature review, while comprehensive, lacks the depth that primary data collection could provide. Additionally, the scoping review methodology employed in this study may be subject to publication bias.

3.12 Assumptions

Several key assumptions underpin this research. Foremost among these is the assumption that the data reported in DHIMS2 and the Yaws Eradication Program are reasonably accurate and representative of the actual yaws' situation in Ghana. The study also assumes a relatively consistent level of reporting and surveillance efforts across different regions and over the past decade. Regarding the literature review, it is assumed that the identified sources accurately reflect the current state of the existing body of knowledge on yaws in Ghana and that the documents available for review adequately represent the state of yaws surveillance and reporting systems in the country.

Furthermore, the effectiveness of the data synthesis methods employed, particularly the thematic analysis, is assumed to be capable of identifying key patterns and trends in yaws epidemiology and surveillance challenges in Ghana. Lastly, there is an underlying assumption that the findings from this analysis will be applicable and useful for informing future yaws control and elimination strategies in Ghana.

CHAPTER 4

4.0 RESULTS

4.1 Introduction

This chapter presents the findings from our comprehensive assessment of yaws prevalence and distribution in Ghana, focusing on the period from 2014 to 2024. This analysis encompasses three core objectives: determining the overall prevalence of yaws infection, investigating the geographic distribution of yaws cases across various regions and districts, and identifying the gaps and challenges in the surveillance and reporting systems of yaws. Data was carefully analyzed to provide a clear picture of the current epidemiological status of yaws in Ghana.

Through a combination of statistical analysis and scoping review, this chapter aims to elucidate the patterns and trends in yaws prevalence, highlight regional disparities, and offer insights into the efficacy of existing public health surveillance mechanisms.

4.2 Characteristics of Studies Included

The features of the included studies are summarized in Table 4.2. The review comprised of 3 papers in total. The year of publication varied between 2015 and 2023.

Table 2: Characteristics of studies included

Table Citation/Year	Title	Purpose/Rationale	Major Findings
Handley BL, Tchatchouang S, Grout L, et al. (2022)	"Evaluating the yaws diagnostic gap: A survey to determine the capacity of and barriers to improving diagnostics in all yaws-endemic countries"	"To understand the current capacity of, and challenges to, improving diagnostics for yaws in all yaws-endemic countries worldwide".	"Over 95% of reported yaws cases from the past five years had not been confirmed with serological or molecular tools. The limited supply of rapid serological tests was a major barrier. Only four countries reported having operational laboratories for molecular yaws diagnosis. Only one country had a validated assay to detect azithromycin resistance".
R. Ghinai, P. El-Duah, K. Chi et al. (2015)	"A Cross-Sectional Study of 'Yaws' in Districts of Ghana Which Have Previously Undertaken Azithromycin Mass Drug Administration for Trachoma Control"	"To investigate the continued presence of yaws in districts of Ghana that had previously undergone mass drug administration (MDA) with azithromycin for trachoma control".	"No evidence of ongoing transmission of yaws was found in the surveyed communities. Haemophilus ducreyi DNA was detected in some lesions, but most lesions remained unexplained. Integration of diagnostic testing into pre- and post-MDA surveillance is recommended".
Laud Anthony Wihibeturo Basing et al., 2023	"Mapping of Yaws Endemicity in Ghana; Lessons to Strengthen the Planning and Implementation of Yaws Eradication."	"To map out yaws endemic communities in Ghana to ensure that Mass Drug Administration (MDA) is effective and financially efficient".	"- 625 children were recruited, with 401 (64.2%) testing DPP positive. 141 participants had Treponema pallidum subsp pertenue DNA. Yaws was endemic in all 4 study sites 154 (24.6%) were positive for Haemophilus ducreyi DNA".

4.3 Overall Prevalence of Yaws Infection in Ghana

This section presents a comprehensive analysis of yaws infection prevalence in Ghana from 2018 to 2023, based on the data retrieved from DHIMS2. While the initial objective was to determine the overall prevalence over the past decade, the available complete data covers a six-year period, which still offers valuable insights into the disease's trends and patterns.

4.3.1 Overall Yaws Case Distribution

The data reveals significant fluctuations in the number of yaws cases over the observed period. Three categories of yaws cases were identified: suspected yaws, probable yaws (RDT positive), and confirmed yaws (DPP positive).

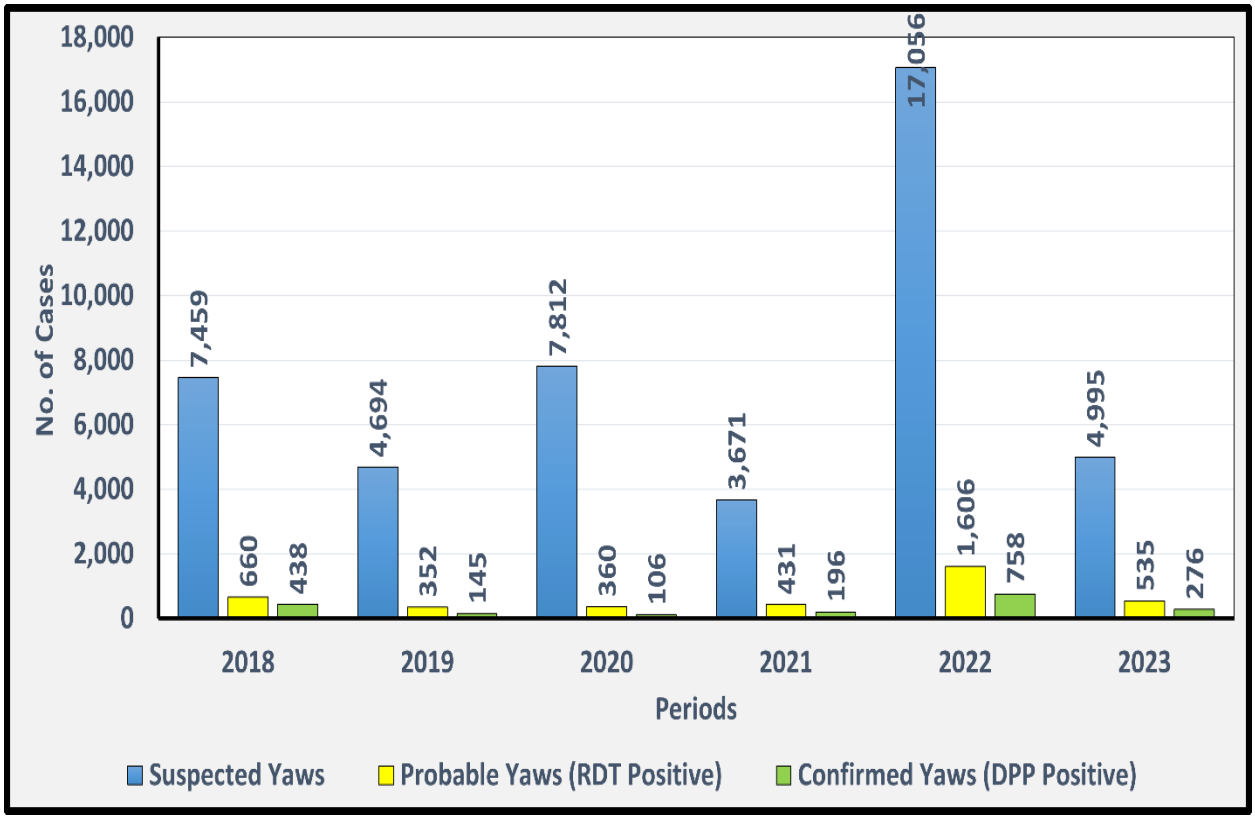


Figure 3: *Annual distribution of Suspected, Probable, and Confirmed Yaws Cases in Ghana from 2018 to 2023.*

Suspected Yaws Cases

Suspected yaws cases demonstrated considerable variation over the six-year period. In 2018, there were 7,459 suspected cases, which decreased to 4,694 cases in 2019, representing a 37.1% reduction. However, 2020 saw a resurgence with 7,812 cases, a 66.4% increase from the previous year. This upward trend was short-lived, as 2021 experienced a significant drop to 3,671 cases, marking a 53.0% decrease. The most striking observation was made in 2022, with an unprecedented surge to 17,056 cases, representing a 364.6% increase from 2021. This dramatic spike was followed by a substantial decline in 2023, with cases falling to 4,995, a 70.7% decrease from the previous year.

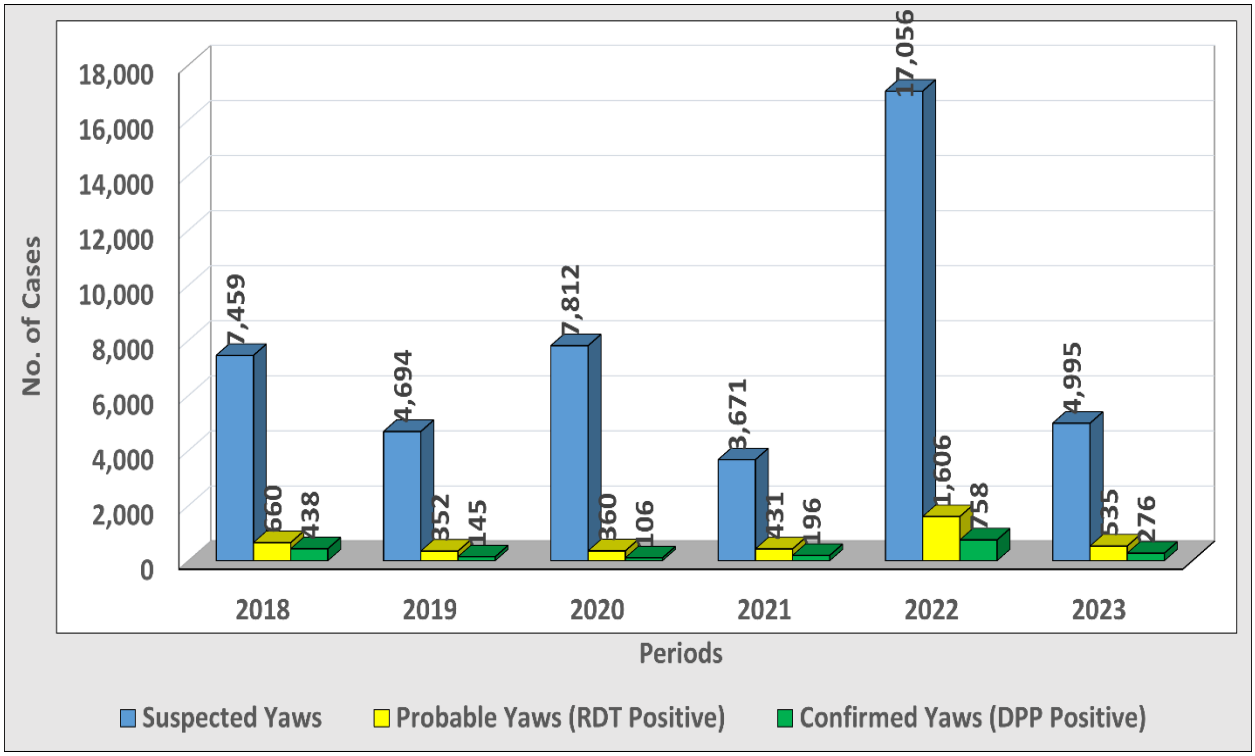


Figure 4: *Trends in Suspected, Probable and confirmed Yaws cases over time from 2018 to 2023.*

Probable Yaws Cases (RDT Positive)

Probable yaws cases, determined by Rapid Diagnostic Test (RDT) positivity, exhibited less dramatic but still noteworthy fluctuations. In 2018, 660 probable cases were recorded, followed by a decrease to 352

cases in 2019, a 46.7% reduction. The years 2020 and 2021 saw slight increases to 360 and 431 cases respectively, representing modest year-on-year growths of 2.3% and 19.7%. Similar to the trend observed in suspected cases, 2022 marked a significant surge with 1,606 probable cases, a 272.6% increase from the previous year. This spike was followed by a substantial decline in 2023 to 535 cases, a 66.7% decrease.

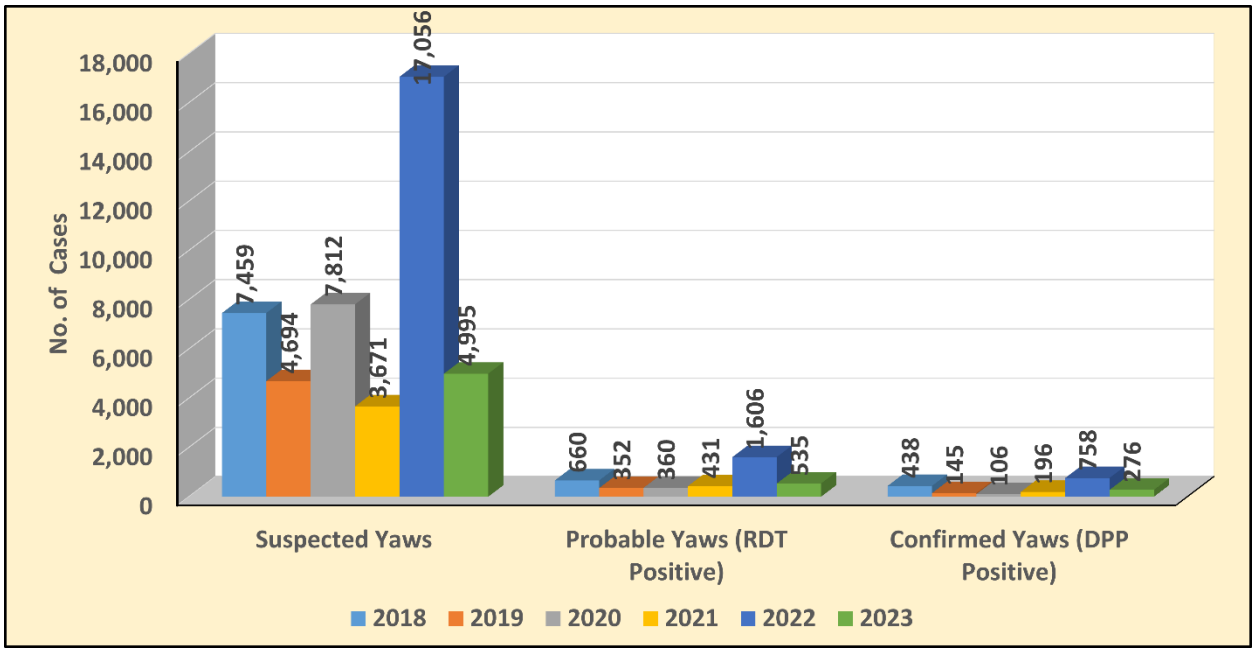


Figure 5: *Comparison of Yaws case types from 2018 to 2023.*

Confirmed Yaws Cases (DPP Positive)

Confirmed yaws cases, identified through Dual Path Platform (DPP) testing demonstrated a unique pattern over the study period. In 2018, 535 cases were confirmed, followed by a sharp decline to 145 cases in 2019, a 72.9% decrease. This downward trend continued into 2020 with 106 confirmed cases, representing a further 26.9% reduction. However, 2021 marked the beginning of an upward trend with 196 cases, an 85.0% increase from the previous year. The year 2022 saw a dramatic surge to 758 confirmed cases, a 286.7% increase, aligning with the peaks observed in suspected and probable cases. In 2023, the numbers decreased to 276 cases, a 63.6% reduction from the 2022 peak.

4.3.2 Age Distribution of DPP Confirmed Yaws Cases

The data provides crucial insights into the age distribution of yaws cases, categorized into two groups: under 15 years and above 15 years.

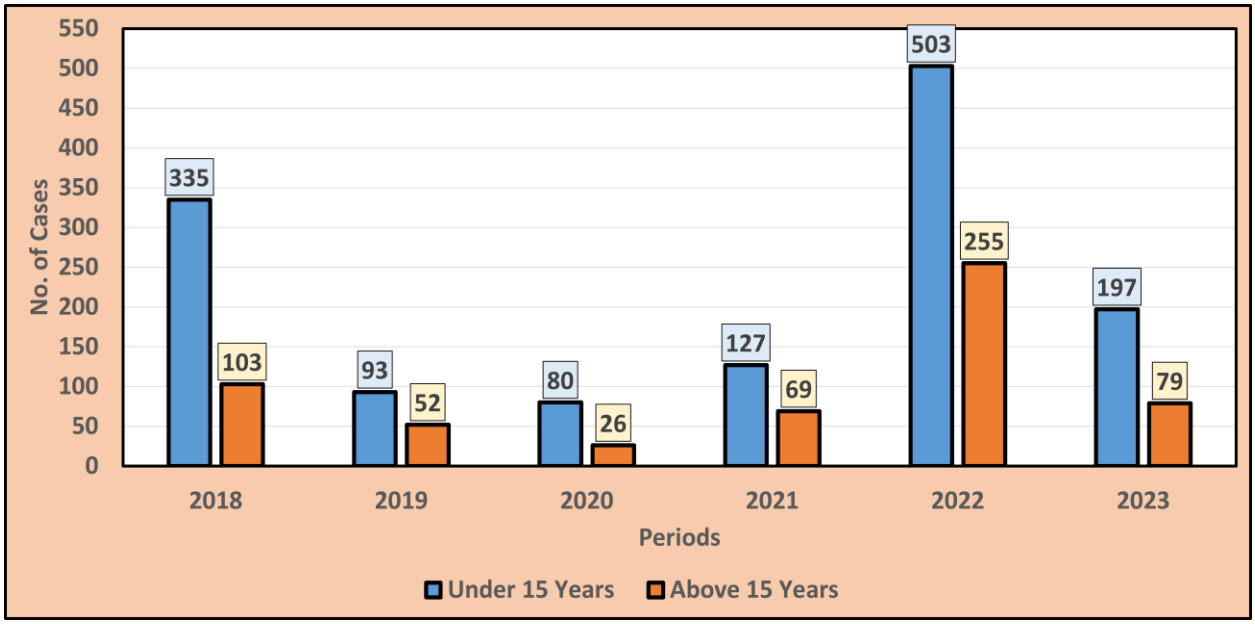


Figure 6: *Age distribution of DPP positive yaws cases from 2018 to 2023*The age distribution of yaws cases in Ghana from 2018 to 2023 highlights significant trends among individuals under and over 15 years of age. The under-15 age group consistently accounted for a larger proportion of cases throughout the study period. In 2018, 335 cases were recorded in this age group. This number sharply decreased to 93 in 2019, representing a 72.2% reduction. The decline continued into 2020, with 80 cases reported, marking a further 14.0% decrease. However, the trend reversed in 2021, with a significant increase to 127 cases, a 58.8% rise from the previous year. The most dramatic change occurred in 2022, with cases surging to 503—a 296.1% increase. This peak was followed by a substantial drop in 2023, with 197 cases reported, a 60.8% decrease from the previous year.

In contrast, the above-15 age group consistently reported fewer cases than the under-15 group but exhibited similar trends. In 2018, 103 cases were recorded, which decreased to 52 in 2019, a 49.5% reduction. This downward trend continued into 2020, with only 26 cases reported, representing a 50% decrease from the previous year. However, like the under-15 age group, 2021 marked a turning point with

an increase to 69 cases, a 165.4% rise. The upward trend continued into 2022, with cases increasing to 255, a 269.6% rise from 2021. The final year, 2023, saw a reduction to 79 cases, marking a 69% decrease from the previous year's peak.

While both age groups exhibited similar trends, the magnitude of changes was often more pronounced in the above-15 group, suggesting that factors influencing yaws prevalence may have different impacts across age groups. The sharp increases in 2022 for both age groups, followed by significant declines in 2023, underscore the need for age-specific interventions and a better understanding of the factors driving these trends.

4.3.3 Gender Distribution of DPP Confirmed Yaws Cases

The analysis of yaws cases in Ghana from 2018 to 2023 reveals a distinct gender disparity in the distribution of infections. This section examines the trends and patterns observed in both male and female cases over the six-year period, providing insights into the gender-specific dynamics of yaws transmission and detection in the regions.

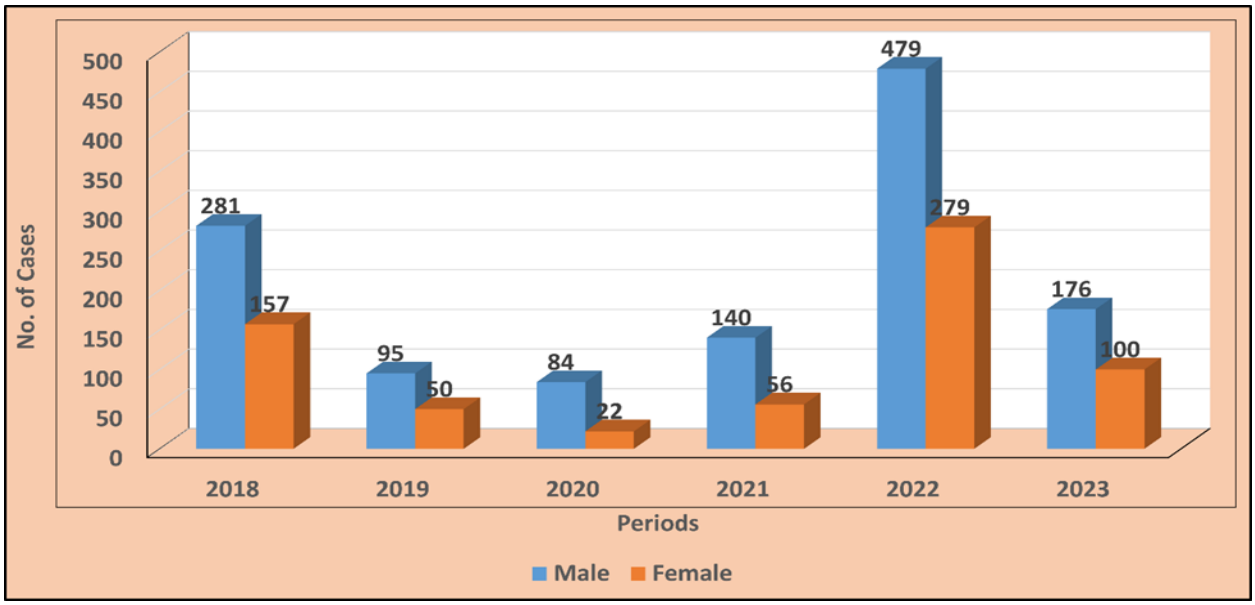


Figure 7: *Gender distribution of DPP confirmed yaws cases from 2018 to 2023*

The gender distribution of yaws cases in Ghana from 2018 to 2023 reveals significant fluctuations for both males and females, with notable disparities in the number of cases reported between the two genders. In 2018, males accounted for a higher baseline of 281 cases, while females had 157 cases, marking the start of a trend where males consistently outnumbered females in reported cases. Both genders experienced sharp declines in 2019, with male cases dropping by 66.2% to 95, and female cases by 68.2% to 50, suggesting that similar factors influenced yaws prevalence across genders.

In 2020, the downward trend continued, though at a slower rate, with male cases decreasing by 11.6% to 84 and female cases by a more significant 56% to 22. This period, which coincided with the COVID-19 pandemic, marked the lowest point in yaws detection for both genders, hinting at broader impacts on healthcare access and reporting.

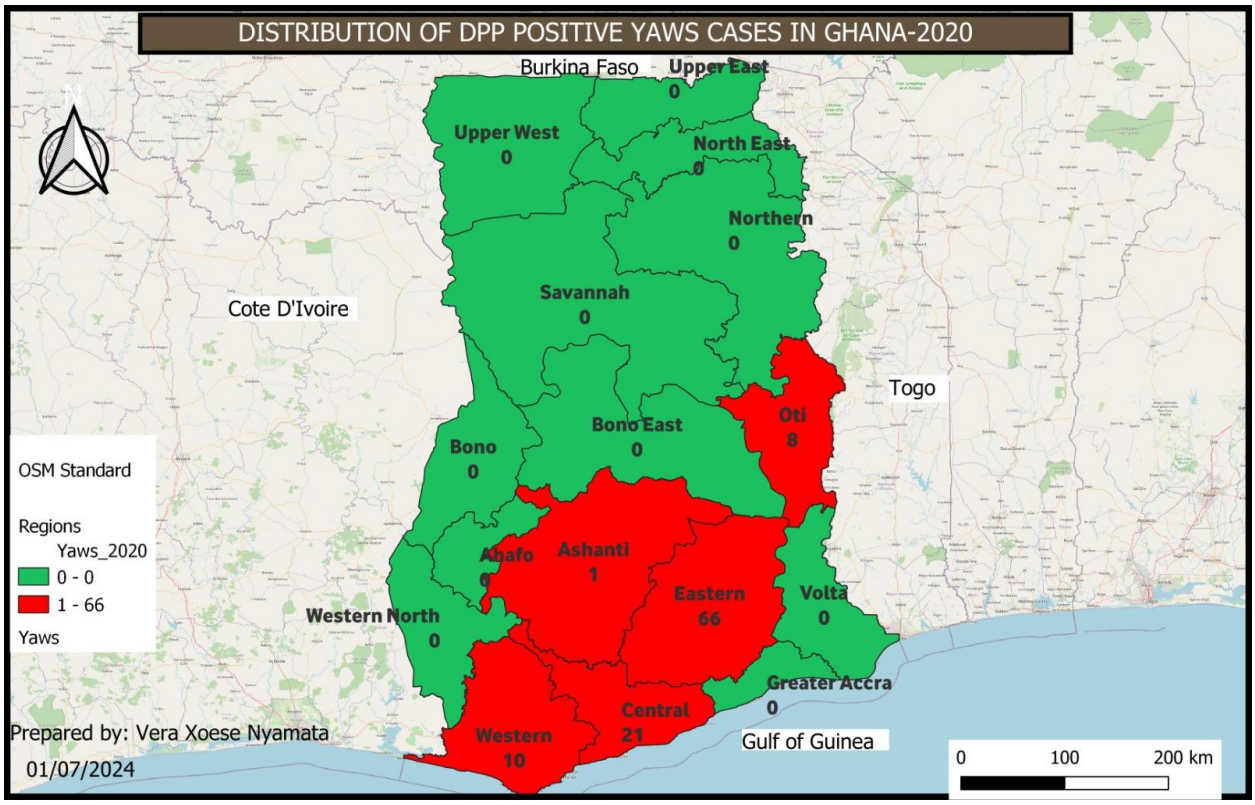
However, 2021 saw a reversal, with male cases increasing by 66.7% to 140 and female cases by a dramatic 154.5% to 56, although female numbers remained well below the initial 2018 levels. The most striking development occurred in 2022, when both genders experienced an unprecedented surge in cases: male cases skyrocketed by 242.1% to 479, and female cases by an even more pronounced 398.2% to 279. This spike suggests a significant event or change in surveillance practices that year.

In the final year of the study, 2023, there was a marked decline in cases for both genders, with male cases dropping by 63.3% to 176 and female cases by 64.2% to 100. This reduction, while substantial, still leaves the 2023 figures higher than those in the earlier years of the study, highlighting ongoing challenges in yaws control and reporting in Ghana. The gender-specific trends observed underscore the need for targeted interventions and research to better understand the factors influencing yaws transmission and detection across different demographic groups.

4.4 Geographic Distribution of Yaws in Ghana

Initially conceived as a decade-long analysis, this section ultimately focused on the years 2020 through 2023, for which reliable, mappable data were available. Incomplete records, underreporting, and inadequate efforts by the health system to track down existing cases have historically impeded a comprehensive understanding of yaws distribution in the country. The absence of consistent, mappable data for the years 2014 through 2019 and for 2024 underscores several critical issues within Ghana's health surveillance infrastructure. Despite these limitations, the available data for 2020-2023 provide valuable insights into the recent geographic distribution of yaws in Ghana. While not comprehensive for the initially intended decade-long period, this information offers a crucial snapshot of the disease's prevalence patterns and trends in recent years.

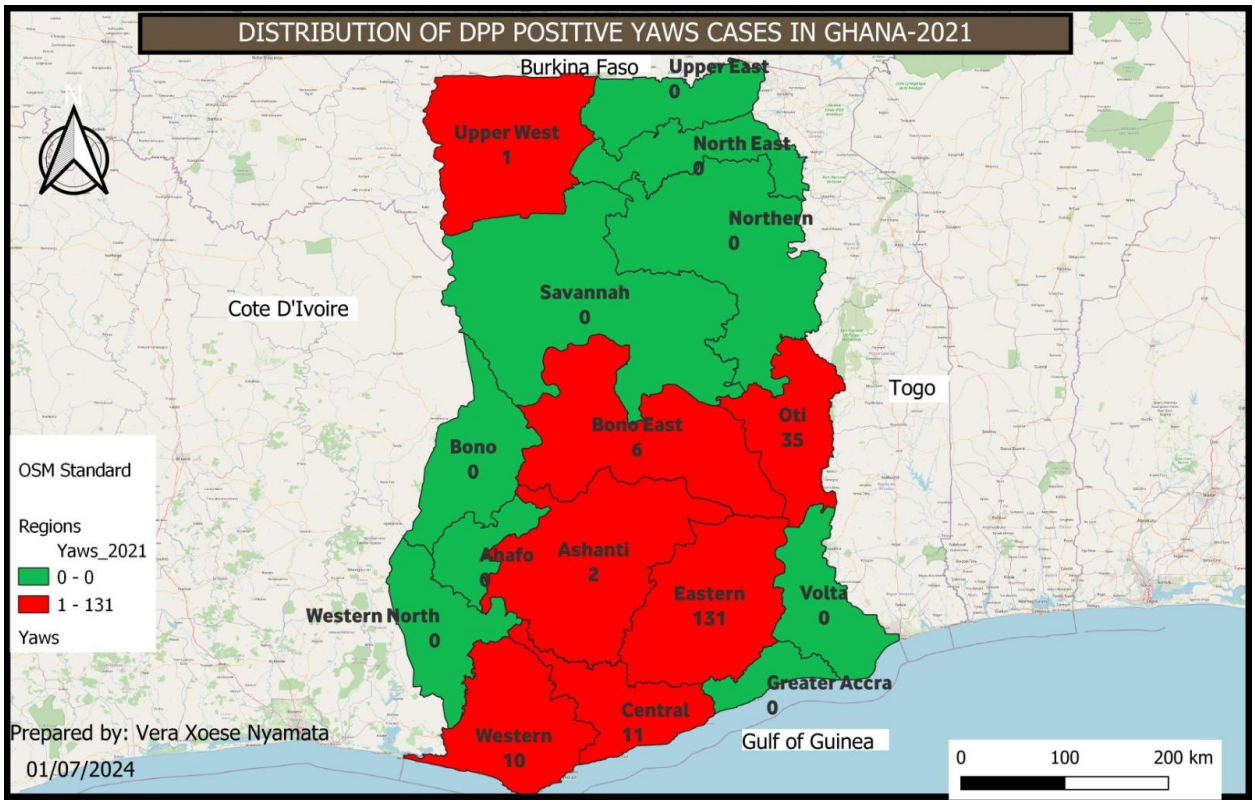
The geographic distribution of yaws cases in Ghana from 2020 to 2021 reveals a complex pattern of disease spread and concentration, with significant implications for public health efforts in the country. Analysis of the retrieved DHIMS2 data indicates a substantial increase in reported cases over this period, accompanied by an expansion of affected regions and shifts in the disease's focal points. In 2020, yaws cases were primarily concentrated in five regions of Ghana: Eastern, Oti, Ashanti, Western, and Central. The Eastern Region emerged as the epicenter of the outbreak, reporting 66 cases, followed by the Central Region with 21 cases. The Oti, Western, and Ashanti regions reported relatively fewer cases, with 8, 10, and 1 cases respectively. Notably, the majority of the country, particularly the northern regions, remained unaffected during this period.



Map 2: *Distribution of DPP positive yaws cases in Ghana, 2020*

The situation evolved significantly in 2021, with the total number of reported cases rising from 106 to 196, representing an 85% increase. This surge was accompanied by a geographical expansion of the disease, with two additional regions - Upper West and Bono East - reporting cases for the first time. The Eastern Region maintained its status as the most severely affected area, with cases nearly doubling to 131. Similarly, the Oti Region experienced a substantial increase, rising from 8 to 35 cases.

While some regions saw increases, others exhibited varying trends. The Central Region, for instance, experienced a decrease from 21 to 11 cases, while the Ashanti Region saw a marginal increase from 1 to 2 cases. The Western Region maintained its case count at 10. Importantly, several regions, including Upper East, North East, Northern, Savannah, Bono, Western North, Volta, and Greater Accra, continued to report no cases throughout both years.



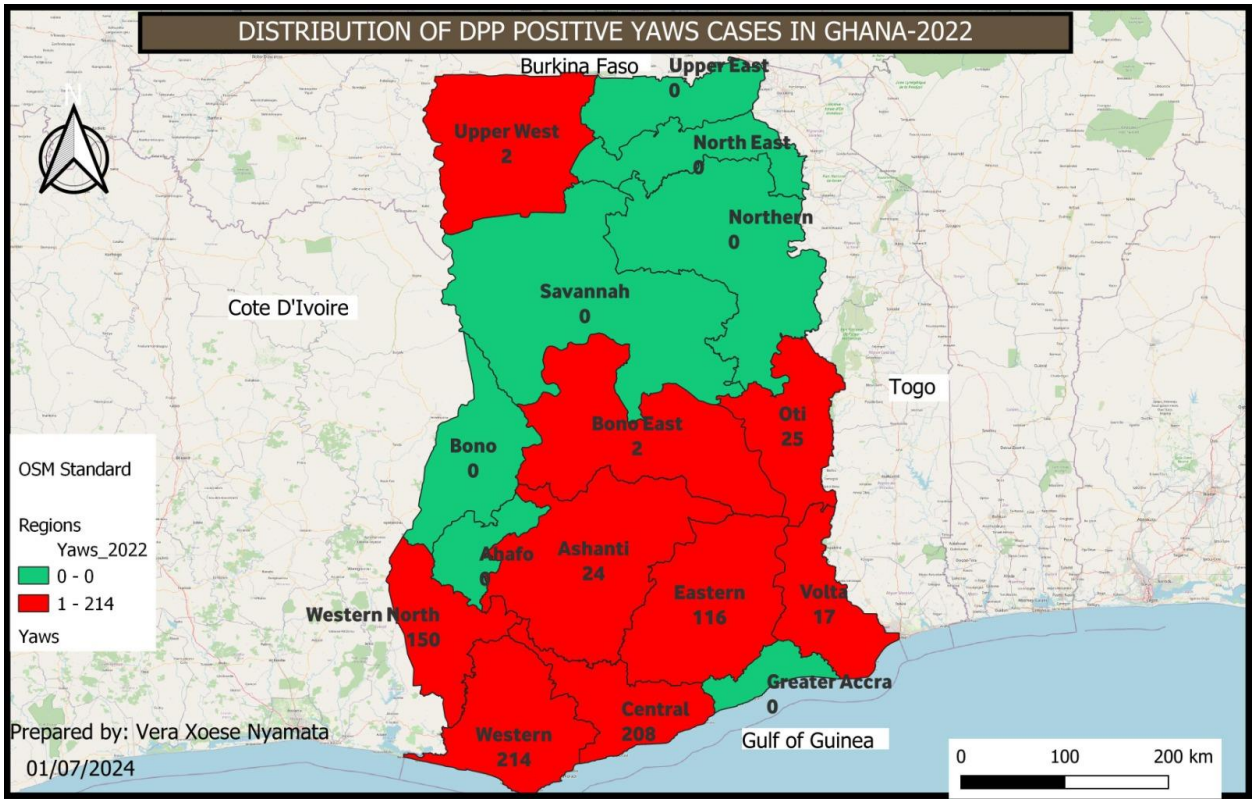
Map 3: *Distribution of DPP positive yaws cases in Ghana, 2021.*

The geographical pattern that emerges from this data suggests a concentration of yaws cases in the eastern and southern parts of Ghana, with the Eastern and Oti regions forming a particular hotspot. The central belt of the country, encompassing the Ashanti and Bono East regions, shows a moderate presence of the disease. In contrast, the northern regions have remained largely unaffected, pointing to potential geographical or socio-economic factors influencing disease transmission.

The significant increase in cases, particularly in the Eastern Region, raises important questions about the underlying causes. This trend could be attributed to improved detection and reporting methods, indicating enhanced surveillance capabilities. Alternatively, it might reflect an actual increase in disease prevalence, possibly due to environmental factors, changes in population dynamics, or shifts in healthcare access.

The distribution of yaws cases in Ghana underwent further significant changes between 2022 and 2023, reflecting a dynamic epidemiological landscape that merits careful analysis. These shifts provide valuable

insights into the evolving nature of the disease's spread and the effectiveness of public health interventions in the country.



Map 4: *Distribution of DPP positive yaws cases in Ghana, 2022.*

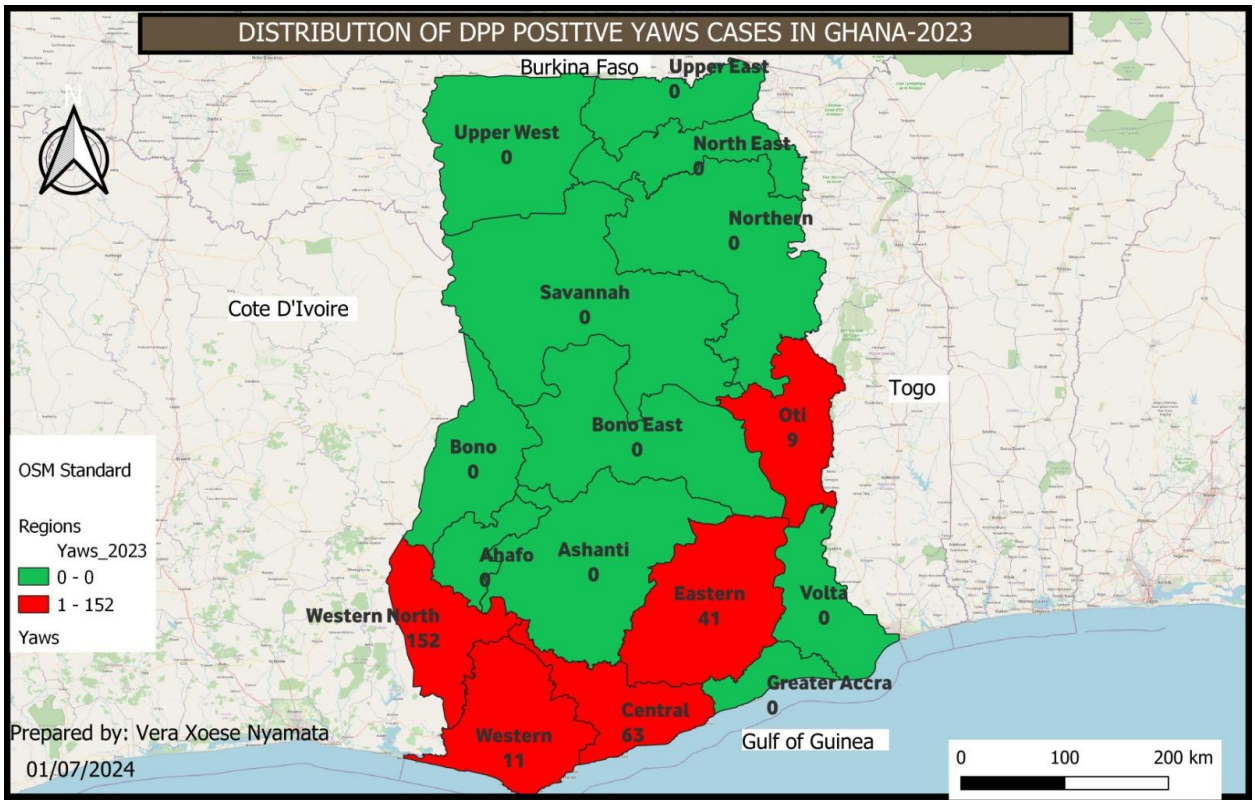
In 2022, the geographic spread of yaws cases expanded considerably compared to previous years. The Eastern Region maintained its position as a major hotspot, reporting 116 cases. However, the most striking development was the dramatic increase in cases in the Western Region, which reported 214 cases, surpassing all other regions. The Central Region also saw a substantial rise, recording 208 cases. This southern concentration of cases was further emphasized by significant numbers in the Ashanti (24 cases) and Oti (25 cases) regions. Notably, the Western North region emerged as a new area of concern with 150 reported cases. The year 2022 also saw the disease affecting new territories, with the Volta Region reporting 17 cases and the Upper West and Bono East regions each reporting 2 cases. This expansion into

previously unaffected areas suggests a potential broadening of the ecological or social conditions conducive to yaws transmission.

The situation in 2023 presents a markedly different picture, indicating a possible shift in disease dynamics or the impact of targeted interventions. The total number of reported cases decreased significantly, with several regions showing substantial reductions. The Western Region, while still heavily affected, saw its case count drop to 11. Similarly, the Eastern Region experienced a notable decrease to 41 cases. The Central Region maintained a relatively high number with 63 cases, though this represented a significant reduction from the previous year.

Intriguingly, the Western North region became the new epicenter of yaws cases in 2023, reporting 152 cases. This shift suggests a potential migration of the disease focus or the emergence of localized factors facilitating transmission in this area. The Oti Region saw a decrease to 9 cases, while the Ashanti Region reported no cases, a marked improvement from the previous year.

It is noteworthy that several regions that reported cases in 2022, including the Volta, Upper West, and Bono East regions, recorded no cases in 2023. This could indicate successful local eradication efforts or fluctuations in reporting and detection capabilities.



Map 5: *Distribution of DPP positive yaws cases in Ghana, 2023.*

The northern regions of Ghana, including Upper East, North East, Northern, and Savannah, continued to report no cases in both years, maintaining their status as non-endemic areas for yaws. Similarly, the Greater Accra region remained free of reported cases, possibly due to urban environmental conditions less conducive to yaws transmission or more robust healthcare infrastructure.

These temporal and spatial variations in yaws distribution from 2022 to 2023 underscore the complex interplay of factors influencing disease prevalence. The significant reductions in some previously high-burden areas may reflect the success of targeted public health interventions or changes in environmental conditions. Conversely, the emergence of new hotspots, particularly in the Western North region, highlights the need for vigilant monitoring and adaptive response strategies.

4.5 Gaps and Challenges Existing in Yaws Surveillance and Reporting Systems in Ghana

The reporting and surveillance of Yaws in Ghana face several significant challenges that hinder accurate diagnosis, effective treatment, and comprehensive monitoring of the disease. These challenges span across diagnostic, operational, and resource-related themes, collectively undermining the efficacy of Yaws control efforts in the country. No hypothesis was however tested.

Theme 1: Diagnostic Challenges

a. **Misdiagnosis and lack of Laboratory confirmation**

One of the primary concerns is the misdiagnosis and lack of laboratory confirmation of Yaws cases. The reliance on clinical diagnosis without laboratory confirmation has led to potential overestimation of Yaws prevalence. This issue is exemplified by a study conducted in Ghana where none of the children with ulcerative lesions clinically compatible with Yaws tested positive for *Treponema pallidum ssp. pertenue* through PCR testing. Instead, *Haemophilus ducreyi* DNA was identified in some lesions, highlighting the risk of misdiagnosis due to similar clinical presentations of different infections. This finding underscores the lack of confidence in surveillance data obtained from clinical case detection alone, without the use of molecular or serological investigations.

Corresponding excerpts from media engagements of the National Yaws Eradication Program executives are presented below to support these assertions:

1. *"Using real-time PCR,* T. p. pertenue *DNA was not detectable in any lesion sample.* H. ducreyi *DNA was detected in 9/98 (9.2%) ulcers from eight children".*
2. *Excerpt 3: "This makes the accuracy of surveillance data based on clinical case detection alone, without serological or molecular diagnostics, uncertain."*

b. **Insufficient use of molecular tools**

The insufficient use of molecular tools further exacerbates the diagnostic challenges. While PCR testing is crucial for accurate diagnosis and detection of azithromycin resistance, its application in Ghana is limited due to high costs, lack of specialized equipment, and shortage of trained personnel. This limitation is particularly pronounced in endemic regions, where diagnostic capacity is most needed. The absence of standardized PCR assays across countries conducting molecular testing for Yaws further complicates the situation, potentially leading to inconsistencies in diagnosis and data collection.

Corresponding excerpts:

- *"Only four countries (Cameroon, Côte d'Ivoire, Ghana, and Togo) reported currently running PCR testing for yaws. No standardised PCR assays were being used across these four countries, however all reported to test for the Pol A pan-treponemal target".*

c. **Inadequate serological testing**

Inadequate serological testing presents another significant gap in Yaws surveillance. Despite recommendations for the use of serological tests such as the DPP® Syphilis Screen & Confirm Assay, their implementation is inconsistent. Stockouts, lack of sustainable supply, and financial constraints often result in suspected cases not being tested with these essential tools. This inconsistency in serological testing compromises the accuracy of surveillance data and hinders the effective monitoring of disease prevalence and treatment outcomes(Becca L. Handley *et al.*, 2022).

Corresponding excerpts:

- *"Again, DPPs are not routinely available to test all patients with suspected yaws presenting at health care centres (Côte d'Ivoire, Ghana, Liberia, Timor-Leste or Vanuatu) or during routine case finding (Liberia, Timor-Leste or Vanuatu)".*

d. **Diagnostic capacity and access to testing**

Limited Diagnostic Tools: Most individuals suspected of having yaws do not undergo serological testing, and molecular testing remains highly limited. Additionally, testing for drug resistance is nearly absent, making it challenging to precisely estimate the prevalence of yaws and to prioritize eradication efforts efficiently (Handley *et al.*, 2022).

Corresponding excerpts:

"Ghana reported funding and logistics were the biggest barrier to enhancing molecular testing capacity, including insufficient funding to set up labs in yaws-endemic health districts".

Theme 2: Overreliance on Donors and Academic Partners

The overreliance on donors and academic partners for diagnostic testing capabilities is a structural weakness in Ghana's Yaws control efforts. This dependency leads to inconsistent availability of necessary diagnostic tools, including treponemal rapid diagnostic tests (RDTs) and dual path platform (DPP) tests. The reliance on external support for these critical components of surveillance and diagnosis creates vulnerability in the sustainability and continuity of Yaws control programs (Handley *et al.*, 2022).

Corresponding excerpts:

1. *"There is a general over-reliance on donors and academic partners for access to diagnostic testing, with many countries struggling with funding for, or access to, serological and molecular tests".*
2. *"There is a reliance on WHO, programme partners, non-governmental organisations or academic studies to provide tests, with some countries saying they had surplus tests from previous projects, but once these were used there were none available and it was unclear how to acquire more"*

3. *"This dependency leads to inconsistent availability of necessary diagnostic tools like treponemal RDTs and DPP tests9"*

Theme 3: Resource Constraints

Resource constraints pose a significant challenge to the National Yaws Eradication Programme in Ghana. The mobilization of adequate resources for active surveillance, early detection, and treatment remains a major hurdle. This limitation impedes the scaling up of surveillance activities and containment efforts, potentially allowing for continued transmission of the disease in affected communities (World Health Organization, 2009).

Corresponding excerpts:

"The main challenge is the mobilization of adequate resources to get the work done within the set target date of 2012"

Theme 4: lack of integration of serological testing

The lack of integration of serological testing into routine surveillance represents a critical gap in Ghana's Yaws control strategy. This deficiency is particularly problematic given the observed absence of ongoing transmission in certain districts that had previously received mass drug treatment for trachoma. The integration of serological testing is crucial for informing national reporting data and guiding control programs effectively (Fornace *et al.*, 2022).

Corresponding excerpts:

1. *"Our study highlights the poor specificity of clinical case reporting and the urgent need to integrate serology into clinical surveillance systems".*
2. *"There is an urgent need to integrate serological testing into surveillance to better inform national reporting data and yaws control programmes".*

Theme 5: Operational Challenges

Operational challenges, particularly in follow-up and treatment monitoring, further compound the surveillance issues. The inconsistent implementation of routine follow-up for treated cases and the lack of systematic collection of swabs from patients with treatment failure limit the ability to detect azithromycin resistance promptly. This gap in monitoring could lead to the emergence and spread of drug-resistant strains, potentially undermining eradication efforts.

Corresponding excerpts:

- *"Despite the high follow up rate reported in many countries, swabs were not routinely collected from patients with treatment failure"*

Theme 6: Poor Specificity of Clinical Case Reporting

The poor specificity of clinical case reporting is another significant challenge. Many national surveillance systems in Ghana report only clinical cases without laboratory confirmation, leading to potential misdiagnosis and inaccurate data on Yaws prevalence. This lack of specificity underscores the urgent need for integrating serological testing into surveillance systems to improve the accuracy of reported data (Handley *et al.*, 2022).

Corresponding excerpts:

- *"Our study highlights the poor specificity of clinical case reporting and the urgent need to integrate serology into clinical surveillance systems. Yaws cases continue to be reported from both the districts we visited but our results show that these cases are extremely unlikely to represent yaws. A rapid diagnostic test for yaws has shown value both in community surveillance [19] and as a confirmatory test in clinically suspected cases [20] and our data strengthen the case for this test to be made available to national yaws programmes as soon as possible".*

Theme 7: Underreporting

Underreporting of yaws is a significant issue, primarily due to a combination of factors. Many individuals do not seek medical attention because the condition is not very painful and is often considered a normal occurrence. This leads to prolonged periods of untreated yaws. The challenge of identifying and managing yaws cases is exacerbated by the fact that many sufferers reside in isolated locations. Dread of being stigmatized further compels individuals to conceal their condition, making active case searches essential. Additionally, the stigma associated with neglected tropical diseases (NTDs) in general discourages many sufferers from reporting to healthcare facilities. Moreover, the absence of pain in most cases results in a lack of urgency to seek early medical intervention (Marks et al., 2014).

Corresponding excerpts:

- *"People don't go to hospital for it because it's not very painful, it's usually considered normal. Some people can have it for a long time."*
- *"The cases are there and are treatable, but problem is identifying and managing since most of the sufferers are in remote areas and for fear of stigma, tend to hide the disease and so, case search is very critical"."*
- *"He said due to stigmatization a lot of people who suffer from any of the NTDs did not report to healthcare facilities"*
- *"Also since majority of the cases are not painful, sufferers do not usually seek health care early"*

CHAPTER 5

5.0 DISCUSSION

5.1 Introduction

This research sought to explore the epidemiology of yaws in Ghana and the challenges and gaps in yaws surveillance and reporting. The study's findings are discussed in this chapter in light of previous research.

5.2 Summary of Key Findings

The current study aimed to assess the prevalence and distribution of yaws in Ghana, examine the geographic spread of cases, and identify challenges within the surveillance and reporting systems. It was found that yaws remain endemic in several regions of Ghana, with significant variability in prevalence across different areas. The geographical distribution of yaws cases was uneven, with a higher concentration in rural and impoverished regions. The study also highlighted substantial gaps and challenges in the surveillance and reporting systems, including inadequate resources, incomplete reporting, and delayed data submission.

5.3 Interpretation of Findings

5.3.1 Prevalence of Yaws

The persistence of yaws in various regions of Ghana, especially in rural areas with poor sanitation and limited healthcare access, underscores the endemic nature of the disease. The study's findings resonate with previous research that links the high prevalence of neglected tropical diseases (NTDs) to factors such as poverty, lack of healthcare infrastructure, and inadequate sanitation. These findings aligns with the findings of (Walter M. Kazadi *et al.*, 2014; Ghinai, El-Duah, Hua, *et al.*, 2015). The fluctuating trends observed in the prevalence of yaws over the past decade reflect both the challenges in maintaining consistent control measures and the impact of sporadic public health interventions. The increased prevalence of yaws in some areas could be related to environmental conditions conducive to its

transmission, socio-economic factors that limit access to healthcare, and cultural practices that may delay the seeking of medical treatment.

5.3.2 Geographic Distribution

The geographical distribution of yaws in Ghana revealed significant regional disparities, with the Eastern, Volta, and Central regions being the most affected. This uneven distribution aligns with known factors that influence the transmission of yaws, including humid climates, dense vegetation, and socioeconomic conditions such as poverty and low levels of education. These findings align with the findings of (Marks, Mitjà, Solomon, *et al.*, 2015). Rural areas, in particular, showed higher incidences of yaws, which can be linked to poor sanitation, limited healthcare infrastructure, and lower levels of health literacy. These regions frequently suffer from inadequate healthcare facilities, making it challenging for residents to obtain timely and effective treatment. This corroborates the findings of a study by (Dzotsi *et al.*, 2017) in West Africa. Moreover, the cultural stigma associated with yaws may lead individuals to hide their symptoms, further complicating the accurate assessment of the disease's prevalence and distribution.

5.3.3 Surveillance and Reporting Challenges

The study identified several critical challenges within the surveillance and reporting systems for yaws in Ghana. Inadequate funding and resources were frequently cited as major barriers to effective surveillance. This issue is compounded by insufficient diagnostic tools and the lack of trained healthcare personnel, which hampers accurate case identification and reporting. Delays in data submission and incomplete reporting also emerged as significant issues, reflecting systemic weaknesses in the health information management system. These challenges hinder the accurate assessment and control of yaws, making it difficult to implement timely and effective interventions. Similar challenges have been documented in other yaws-endemic countries, highlighting the need for robust and integrated surveillance systems that

can provide real-time data for effective disease management. These findings corroborates the findings of (Ghinai, El-Duah, Hua, *et al.*, 2015; Marks, Mitjà, Solomon, *et al.*, 2015).

5.4 Implications of the study

5.4.1 Public Health Interventions

The findings of this study underscore the urgent need for targeted public health interventions in the Eastern, Volta, and Central regions of Ghana regions with high prevalence of yaws. Effective strategies should include improving access to healthcare services, enhancing water and sanitation infrastructure, and conducting regular mass treatment campaigns. Community education programs are also essential to reduce the stigma associated with yaws and encourage early treatment-seeking behavior. These interventions should be culturally sensitive and involve community leaders to ensure broader acceptance and participation. Additionally, integrating yaws control efforts with other NTD programs could optimize resource use and enhance overall effectiveness.

5.4.2 Policy and Resource Allocation

Policymakers must prioritize funding and resources for yaws surveillance and control. Strengthening diagnostic capabilities, ensuring timely data reporting, and providing adequate training for healthcare workers are crucial steps toward achieving the World Health Organization's goal of yaws eradication. The study's findings provide a strong evidence base to inform policy decisions and resource allocation. By addressing the identified gaps and challenges, policymakers can enhance the effectiveness of yaws control programs and move closer to the goal of disease eradication. Furthermore, sustained political commitment and international support are necessary to maintain momentum in the fight against yaws and other NTDs.

5.5 Limitations of the Study

This study faced several limitations that must be acknowledged. First, the incomplete nature of surveillance data may mean that the prevalence and distribution figures reported do not fully capture the actual burden of yaws in Ghana. This limitation is a direct result of the systemic challenges in data collection and reporting identified in the study. Second, resource constraints, including the lack of access to advanced diagnostic tools, may have affected the accuracy of case identification and reporting. Third, the cross-sectional design of the study limits the ability to capture the dynamic nature of yaws transmission and prevalence over time. Longitudinal studies would be more effective in understanding these trends and the impact of various interventions.

5.6 Recommendations for Future Research

Future research should concentrate on several critical areas to expand upon the findings of this study. Longitudinal studies are essential to monitor yaws trends over time and evaluate the effectiveness of intervention strategies. Such studies can provide valuable insights into the long-term impact of public health interventions and help to identify factors that influence the success or failure of these efforts. Expanding surveillance systems to include more comprehensive and timely data collection is also crucial. This expansion should involve the use of advanced diagnostic tools and the integration of community-based reporting mechanisms to ensure that data is accurate and representative. Additionally, investigating the social and behavioral factors that influence yaws transmission and treatment-seeking behavior in affected communities can provide a deeper understanding of the barriers to effective disease control. This knowledge can inform the development of targeted interventions that address these barriers and promote more effective disease management.

5.7 Conclusion

This study has provided valuable insights into the prevalence, distribution, and challenges associated with yaws in Ghana. The findings highlight the critical need for enhanced public health interventions, improved surveillance systems, and informed policy decisions to combat yaws effectively. Addressing the identified gaps and challenges requires a multifaceted approach that involves strengthening healthcare infrastructure, increasing funding and resources, and fostering community engagement. By implementing these strategies, Ghana can make significant strides toward the eradication of yaws and contribute to global efforts to eliminate this neglected tropical disease. The study's findings also underscore the importance of ongoing research to monitor the impact of interventions and identify emerging trends in yaws epidemiology. Such research is essential to ensure that control and eradication efforts remain effective and responsive to changing conditions.

CHAPTER 6

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions

This epidemiological analysis of yaws in Ghana has provided valuable insights into the prevalence, distribution, and surveillance challenges associated with this neglected tropical disease. The study's findings contribute significantly to the understanding of yaws epidemiology in Ghana and have important implications for public health policy and practice.

The overall prevalence of yaws in Ghana over the past decade has shown a general declining trend, which aligns with global efforts to eradicate the disease. However, the persistence of cases, particularly in certain regions, underscores the need for continued vigilance and targeted interventions. The geographical distribution of yaws cases across different regions and districts in Ghana revealed notable disparities, with some areas experiencing a higher burden of the disease. This spatial heterogeneity highlights the importance of tailored, location-specific strategies for yaws control and elimination.

The analysis of age and gender distribution of yaws cases confirmed that children under 15 years remain the most affected demographic group, consistent with global epidemiological patterns. This finding emphasizes the need for interventions that specifically target school-aged children and adolescents in endemic areas.

Furthermore, the research highlighted the complex interplay of socioeconomic, environmental, and healthcare access factors that influence yaws transmission and persistence in certain communities. The relationship between poverty, limited access to healthcare, poor sanitation, and yaws prevalence underscores the need for a holistic approach to disease control that addresses these underlying determinants.

6.2 Recommendations

Based on the findings of this study, the following recommendations are proposed to strengthen yaws control and elimination efforts in Ghana:

i. Ghana Health Service should implement standardized case definitions and reporting protocols across all health facilities. This will improve on the accuracy and validity of the yaws data, ensuring consistency across all regions.

ii. Ghana Health Service should integrate yaws surveillance into the existing national health information system to improve data quality.

iii. The National Buruli Ulcer/Yaws Eradication Program should engage community leaders and local health workers in yaws elimination efforts to improve case detection and treatment adherence.

iv. The National Buruli Ulcer/Yaws Eradication Program should conduct operational research to evaluate the effectiveness of current control strategies and identify innovative approaches.

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APPENDICES

Appendix 1: Ethical Clearance

ENSIGN GLOBAL
COLLEGE

OUR REF: ENSIGN/IRB/EL/SN-255/02 April 29, 2024.
YOUR REF:

INSTITUTIONAL REVIEW BOARD SECRETARIAT

Vera Xoese Nyamata
Ensign Global College
Kpong.

Dear Vera,

ETHICAL CLEARANCE TO UNDERTAKE POSTGRADUATE RESEARCH

At the General Research Proposals Review Meeting of the *INSTITUTIONAL REVIEW BOARD (IRB)* of Ensign Global College held on Thursday, April 25, 2024, your research proposal entitled **"Epidemiological Analysis of Yaws in Ghana"** was considered.

You have been granted Ethical Clearance to collect data for the said research under academic supervision within the IRB's specified frameworks and guidelines.

We wish you all the best.

Sincerely,

Dr. (Mrs.) Rebecca Acquaah-Arhin
IRB Chairperson

P. O. Box AK 136 | Tema-Akosombo Highway, Kpong, Eastern Region, Ghana |
https://www.ensign.edu.gh | +233 245 762 229

Appendix 2: Permission letter from NBUYEP

In case of reply the number and the date of this letter should be quoted.

OUR CORE VALUES
- People-Centered
- Professionalism
- Team work
- Innovation
- Discipline
- Integrity

GHANA HEALTH SERVICE
Your Health - Our Concern

National Buruli Ulcer Control/ Yaws Eradication programme
Disease Control and Prevention Dept.
Ghana Health Service
P. O. Box KB 493
Korle-Bu
Accra-GHANA
*Tel:*0302 662014
Fax: 0302 680892
Email: dg@ghsmail.org

My Ref. No.: GHS/PHD/NBUCP/NYEP/2024/01
Your Ref. No. .....

April 22, 2024

TO WHOM IT MAY CONCERN

PERMISSION TO CONDUCT RESEARCH ON EPIDEMIOLOGICAL ANALYSIS OF YAWS IN GHANA

I am writing to formally grant permission to **Ms Vera Xoese Nyamata,** a **Master of Public Health (MPH) student,** to conduct her research on the topic "**Epidemiological Analysis of Yaws in Ghana**." As the National Yaws Eradication Program in Ghana, we recognize the importance of scientific inquiry in furthering our understanding of yaws epidemiology and informing public health interventions.

She has expressed a keen interest in investigating the epidemiology of Yaws in Ghana. Her research aims to analyze Yaws cases, risk factors, and geographical distribution to identify areas for targeted intervention and control measures.

She will obtain appropriate ethical clearance from the relevant Institutional Review Board and seek informed consent from participants involved in data collection.

We will support Ms Vera Xoese Nyamata with relevant data and resources necessary for the successful completion of her research. I trust that her findings will provide valuable insights to our ongoing efforts towards Yaws eradication in Ghana.

Should you require any further information or clarification regarding this matter, please do not hesitate to contact us at . nana.konama@yahoo.com.

Thank you.

for

DR. NANA KONAMA KOTEY
PROGRAMME MANAGER
NBUCYEP

Appendix 3: PRISMA Checklist

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	i
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	vii
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	4
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	7
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	Click here to enter text.
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	23
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	24,25
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	25
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	23
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	23
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	27
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	27
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	27
RESULTS			

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	23
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	31,32
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	27
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	22
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	27
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	50
Limitations	20	Discuss the limitations of the scoping review process.	52
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	53
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	Click here to enter text.

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850.

Appendix 4:Plagiarism Report

Vera Xoese Nyamata-Final thesis.docx

ORIGINALITY REPORT

9%	8%	6%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.ncbi.nlm.nih.gov Internet Source	1%
2	www.medrxiv.org Internet Source	1%
3	www.i-jmr.org Internet Source	<1%
4	Submitted to Kwame Nkrumah University of Science and Technology Student Paper	<1%
5	Submitted to University of Derby Student Paper	<1%
6	Yohannes Hailemichael, Jacob Novignon, Lucy Owusu, Daniel Okyere et al. "The role of economic factors in shaping and constituting the household burden of neglected tropical diseases of the skin: Qualitative findings from Ghana and Ethiopia", Social Science & Medicine, 2024 Publication	<1%