FUNGAL *TINEA CAPITIS* AND ASSOCIATED RISK FACTORS IN SCHOOL GOING CHILDREN AGED 3-14 YEARS IN KAKAMEGA CENTRAL SUB- COUNTY

BY

RONALD WAMALWA

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE MEDICAL MICROBIOLOGY

SCHOOL OF PUBLIC HEALTH AND COMMUNITY DEVELOPMENT

MASENO UNIVERSITY

DECLARATION

(This thesis is my original work and has not been presented for a degree in any other university.)

Signature ……..... Date……

Mr. Ronald Wamalwa

PG/MSC/00038/2013

This thesis has been submitted for examination with our approval as University supervisors.

1. Signature ……..... Date…….
   Dr. Bernard Guyah, PhD

   Maseno University, School of Public Health and Community Development

2. Signature ……..... Date…….....….....
   Dr. Christine Bii, PhD

   Kenya Medical Research Institute, Nairobi,

ACKNOWLEDGEMENT

I am grateful to people who supported me intellectually, morally, spiritually and financially in the process of writing this thesis. Above all, I thank the Almighty God for giving me strength, peace of mind and wisdom. My deep gratitude to my supervisors and advisors, Dr Bernard Guyah and Dr Christine Bii who provided enlightenment, timely guidance and wise counsel in every step of this study. Thanks to my parents Mr. Peter Wamalwa and Mrs. Electina Nanyama Wamalwa who painstakingly gave their moral and financial support so that I may achieve my goals. Thanks for your endless prayers. Thanks to my wife, Mrs. Diana Akhabosa Wanyonyi and our children Chris, Nebat, Nathanael and Princess Asenath for being there for me at all times, especially the prayers they offered me and encouragement when writing my thesis. I also appreciate my brothers and Sisters: Janerose, Chris, Martin, Eunince, Cyrus, Fred, Protus, Alex and Ruth for their consistent encouragement despite the many challenges I encountered.

My friends; Agnes Amugamwa, Nathan Shaviya, Samuel Kibaru, Mustafa Barasa, Sarah Muyonga and Beatrice Chumba for their words of encouragement. More so, am indebted to Dr. Nathan Shaviya for the technical support he offered me and his immense contribution during my thesis writing. The journey was not easy but you made it enjoyable. I give glory to God**.** Furthermore, I m really indebted to my brother Chris Wanjala Peter for the financial support he offered me so as to continue with my education.

DEDICATION

I dedicate this work to my wife Diana Salome Akhabosa Wanyonyi.

ABSTRACT

Tinea capitis (ring worm) is a superficial fungal infection of the scalp and hair of the head. According to World Health Organization (WHO), the prevalence rate of superficial mycotic infection worldwide has been found to be 20-25% and the infection presents a major public health problem in primary school-age children especially those from low and middle income countries like Kenya. *Tinea capitis* inflicts a lot of psychosocial trauma in children due to attached stigma, ulceration and irritation that hampers pupil's concentration and performance in class. Moreover, rural and urban/peri-urban settings in Kenya have varied access to social amenities including clean tap water, schools with poor environmental sanitation and overcrowded classrooms, limited playing grounds and communal barber shops which contribute to *Tinea capitis* disease burden. It is therefore important to look at the distribution in these settings. Additionally, the infection is common in children particularly those of pre-pubertal age. These children are susceptible to dermatophytic infections because of their poor personal hygiene habits and poor environmental sanitation. Many children in developing countries attend public schools which are overcrowded. In Kenya, it is estimated 9.6% primary school going children are infected by *Tinea capitis*, Tanzania 13%, Nigeria 31.2%, Germany 0.1% and London 0.1% children are infected respectively. A significant number of primary school-going children in Kakamega Central Sub-County have observable clinical symptoms suggestive of *Tinea capitis* infection. However, the *Tinea capitis* causing fungal species among these children have not been identified. Fungal agents causing *Tinea capitis* vary in virulence and clinical presentation. In addition, their distribution varies depending on geographical location. This study investigated the etiological agents of *Tinea capitis* and associated risk factors among primary school-going children in Kakamega Central Sub-County. The specific objectives were; to determine the prevalence of *Tinea capitis* among primary school going children in Kakamega Central Sub-County, to characterize the fungal species causing *Tinea capitis* in primary school going children in Kakamega Central Sub-County and to determine the risk factors associated with *Tinea capitis* infection in primary school going children in Kakamega central Sub-County. A cross-sectional study design was used where 375 primary school-going children from four public schools, two rural and two urban primary schools in Kakamega Central Sub-County were sampled from a population of 4611 pupils. The children were examined for fungal agents using microscopy and laboratory culture techniques. This study established a prevalence of 17.4% *Tinea capitis* infection in Kakamega Central Sub-County. The causative species isolated were *T. tonsurans spp* constituting 51.9%, *M. canis* 13.5%, *T. rubrum* 3.8%, *M. auduoinii* 5.8%, *A. niger* 5.8%, *T. mentagrophytes* 5.8%, *A. flavus*, *C. glugosa* and *E. flocosum* had 1.9% each while co-infections were reported at 7.7%. Risk factors associated with *Tinea capitis* were found to be age (OR; 2.79, 95% CI; 1.43-5.17, P=0.002), number of baths per week (OR; 4.65, 95% CI; 2.03-5.91, P<0.0001), sharing of bed (OR; 1.96, 95% CI; 1.27-3.74, P=0.021), sharing of combs (OR; 3.82 95% CI; 1.93-6.77, P<0.0001) and number of occupants in a bedroom (OR; 6.01, 95% CI; 2.01-8.36, P<0.0001). These finding show a high prevalence of *tinea capitis* with *Trichophyton* genus as the most prevalent fungal etiological agent causing *Tinea capitis* among school-going children in Kakamega Central Sub-County and is associated strongly with environmental sanitation and personal hygiene practices. Prophylactic measures on *Trichophyton* genus can significantly reduce *Tinea capitis* burden. The results are useful in advocacy for proper environmental sanitation and personal hygiene practices which may offer solutions to reduce the *Tinea capitis* prevalence in Kakamega Central Sub-County.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS AND ACRONYSMS

WHO	World Health Organization
TC	*Tinea capitis*
MUERC	Maseno University Ethics Review Committee
BOM	Board of Management
HC	Health Controls
KNBS	Kenya National Bureau of Statistics
RA	Research Assistants
KOH	Potassium Hydroxide
SDA	Sabouraud Dextrose Agar
OR	Odds Ratio

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Tinea capitis (ring worm) is a superficial fungal infection of the scalp and hair of the head. Globally, it is common in school children aged between three and thirteen years (Guerrant *et al*., 2011; Terragni *et al.,* 1991). Fungal agents responsible for *Tinea capitis* can live on the dead tissue of the scalp which is caused by mold-like fungi that belong to a group of fungi called dermatophytes (cause infections of the skin, hair and nails) that entails three genera: *Microsporum, Epidermophyton* and *Trichophyton*. According to World Health Organization (WHO), prevalence of superficial mycotic including *Tinea capitis* infection is estimated to be 20-25% of the world's population (Coulibaly *et al.,* 2018; Lakshmanan *et al*., 2015). Africa being among the settings mostly affected, it is estimated that the range of *Tinea capitis* infection ranges between 10-30% among primary school aged children (Moto *et al*., 2015). Dermatophytes commonly cause skin disease in animals and humans. Up to date, there are about 40 species causing dermatophytosis, though only 8 species are associated with *Tinea capitis*. However, epidemiological distribution of fungal agents causing *Tinea capitis* varies depending on the geographical location and seasonal factors that includes emigration, immigration, life style, type of population and climatic conditions (Moto *et al.,* 2015). Additionally, research by reviewers have indicated that as much as some species of etiologic agents causing TC have been reported from every continent, others have geographically limited areas (Balci *et al.,* 2014). For instance, *Trichophyton* infections are common in Central America and parts of Western Europe while *Microsporum* species have been identified as the key etiological agents of *Tinea capitis* in South America, Southern and Central Europe, Africa and Middle East. However, studies have revealed that, *Tinea capitis* is more common in Africa than in European and Asian countries

and this is corroborated by another study in India which observed that in developing countries TC is high because of factors like poverty, overcrowding, improper hygiene and illiteracy**.** *Tinea capitis* causing agents usually colonize the keratin tissues of the scalp hence inflammation occurs around the infected area due to host response to metabolic by-products (Tainwala & Sharma, 2011) hence causing discomfort to infected children due to itching and this could affect their concentration in class. The causative agents are generally restricted to non-living cornified layer of the epidermis due to their inability to penetrate viable tissues of an immune competent host (Lee & Hsu, 1992).

Previous studies have associated *Tinea capitis* with a number of factors including socio-demographic, geographical regions, species virulence and environmental (Olutoyin *et al*., 2017; Philpot, 1978). For instance, antropophilic fungal agents that causes *Tinea capitis* like *Trichophyton tonsurans*, *violaceum sudanense* and *Microsporum audouinii* are most prominent in tropical areas (Elewski, 2000; Fuller, 2009; Hay *et al*., 2001). Also, *Trichophyton tonsurans* has been found to be the common cause of out breaks of *Tinea capitis* in children and it's the main cause of endothrix (inside the hair follicles) infections. Additionally, *Trichophyton rubrum* has been shown to be the common cause of favusin, (crusts are seen on scalp) (Michaels & Del Rosso, 2012). A recent cross-sectional study in the Mathare slums, informal settlement in Nairobi City reported an overall *Tinea capitis* prevalence of 81.3% (Moto *et al.*, 2015). These findings in Mathare study implies that TC is still a disease of concern in Kenya, though unlike the current study, it had a smaller sample size and few risk factors associated with dermatophytosis.

Kakamega County is the second most populous county in Kenya (KNBS, 2009), it comprise of 12 sub-counties. Kakamega Central Sub-County; my study site, has an estimated population of

100, 000 people where 57% of the population stays below poverty lines. Primary school going children comprise 36,918 (KNBS, 2009). A significant number of Primary school going children in this Sub-County have observable clinical signs of *Tinea capitis* and most of the primary schools are characterized by overcrowding of pupils in classes (Barasa, 2016). Etiological agents and associated risk factors of *Tinea capitis* among primary school going children in Kakamega Central Sub- County have not been identified. Currently, there is very limited data on the etiology and associated risk factors of *Tinea capitis* in school going children in Kakamega Central Sub-County. Therefore, this study sought to find out the specific fungal causative agents of *Tinea capitis* and their associated risk factors in primary school going children and the finding of this study can help Kakamega County plan on how to treat the disease and prevent further spreading of the disease and by so doing improving the concentration and performance of children in school.

1.2 Epidemiology of *Tinea capitis*

Dermatophytosis is one of the most commonly encountered cutaneous fungal infections worldwide. The higher prevalence in tropical and subtropical areas is supposedly due to the hot and humid climatic condition. Other factors like personal hygiene habits and prevalence of virulent species in the soil are also known to influence the infection.

Tinea capitis can occur in three distinctly different forms, "gray patch," "black dot" and favus. Black dot *Tinea capitis*, most often caused by *Trichophyton tonsurans*, is the form predominantly seen in the United States. *Tinea favosa* due to *Trychophyton Schoenleinii* is an important anhtropophilic dermatophytes that is endemic in Africa, for example in Tunisia and Nigeria *T. Schoenleinii* is significantly observed in primary school going children (Khaled *et al.*, 2007). However researchers have observed that improvement in hygiene practices and living

standards has reduced favus infection significantly. Immigration and travel may contribute to the occurrence of favus in patients who live in non-endemic areas. Gray-patch ringworm (*Microsporosis*) is an ectothrix infection or pre-pubertal *Tinea capitis* (is common in an African-American male child). Hairs in the involved areas assume a characteristic dull, grayish, discolored appearance. Infected hairs are broken and shorter. Papular lesions around hair shafts spread and form typical patches of ring form.

Tinea capitis occurs primarily in children and occasionally in other age groups. It is seen most commonly in children younger than 10 years. Most commonly affected range is children aged 3-7 years (Ginter-Hanselmayer *et al.*, 2007) In adults, women are infected more frequently than men, possibly because of women having greater exposure to infected children and possibly because of hormonal factors . *Microsporum audouinii* is also a common fungal agent that causes TC in primary school children and a study in Swiss primary schools observed that *M. audouinii* is more common in boys than in girls (Donghi, Hauser, & Bosshard, 2011). More recently, the most prevalent organisms causing *Tinea capitis* infections in children are anthropophilic organisms, which spread directly from person to person.

Severity of *Tinea capitis* depends on the site of formation of their arthroconidia. Some mild ringworm or pre-pubertal *Tinea capitis* infections are of the ectothrix (fragmentation of mycelium into conidia around the hair shaft) type. It is also termed the grey-patch type (microsporosis). Depending on the extent of associated inflammation, lesions may heal with scarring. Endothrix infections are noted by the arthrospores present within the hair shaft, this contributes to the chronicity of the infections which tend to progress and may last into adult life. Since the organisms usually remain superficial, little potential for mortality exists. However, TC

caused by *T. tonsurans* has been reported to cause lesions in form of concentric rings known as tinea imbracata, which eventually causes disseminated systemic disease that has been observed in patients who are severely immune compromised (Narang *et al*., 2012).

A **s**urvey done in primary schools in Kisumu District (western Kenya) in 1993 had a prevalence rate of superficial mycoses of 10.1%. Three-quarters of the affected children suffered from *Tinea capitis* with a prevalence rate 7.8% and the common causative agents were: *Microsporum audouinii, Trichophyton violaceum* and *Microsporum canis* (Schmeller *et al*., 1997). Another study was done in Eldoret which found a significant *Tinea capitis* infection of 33.3%, *(Ayaya et al*., 2001) while another study in Kibera slums in Nairobi, Kenya had a prevalence of incidence of 11.2% *Tinea capitis* (Chepchirchir *et al*., 2009) and a more recent study was done in Mathare, informal settlement in Nairobi reported a much higher prevalence of 81.2%. (Moto *et al*., 2015). Superficial mycoses have neither been the focus of intensive study nor of active control programmes in the sub-Saharan Africa, including Kenya. Consequently, there is scarcity of information on the epidemiology of superficial mycoses in Kenya and this lack of scientific information has negatively affected development of adequate patient diagnosis, disease control and antifungal drug resistance surveillance. The findings of this study can assist to address these gaps in school going children in Kakamega Central Sub-County.

1.3 Statement of the Problem

Studies elsewhere have shown that scalp ringworm infections are endemic among school children in tropical Africa. These infections have been known to inflict a lot of psychosocial trauma on children due to attached social stigma, ulceration, and sometimes irritation which hampers pupil's concentration in class. A significant number of primary school going children in Kakamega Central Sub-County has observable clinical symptoms suggestive of *Tinea capitis*

infection. Although the prevalence, fungal species causing *Tinea capitis* among primary school going children and risk factors associated with TC infection have been identified elsewhere in Kenya, this has not been done in Kakamega Central Sub-County, and this remains a problem because, fungal agents causing *Tinea capitis* vary in virulence, clinical presentation and they are geographically limited of greater or less extent, this study sought to find out the prevalence, fungal etiologic agents causing TC and risk factors associated with the TC in Kakamega central Sub-County.

1.4 General Objective

To determine the prevalence, characterize fungal agents causing *Tinea capitis* and associated risk factors among primary school going children aged 3 – 14 years in Kakamega Central Sub-County.

1.4.1 Specific Objectives

1. To determine the prevalence of *Tinea capitis* among primary school going children in Kakamega Central Sub-County.
2. To characterize the fungal species causing *Tinea capitis* in primary school going children in Kakamega Central Sub-County.
3. To determine the risk factors associated with *Tinea capitis* infection in primary school going children in Kakamega central Sub-County.

1.4.2 Research Questions

1. What is the prevalence of *Tinea capitis* among primary school going children in Kakamega Central Sub-County?
2. What are the fungal species causing *Tinea capitis* in primary school going children in Kakamega Central Sub-County?

3. What are the risk factors associated with *Tinea capitis* infection in primary school going children in Kakamega Central Sub-County.

1.5 Significance of the Study

This study has established a prevalence of 17.3% of TC infection in primary school going children in Kakamega Central Sub-County hygiene practices and age are among the major risk factors associated with prevalence of *Tinea capitis* in Kakamega Central Sub-County; children at the age group of 3-8 years were three times at risk of having *Tinea capitis* compared to those in the aged 9-14 years. Also, it was revealed that, children that did not take baths daily, over-crowding in schools, shared beddings, combs and many bed occupants are strongly associated with having *Tinea capitis* than those who take bath daily, don't share beddings, combs and bed. These results can help County government of Kakamega, to plan on how to curb the risk factors and hygiene practices associated with *Tinea capitis* infection in Kakamega Central Sub-County. By alleviating such factors in primary schools and homes, it will assist in eradicating *Tinea capitis* in the county and this will eventually improve the overall well-being of children in school.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Tinea capitis is a common superficial fungal infection of the scalp and hair. It is an exogenous infection that is characterized by invasion of dermatophytes into hair follicles and keratinized layer of hairy skin leading to hair loss, scaling, kerion agminate folliculitis, favus black dot, grey patch type, erthema or impetigo-like grey patch type, erythema or impetigo-like lesions. It is commonly caused by dermatophytes in the *Epidermophyton*, *Trichophyton*, and *Microsporum* genera. Dermatophytes metabolize keratin and cause a range of pathologic clinical presentations, including *Tinea capitis*, tinea pedis, tinea corporis, tinea cruris, and Majocchi's granuloma (Boral, Durdu, & Ilkit, 2018). *T. rubrum* is the main cause of Majocchi's granuloma, though other fungal species like *T. mentagrophytes, T.violaceum* and *T. tonsurans* also causes the disease**.** *Tinea capitis* is a worldwide infection occurring in both rural and urban areas; it has commonly been reported in children of Afro-Caribbean origin in North America, Central America, and South America. In the United States *T. tonsurans* now causes more than 95% of TC infections (Magill *et al*., 2007). Africa being among the settings mostly affected the rate of TC infection ranges between 10-70% among school aged children (Coulibaly *et al.*, 2018).

2.2 Prevalence of *Tinea capitis*

The prevalence of superficial mycosis infections has globally risen to such a level that skin mycoses now affect more than 20-25% of the world's population, (Bassiri-Jahromi & Khaksari, 2009), in Europe, *Tinea capitis* (scalp ringworm) is the most common dermatophytes infection of the scalp affecting mainly children and rarely adults. Studies have established that, prevalence of *Tinea capitis* varies within different geographical areas throughout the world hence it can occur sporadically or epidemically and an increase in its incidence has been noted over the last few

decades. In Europe, the countries reporting the highest incidence of *Tinea capitis* infections are mainly in the Mediterranean but also bordering countries like Austria, Hungary, Germany and Poland. Research done in São Paulo, Brazil in 1996, in Private and Public Pediatrics Service involving children from 0 to 15 years established a prevalence of 85% (Moraes *et al.,* 2006) which is quite similar to the TC prevalence in African set up. In South-East Amsterdam, research established prevalence of 7% TC infection (Timen *et al*.,1999). This was much lower than that of São Paulo, Brazil. In Nablus district in Palestine, a study reported a much decreased prevalence of 1% *Tinea capitis* infection, the infection occurred both in rural and urban school going children, although the incidence was higher in schools in rural areas (1.9%) than urban areas (0.4%) where boys were more commonly affected than girls (Ali-Shtayeh *et al*., 1998).

In Africa, *Tinea capitis* disease is a public health burden. It is the mostly affected continent with infection ranging between 10 and 70% among school-aged children of below 15years (Coulibaly *et al.*, 2018).

The predominant clinical forms and causative agents vary from one region to another. Poor socioeconomic status, high population densities, and poor sanitary conditions are some of the factors accountable for the high prevalence of dermatophytosis in many developing countries, which include countries in southern and eastern Africa. A Study carried out to review the prevalence of *Tinea capitis* in countries including Kenya, Ethiopia, Tanzania, South Africa, Mozambique, Madagascar, Malawi, Rwanda, Burundi, Uganda, Zambia, Zimbabwe and Botswana had a prevalence ranging from 56.7% to 95%. For instance, a study done in Nigeria, Nok community of Kaduna State, reported a prevalence of 45% and girls had higher prevalence (51.4%) than boys (41.5%) but not significantly different. Another study done in Gabon, established *Tinea capitis* infection rate that varied according to the school studied, the prevalence

ranged from 20.4% in the urban school with a higher socioeconomic status to 26.3% in the rural school with a lower socioeconomic status (Hogewoning *et al*., 2011). In India, Kolkata, West Bengal state 10% TC infection rate was reported which was slightly lower that in Gabon. This trend is similar to that of United Kingdom and North America.

In Kenya, a study done in Mathare slums, informal settlement in Nairobi, Kenya established a prevalence rate of 81.3% infection rate of TC in primary school going children, *Trichophyton* species (61.3%) were the common fungal agents detected with *T. tonsurans* being the most prevalent, children in age groups 3-5 and 6-8years were the most affected (Moto *et al*., 2015). In another study carried out in Eldoret town in primary school going children aged 3-14years, reported a prevalence of 33.3% TC infection with a pick age of 10years (Ayaya *et al*, 2001), Similarly, *T. tonsurans* was identified as the most common fungal agent causing TC like in Mathare research. In Kisumu town, a study reported 10.1% prevalence of dermatophyto-mycoses infection in primary school going children with three-quarter of the infected children suffering from TC infection (7.8%), and the commonly isolated fungal agent was *M. audouinii var.langeronii* (Schmeller *et al.*, 1997).

Additionally, research done in primary school children in Kibera slums in Nairobi established 11.2% prevalence of dermatophytes infection with TC being the most common (Chepchirchir *et al*., 2009). In these studies carried out in Kenya, most of the fungal agents species causing TC disease are different, for instance, in Kisumu TC infection was mainly caused by *Microsporum audouinii* var. *langeronii*, *Trichophyton violaceum* and *Microsporum canis* while in Kibera slums Nairobi City *T. violecium* was the predominant species isolated followed by *T. mentagrophytes*; although Mathare and Eldoret researches reported *T. tonsurans* as the most prevalent species causing TC infection in primary school children. There is no research that has

been done in Kakamega County to establish the prevalence of *Tinea capitis* infection despite the observable clinical presentation of primary school going children with ring worms of the scalp, lack of this scientific knowledge that can help the Kakamega County plan how to eradicate the disease motivated this current study to research to establish the extent of TC infection.

2.3 Fungal Species Causing *Tinea capitis*

Tinea capitis is a superficial fungal infection of the scalp and hair that is caused by dermatophytes commonly in the *Epidermophyton, Trichophyton*, and *Microsporum* genera. Up to date, we have about 40 species causing dermatophytosis (Pai *et al.*, 2013), though only 8 species are associated with *Tinea capitis*. Epidemiological distribution of *Tinea capitis* causing agent varies depending on the geographical location. For instance, *Trichophyton* infections are common in Central America and parts of Western Europe while *Microsporum* species have been identified as the key etiological agents of *Tinea capitis* in South America, Southern and Central Europe, Africa and Middle East. *Trichophyton tonsurans* is an anthropophilic dermatophyte, with a worldwide distribution, although its prevalence varies considerably between different geographical regions. Whereas in North America *T. tonsurans* is the main fungal species causing TC infections in children below 15 years in the European continent they appear relatively rare. However, *T. tonsurans* is primarily associated with *Tinea capitis* (Hryncewicz *et al.,* 2011*).* Similarly, a study done in Irish pediatric population reported *T. tonsurans* to be the predominant fungal etiological agent causing TC disease in Ireland, same results were reported in Netherlands, southeastern Amsterdam, and Cleveland. Contrary to other studies which indicates *T. tonsurans* as a dominant fungal species causing TC in Europe, another study by (Ginter-Hanselmayer *et al.,* 2007) reported *Microsporum canis, (zoophilic dermatophytes,)* as the most common causative agent of *Tinea capitis* in Europe. Another study has observed that *T. rubrum*

is a common cause of superficial mycosis in developing countries in Europe, it's a predominant pathogen in Germany, Finland and Russia regions (Tietz *et al.,* 1999). However there is a significant shift towards anthropophilic *Tinea capitis* mainly in urban areas in Europe, with exception of France that reported *Trichophyton soudanense and Microsporum audouinii* as common species causing TC infection (Ginter-Hanselmayer *et al.,* 2007*).*

Tinea capitis is more common in Africa than in Europe and Asia (Ali *et al.,* 2009). Poor socioeconomic status, high population densities, and poor sanitary conditions are some of the factors responsible for the high prevalence of dermatophytosis in many developing countries (Nweze & Eke, 2017). By contrast, species such as *T. violaceum* and *T.Soudanense* were reported to be the most common fungal species causing TC in primary school going children in parts of Africa and West Asia (Magill, 2007), have rarely been isolated from patients in the United States. But studies in Abidjan, Cote d'Ivoire, Gabon and Ivory Coast identified *Trichophyton soudanense* as the most prominent fungal etiological agents causing TC infection (Adou-Bryn *et al.,* 2004; Fulgence *et al.,* 2013; Hogewoning *et al.,* 2011) while among school children in Nok community of Kaduna State, Nigeria, studies reported *Trichophyton rubrum* followed by *Microsporum canis* as the most prevalent dermatophytes isolated. Notably, in Egypt recent studies reveals a shift of trend of TC infection, where *M. canis* is replacing *T. violaceum* as a prominent fungal species casing TC disease in primary school going children (Bassyouni *et al*., 2017).

Studies done in Kenya have similarly reported same trend like other parts of the world, where TC infection is associated with different geographical location though, most of the infections are caused by etiologic agents commonly from the three genera that causes TC; *Trichophyton, Microsporum* and *Epidermophyton*. For instance, a study done in primary school children in

Eldoret town found out that, *T. tonsurans* was predominantly isolated as TC causative fungal agent (Ayaya *et al.,* 2001). This finding was different from a study done in Kisumu town which found that *Microsporum audouinii* var. *langeronii,* was the most predominant species causing TC in primary school going children however, *Trichophyton violaceum* and *Microsporum canis* were also isolated (Schmeller *et al.*, 1997). In Kibera slums of Nairobi, a study reported *T. violaceum* as the predominant fungal species causing TC (Chepchirchir *et al*., 2009). A recent study that was done in school going children from Mathare informal settlement in Nairobi Kenya, reported *T. tonsurans* as the common dermatophyte causing TC (Moto *et al*., 2015). Previous studies done found that more than 90% of the *Tinea capitis* infection in children worldwide is caused by *T. tonsurans* and less than 5% infections are caused by *Microsporum, species* especially in Europe and some parts of Africa (Abd Elmegeed *et al*., 2015). But *Trichophyton soudanense* and *M.audouinii* has been reported to be the most common fungal agents causing TC in France (Donghi *et al.,* 2011). Similar studies of *T. soudanense* being most prevalent etiologic agent of TC has been observed in, Gabon (Hogewoning *et al.*, 2011) and Ivory Coast.

However, as much as some fungal etiological agents causing TC have been reported from every continent, studies have shown that most of the species have geographically limited areas of greater or less extent (Ginter-Hanselmayer *et al.*, 2007) or can change overtime (Pai *et al.,* 2013; Soyinka, 1978; Fuller, 2009). The diversity in geographical and seasonal variation of fungal agent causing TC can be attributed to factors such as; widespread use of antifungal agents like griseofulvin which is more effective against *M. auduoinii* than *T. tonsurans*, changes in immigration patterns and increase in internal travel (Pai *et al.,* 2013). Additionally, other studies have corroborated this findings by attributing the geographical diversity of TC fungal causing

agents to life style, type of population, endemicity, type of animal reservoirs and climatic conditions (Dogo *et al*., 2016; Elewski, *et al.,* 2000; Soyinka, 1978). Other studies have shown that *Tinea capitis* is more endemic to tropical and subtropical African regions because dermatophytes grow best in warm and moist (humid) conditions (Dogo *et al*., 2016).

Furthermore, there is progressively changing patterns in etiology and chemical manifestation of *Tinea capitis* infections (Chokoeva *et al*., 2016). This therefore may mean that even with well-known diseases, there could be other facts still hidden for future revelations. Studies have revealed that, apart from the known dermatophytes that causes *Tinea capitis*, molds also have been reported to be on the rise in causing TC infections (Chokoeva *et al*., 2016). For example, genus *Apergillus* is significantly being reported as an emerging mould-induced fungal etiological agent causing TC. For instance, in a retrospective study done in Brazil reported that *A. niger* and *A. flavus* species are responsible for causing TC (Chokoeva *et al*., 2016).

The presence of clinically observable signs of *Tinea capitis* in a significant number of primary school going children in Kakamega Central Sub-County and also considering factors that influence the presence of fungal agent causing TC like geographical and seasonal variation, endemicity of the disease, changes in immigration patterns and increase in internal travels and limited information in this setting about characterization of fungal agents causing *Tinea capitis* and risk factor associated with *Tinea capitis* infection motivated me to carry out this study at Kakamega Central Sub-County.

2.4 Risk Factors Associated with *Tinea capitis* Infection

Tinea capitis infection has remained a public health problem worldwide and some of the risk factors that are attributed to predispose a population to an infection include poor hygiene, sharing of formites, overcrowding and low socio economic factors (Moto *et al*., 2015). Growth of

dermatophytes including TC causing agents are supported by warmth and moist environment (Dogo *et al*., 2016). Also prevalence of TC disease can be attributed to Lack of frequent bathing, having damp skin for extended periods of time for instance, not showering and drying off completely, sweating, minor skin and injuries, close contact with others who have ringworm, such as sharing of combs or a room or sitting in close conduct in an overcrowded classroom with infected classmates (Enendu & Ibe, 2005). A study done in Turkey, established that school settlement is a risk factor for *Tinea capitis* infection and spread (Balci *et al.,* 2014). The same study of Turkey reported that TC was more frequent in children under the age of 12 years and more common in boys than girls. Also, prevalence of *Tinea capitis* varies within different geographical areas and climatic conditions, these are some of the major risk factors that determines the fungal agents that cause TC throughout the world, (Hibstu & Kebede, 2017) .

In Africa, *Tinea capitis* is common in humid countries and its spread is promoted by poor-living, poor sanitary conditions with overcrowding, sharing of combs, towels, barbers clippers, house hold pets e.g cats (Enendu & Ibe, 2005), the same associated factors were reported in Gabon and Ivory coast (Adou-Bryn *et al.,* 2004; Fulgence *et al.,* 2013; Hogewoning *et al.,* 2011).

In Kenya, risk factors associated with the infection and spread of TC were partially mentioned in studies done in Kibera, Narobi city, and in Mathare informal settlement in Nairobi (Chepchirchir *et al.,* 2009; Moto *et al.,* 2015). There are no studies that have been done to find out the risk factors associated with TC infection in Kakamega Central Sub-County to assist in prevention and treatment of *Tinea capitis*.

2.5 Summary of Knowledge Gaps

Kakamega Central Sub-County is warm and humid area hence conducive for *Tinea capitis*. In as much as primary school going children present with *Tinea capitis*, the fungal etiological agents causing this infection have not been characterized. Additionally, the burden of *Tinea capitis* in Kakamega Central Sub-County has not been examined in Kakamega Central Sub-County. This study, established the prevalence of *Tinea capitis* in the school going children aged 3-14 years, identified the fungal etiologic agents causing the *Tinea capitis* disease and the relationship between the disease and personal hygiene practices and environmental sanitation.

CHAPTER THREE

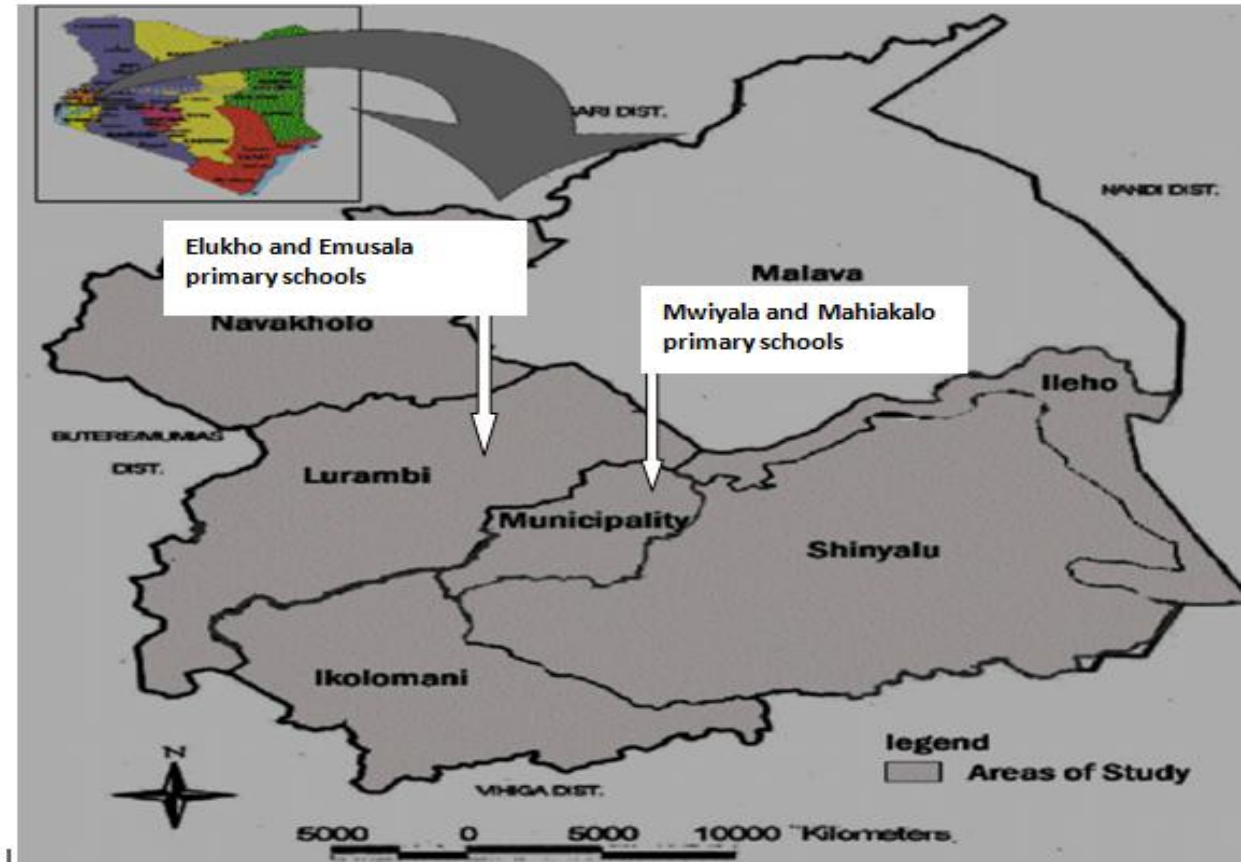
MATERIALS AND METHODS

3.1 Study Area

The study was done between January and June 2016 among primary school going children aged 3-14 years attending public primary schools in Kakamega Central Sub-County, Kakamega County. The Sub-County has an estimated population of 100,000 of whom 36,918 are primary school going children; 18,268 (49%) boys and 18,852 (51%) girls. In addition, the Sub-County has a total of 65 public primary schools, of which 26 are urban and 39 rural (Ogola, 2010). Kakamega Central Sub-County is approximately 415 KMs west of Nairobi located within Kakamega County latitude: 0°16'60.00"N and longitude: 34° 44' 59.99" E (Figure 3.1). There are two distinct climatic seasons; the wet and dry seasons. The former has long and short rainfall; long rains in April to July and short rains in September to November, while the latter season is between December and April (Ndetei, 2013).

The average atmospheric temperature is 31°C. The study site is encompassed by Kakamega forest and Lake Victoria which is around 68kms south of Kakamega town, these contributes to humidity and warm weather that is conducive for growth and multiplication of dermatophytes including ring worm of the scalp presently under investigation. Furthermore, census 2009 indicates that, an estimated 57% of the populations lives below the poverty line (KNBS, 2009). The main economic activities are: large scale farming of sugar cane, mixed farming, commercial businesses and boda boda transport which is popular among youths aged 18-35 years. Kakamega Central Sub-County has both urban and rural settings both of which vary in access to social amenities including clean tap water, healthcare services.

Figure 3.1: A map showing Kakamega Central Sub-County



3.2 Study Design

The study adopted cross-sectional study design.

3.3 Study Population

Study population of 4,611 children from the four selected schools constituted the study population (Table 3.1). A total of 375 children were randomly recruited to participate in the study: 65 children with *T. capitis* were the subjects and 310 who were *Tinea capitis* negative as control.

All the schools selected for this study were public schools. Two schools were from urban setting and the other two from rural.

3.3.1 Inclusion Criteria

All pupils aged 3 – 14 years present in school at the time of study, whose parents had consented (Appendix 1) for English and (Appendix 2) for Kiwahili version, and those who had assented (Appendix 3) were included in the study.

3.3.2 Exclusion Criteria

Children on treatment for *Tinea capitis* and those whose parents did not consent or those children who did not give assent were exempted from the study.

3.4 Sample Size

Sample size determination was calculated using the following formula:

$n = z^2pq/d^2$ (Fisher *et al.*, 1978)

Where n = sample size

z = the standard normal deviate (1.96 for a 95% confidence level)

p = prevalence- Prevalence of 33.3% from Eldoret study (Ayaya *et al.*, 2001) was used due to lack of prevalence information in these settings.

q = 1-p

d = 0.05 as the level of statistical significance.

Therefore: $n=1.96^2 x 0.0333 (1-0.333)/0.05^2=341$

10% of the 341 participants were included to cater for non-response.

= 10% X 341 = 34 participants.

Therefore, 375 study participants were recruited.

The sample size of 375 school going children randomly selected from the 4611 is a representative of the population of primary school going children in Kakamega Central Sub-County. Prevalence of 33.3% of a study in Eldoret was used (Ayaya *et al.*, 2001). This is corroborated by other studies where, if the prevalence is unknown, then the prevalence of previous studies published within the study domain can be used (Pourhoseingholi *et al.*, 2013).

Present study settled on sample size of 375 primary school going children based on the formula used in 3.2 above, and also as corroborated by study done in Kayseri city in Turkey, which had a total 139,422, primary school children, out of which 8122 children were selected to participate in the study (Balci *et al*., 2014). Another study in Mathare slums informal settlement in Nairobi, Kenya, 150 primary school going children were selected to participate in the study (Moto Maingi, & Nyamache., 2015). Also, another study in Ebonyi state, in Nigeria had a sample size of 279 primary school going children randomly selected from four schools to participate in the study (Anosike *et al*., 2005).

3.5 Sampling Techniques

The number of study participants per primary school is shown in Table 3.1. Purposive sampling technique was used to select the four schools in the Sub-County that was used as a representative sample of Kakamega Central Sub-County primary schools; this technique was used so that to get both rural and urban schools to be included in the study. Two schools were from urban set up and two from rural. Systematic random sampling method was then used to select the participants. The desired sample size (n) was 375 while the study population (p) was 4611. The interval of study subjects` selection was given by p /n (4611/375) which was 12. Therefore, every 12th

pupil was selected. Same sampling technique was used to identify children presenting clinically with scalp ring worms. The sample size (n) in this case was proportionately distributed to each of the four primary school; Mwiyala primary school 71, Mahiakalo 123, Elukho 102 and Emusala 79 participants. Study participants were then selected with the predetermined sampling interval. This was done until the required sample size was reached. This was replicated in all the four schools. The total number of participants included in the study was sum of participants sampled from all the four schools.

Table 3 .1 Number of study participants per school

School	***Children* population**	**Formula**	**Sample**
Mwiyala (Urban)	876	876/4611*375	71
Mahiakalo (Urban)	1515	1515/4611*375	123
Elukho (Rural)	1250	1250/4611*375	102
Emusala (Rural)	970	970/4611*375	79
Total population	**4,611**	**Total Sample Size**	**375**

3.6 Data Collection Process

3.6.1 Recruitment of research assistants

Two research assistants (RAs) with a qualification with at least certificate in Medical Laboratory Technology with working experience in a Mycology laboratory were recruited. The RAs were hired for two months to assist in sample collection.

3.6.2 Training of research assistants

The RA were trained for two weeks on standard operating procedures of how to screen, collect and transport samples from the schools to Masinde Muliro University Microbiology laboratory for processing and analysis.

3.6.3 Pre-testing

The pre-testing study was done in the neighboring Kisumu County to test the research tools where 10% of the sample size was used. A Questionnaire was tested for collection of socio-demographic data (Appendix 4).

3.6.4 Data Collection

There was two types of data collected: 1) Clinical samples; scalp scrapings and hair for fungal identification was collected in sterile white envelopes; 2) Socio-demographic and anthropometric data was obtained through semi-structured questionnaires (Appendix 5) for English version or (Appendix 6) for Kiswahili version. Information both from children participating in the study on the age, gender, weight, education level was collected, Also, socio-demographic data from parents/ care givers on age, age of the mother when giving birth, marital status, education level, occupation and monthly income, of parents was collected too.

The 375 pupils examined to the study went through the following procedure: physical assessment- was carried out to screen the presence of *Tinea capitis* (clinical symptoms) infections. The examination took place at a designated room in each of the selected schools. The skin scalp, eyebrows, and eyelashes of each child was carefully examined for characteristic features of ring worm of the scalp as before collection, thereafter the pupils were interviewed to collect socio-demographic data.

3.6.5 Specimen Collection

Each child was examined in a room with sufficient light; the scalp was examined for scaly grey patches, lusterless hair strands and purulent lesions. Affected areas were cleansed with 70% v/v ethanol, allowed to dry and light scrapings (skin scales, crusts, hair pieces) were taken from the active edge of lesion using a disposable blunt sterile scalpel blade. The samples were collected in

a sterile brown envelopes with each participant's sample handled separately to avoid scrapings getting mixed and code labeled, samples were then transported to the laboratory within 2 hours at room temperature for microscopic and culture analysis.

3.7 Laboratory Analyses

Preliminary mycological analysis of specimens was carried out at Masinde Muliro University of Science and Technology in Microbiology Labs, Kakamega. Direct microscopy as a preliminary test was done to get an impression of the presence of fungal cells prior to culture. A portion of each specimen was placed on a clean sterile slide and a drop of about 20% potassium hydroxide (KOH) was added to the sample and incubated for 30 minutes for the digestion of keratin to occur; then examined for the presence of hyphae and/or arthroconidia under low (x10) and high (x40) power objective. However, direct microscopy method is not an identification method for fungal agents but it augments' culture during characterization of fungal agents. Modified Sabourauds Dextrose Agar (SDA) is the preferred selective medium primarily used for the isolation of dermatophytes (Rijal, 2015).

Scrapings were inoculated onto modified SDA plates with 0.05g/mL chloramphenical and cycloheximide 0.5mg/mL (Weitzman & Summerbell, 1995) and on another set of SDA media plates without cycloheximide (Chepchirchir *et al.*, 2009). The media was prepared according to the standard procedures ((Rijal, 2015) . Chloramphenical inhibits the growth of bacterial contaminants while cycloheximide suppresses saprophytic fungi. Sample were separately inoculated onto the prepared SDA using a sterile wire loop then incubated the plates at 30°C in an inverted position with humidity. Samples were examined daily to capture pathogens as per their rate of growth (Attal, 2016). Cultures were kept for a maximum of eight weeks before being ruled out as negative for growth. The cultural characteristics of the isolates were noted and

identified based on duration of growth, surface morphology, pigment production on the reverse ,the texture, whether fluffy, powdery cottony or floccose, buff, whether the hyphae was radiating at the margins or whether their colony were folded. Microscopic examination was done by making a thin preparation of the fungal culture with a drop of lacto phenol cotton blue stain on a glass slide, covered with a coverslip and observed under a microscope using (x10) and (x40) objectives. Identification was based on macroscopic (growth characteristics and pigmentation) and microscopic morphology (formation of macroconidia and microconidia or other typical elements).

3.8 Data Management and Analysis

Each study questionnaire had a coded study identity that is uniquely associated with each study participant and clinical and laboratory tests. Biological samples were coded in line with study participant's codes. Socio-demographic, clinical and laboratory information was entered into Microsoft Office Access data bases, dated and time-stamped with an electronic signature. The database was configured such that an audit trial is created to track any changes made to the record(s), with time- and date-stamping, and an electronic signature appended. Electronic data was backed-up daily in google drive, a web-based storage device. Scanned images of study participant questionnaires were saved on google drive while source documents were placed in lockable cabinets. Data was summarized as numbers and percentages and presented in tables. Categorical variables were analyzed using Chi square test of homogeneity. Two by two contingency tables were analyzed using the Fischer's exact test and three by two tables were analyzed using Chi-square test. Continuous variables such as weight and height were analyzed using Mann Whitney U test. Binary logistic regression was used to determine the associations between variables for objective three. Statistical analysis was set at $P \leq 0.05$.

3.9 Ethical Considerations

Scientific approval was sought from Maseno University Ethics Review Committee (MUERC) School of Graduate Studies (Appendix 7). Permission was also sought from the Board of Management (BOM) through the Head masters of the selected schools for the study (Appendix 8, 9, 10 and 11). Before samples were taken and socio demographic data collected, parents/caregivers consented for the children below 13 years (Appendix 1) for English version, (Appendix 2) for Kiswahili version and assent was obtained (Appendix 3) from participants who were above 13 years.

Participation into the study was on voluntary basis and the participants were encouraged to feel free to withdraw from the study at any stage. The approval was on the agreement that participant's anonymity and confidentiality shall be maintained. Interviews were one-to-one interaction and no information was given to any other unauthorized person. No names were recorded; only serial numbers were entered into the questionnaire. Also, any information concerning this study was stored in password protected computers that are accessible only by the principal investigator.

Additionally, good laboratory practice/quality control was observed to ensure materials collected from participants containing infectious materials do not infect laboratory workers. Those participants that were infected by TC were treated by Ketoconazole cream, they were instructed by a pharmaceutical Technologist to apply twice (morning and evening) daily for 7-14 days. Thin layer of the ointment is applied at the affected area then rub gently, for those whose ring worm would not have cleared by end of 2 weeks or experiencing side effects like irritation, itching, reddening of the area being treated, they were advised to visit the nearest health facility

for further assistance. Additionally safety measures were observed during the disposal of laboratory wastes to prevent contaminating the environment and in turn the public get infected. There were no foreseeable risks attached to this study.

CHAPTER FOUR

RESULTS

4.1 Prevalence of *Tinea capitis* among primary school going children in Kakamega Central Sub-County

This study had a total of 375 participants randomly selected from the four primary schools. Up on screening of the participants based on clinical observation, 65 children presented clinically with symptoms of *Tinea capitis* hence revealing a prevalence of 17.3% of *Tinea capitis* infection in primary school going children in Kakamega Central Sub-County [Table 4.1]. Of the infected population 33 (50.8%) were male and 32 (49.2%) female. Children in these primary schools were clustered into four categories; 3-5years, 6-8years, 9-11years and 12-14years. Children in these clusters have more less the same behavior in terms of playing and personal hygiene practices. The clusters have some common characteristics both at school and at home like playing together and similar hygiene practices.

Table 4.1 Prevalence of *Tinea capitis* in school going children in Kakamega Central Sub-County.

Age group (years)	**Schools**								
	Mwiyala (n=71)		**Mahiakalo (n=123)**		**Elukho (n=102)**		**Emusala (n=79)**		**Total n (%)**
	M (n=36)	F (n=35)	M (n=64)	F (n=59)	M (n=52)	F (n=50)	M (n=38)	F (n=41)	
3-5	1	3	3	3	3	4	1	2	**20**
6-8	3	5	4	2	4	3	4	3	**28**
9-11	1	1	2	0	3	2	1	2	**12**
12-14	0	1	1	0	1	0	1	1	**5**
Totals	**5**	**10**	**10**	**5**	**11**	**9**	**7**	**8**	**65/375 (17.3)**

Data are presented as numbers (n) or as prevalence (%). M, male children within an age bracket. F, female children within an age bracket. The data represents the overall prevalence of children presenting physically with *Tinea capitis* in the four schools in Kakamega Central Sub-County, Kakamega County.

4.2 Characterization of the fungal species causing *Tinea capitis* in school going children in Kakamega Central Sub-County

4.2.1 Characterization of the fungal species causing *Tinea capitis*

After culture, 52 (80%) samples out of the 65 collected samples had growth and 13 (20%) had no growth after eight weeks of incubation at 30°C. Lack of growth for the 13 samples, could be inferred that, some of the dry lesions had almost healed hence the lack of growth and recovery of the arthroconidia. The cultural characteristics of the isolates were used to identify fungal agents; surface morphology, pigment production on the reverse, the texture, whether fluffy, powdery cottony or floccose, buff, whether the hyphae was radiating at the margins or whether their

colony were folded (Table 4.2). Microscopic examination was done using lacto phenol blue to reveal the arrangement of hyphae (Table 4.2).

Table 4.2 Characterization of fungal isolates grown on SDA at 30°C

Incubation period	Cultural characteristics		Microscopic description of lactophenol blue	Isolates
	Surface	Reverse		
5-9 days	Brown to tan waxy colony with brownish powdery aerial mycelia colonies often with radial grooves.	Orange to Cream	Broad hyphae, irregular , much branched and mulitiseptate	*T. tonsurans*
2-4 days	Woolly or cottony white , beige with flat colonies and radiating edges	Pale white	Rough thick walled and multiseptate macroconidia	*M. canis*
3-5 days	White to cream colony of closely matted mycelia. Central knob with radiating and unfolded surface	Yellow-brown to reddish-brown	Short segmented and relative hyphae present	*M. audouinii*
3-5 days	Red flat granular colonies with clear tinted center.	Rose brown	Numerous microconidia , conidia, rounded and pea born singly or in clusters spiral hyphae present.	*T. mentagrophyte*
5-7 days	Heaped up white to reddish cottony colonies	Cherry red		*T. rubrum*
2-7 days	Initially white then Green brown or black velvety or cottony	Whitish golden or brown	Septate hyphae, enlarged conidiophore	*A .niger*
2-7 days	Dark green	hyaline	Coarsely roughend conidiophore	*A. flavus*
5-12 days	Greenish-brown/ khakicoloured with suedelike surface. Raised & folded in the centre, flat periphery and submerged growth.	Deep yellow-brown pigment	Smooth, thin-walled macroconidia in clusters	*E. floccosum*
3-5 days	White to cream flat glabrous with submerged edge	Cream to white	Elongated cells with multilateral budding and pseudohyphae	*Candida rugosa*

Data presented as incubation period; time taken before the growth is noticed, Surface is front appearance of the colonies, reverse, the back appearance of the culture plates, Microscopy of colonial morphology in lacto phenol blue preparation, isolates; fungal agents identified from the cultures

4.2.2 Prevalence of Fungal Agents Isolated from the Cultures

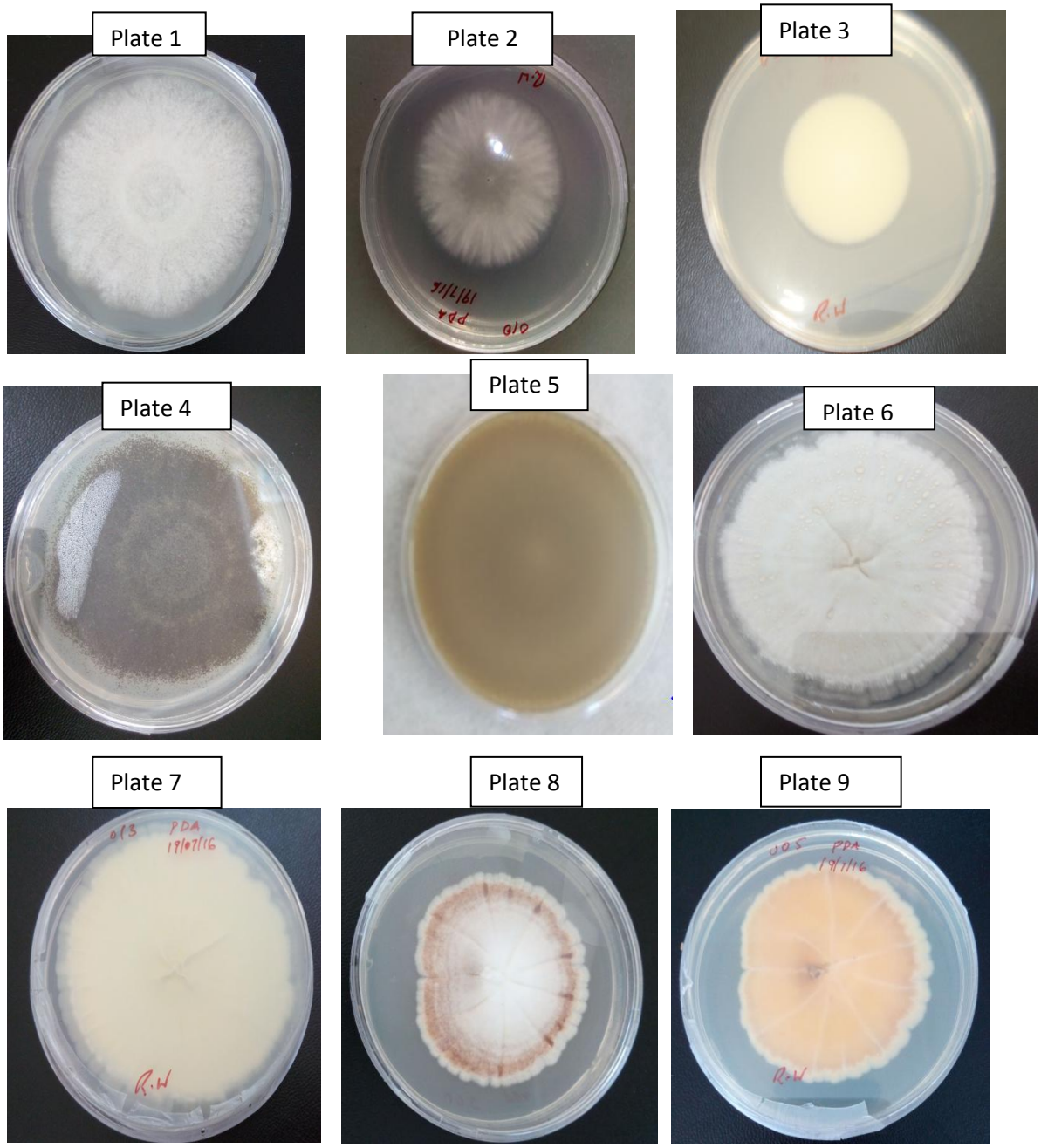
Out of the 52 isolates, 31 (60%) were of the genus *Trichophyton*. In the genus trichophyton, the most prevalent fungal agent was *Trichophyton tonsurans* which accounted for 51.9% of the fungal agents identified and 84.9% of the genus *Trichophyton* [Table 4.3]. Other fungal species in the genus *Trichophyton* identified were, *Trichophyton mentagrophyte* 3 (5.8%) and *Trichophyton rubrum* 2 (3.8%). The other fungal agents identified were of the genus *Microsporum* which accounted for 23.9% of all the fungal agents. In the genus *Microsporum*; *Micropsporum canis* was the most prevalent accounting for 13.6% of the entire fungal agents identified. The other fungal agent in this genus identified was *Micropsporum audouinii* accounted for 5.8% of all fungal agents identified in study participants. Another genus identified was *Aspergillus* in which two species were identified; *Aspergillus niger* 3 (5.8%) and *Aspergillus flavus* 1 (1.9%) [Table 4.3]. Additionally, *Epidermophyton flocosum* was also identified accounting for 1.9% of the total fungal agents. Interestingly, 1 isolate of *Candida rugosa* was identified among the fungal species. It accounted for 1.9% of all the fungal agents identified. Among the children presenting with *Tinea capitis,* 4 (7.7%) had co-infection of two or more fungal causing agents [Table 4.3].

Table 4.3: Summary of isolated fungal agents

Fungal agents	Number identified (n/65)	Prevalence (%)
Trichophyton tonsurans	27	51.9%
Microsporum audouinii	3	5.8%
Trichophyton mentagrophyte	3	5.8%
Micropsporum canis	7	13.5%
Aspergillus niger	3	5.8%
Aspergillus flavus	1	1.9%
Candida rugosa	1	1.9%
Epidermophyton flocosum	1	1.9%
Trichophyton rubrum	2	3.8%
Co-infections	4	7.7%

Data are presented as numbers (n) and prevalence (%). Co-infections, two or more fungal agents were identified in a sample.

4.2.3 Sampled culture plates of fungal isolates after 2-7 days growth at 30°C on SDA



Key: Plate 1: *M. canis-surface;* woolly or cottony white flat colonies, plate 2: *M. canis*-Reverse; pale white, plate 3: *C. rugosa- surface;* white to cream colonies, plate 4: *A. flavus*- surface; dark green colonies, plate 5: *A. niger*- surface; green to brown velvety colonies, plate 6: *M. audouinii* – surface; white to cream colony with central knob with radiating surface, plate 7: *M. audouinii*- reverse yellow-brown. Plate 8: *E. flocossum* -surface; greenish to brown/khaki colonies with suede like surface, plate 9: : *E. flocossum*- reverse; deep yellow to brown pigment.

4.3 The risk factors associated with *Tinea capitis* infection in primary school going children in Kakamega central Sub-County

4.3.1 Socio demographic and anthropometric characteristics of study participants

A total of 375 children aged between 3 and 14 years were enrolled in the study. 194 (51.7%) were male children and 181 (48.3%) accounted for female children. 65 (17.3%) children presented clinically with *Tinea capitis* while 310 (82.6%) children were without clinical manifestation hence regarded as *Tinea capitis* negative.

Gender of those participants who had *Tinea capitis* disease and those who were negative was comparable (P=0.391) [Table 4.4]. Male children accounted for 55.2% of the *Tinea capitis* negative and 50.8% of the *Tinea capitis* positive while female accounted for 44.8% *Tinea capitis* negative and 49.2% *Tinea capitis* positive. Similarly, age did not vary significantly between the groups (P=0.907) with the children ages in both groups ranging from 3 to 14 years. Additionally, the anthropometric measures of weight and height of the children participating in the study did not differ (P= 0.941 and P=0.849) respectively [Table 4.4]. Likewise, the religion and ethnicity of children with TC and those without did not differ.

The age of the mother and (or) caregiver was not significantly different between those children with the disease and those who were negative (P=0.828, 0.896 and 0.543), respectively. Contrastingly, the age of the mother when giving birth to the child was significantly different between the two clinical groups (P=0.0001) with mothers in the *Tinea capitis* negative group being older than those of the cases. Birth order of the child also varied significantly (P=0.0001) with the cases being of a higher birth order. Marital status of the caregivers did not differ between the groups (P=0.457). Education level of the caregivers varied significantly (P=0.002) with the *Tinea capitis* negative being better schooled than the cases. Similarly, income of the

caregiver differed significantly (*P*=0.0001) between the groups. Occupation of the caregivers did not vary (*P*=0.996). However, the meal frequency per day differed significantly between the groups (P=0.0001) with majority of participants in the *Tinea capitis* negative group having more than 3 meals in a day compared with the *Tinea capitis* positive cases.

Table 4.4 Socio demographic and anthropometric characteristics of children and their caregivers participating in the study

Variable	Category	*Tinea capitis* Status		*P*
		***T. capitis* [-] (n=310)**	***T. capitis* [+] (n=65)**	
Gender	Male Female	171 (55.2) 139(44.8)	33 (50.8) 32(49.2)	0.391[b]
Age	3-5 yrs. 6-8 yrs. 9-11 yrs. 12-14 yrs.	93 (30.0) 126 (40.6) 76 (24.6) 15 (4.8)	20 (30.8) 28 (43.1) 12 (18.5) 5 (7.6)	0.546[a]
Weight, kg	-	18.5 (10.3)	18.0 (10.3)	0.941
Height, cm	-	63.0 (18.0)	63.0 (15.3)	0.849
Religion	Christian Muslim	230 (74.2) 80 (25.8)	47 (72.3) 18 (27.7)	0.828[b]
Ethnicity	Luhya Kalenjin Luo Teso Other Bantus	146 (47.1) 44 (14.2) 18 (5.8) 22 (7.1) 80 (25.8)	30 (46.1) 10 (15.4) 4(6.2) 5 (7.7) 16 (24.6)	0.896[a]

Age of caregiver	20-35 yrs. 36-45 yrs. >45 yrs.	273 (88.2) 37 (11.8) 0 (0.0)	55 (84.6) 9 (13.8) 1 (1.5)	0.543[a]
Age of mother when giving birth to the child	<20 yrs. 20-30 yrs. >30 yrs.	21 (6.8) 171 (55.2) 107 (34.5)	12 (18.5) 52 (80.0) 1 (0.9)	**<0.0001[a]**
Birth order of the child	≤2 >2	230 (74.2) 80 (25.8)	17 (26.2) 48 (73.8)	**<0.0001[b]**
Marital status of caregiver	Married Divorced Widowed Unmarried	241 (77.7) 18 (5.9) 37 (11.9) 14 (4.5)	53(81.5) 5 (7.7) 3.5 (5.4) 3.5 (5.4)	0.457[a]
Education level of caregiver	Primary Secondary College and above	18 (5.8) 113 (36.5) 178 (57.4)	22 (32) 19 (28) 26 (40)	**0.002[a]**
Income of the caregiver	<5000Kshs 5000-29999Kshs >30000Kshs	22 (7.1) 219 (70.6) 69 (22.3)	31 (47.6) 30 (46.2) 4 (6.2)	**<0.0001[a]**
Occupation of the caregiver	Employed Self-employed Peasant farmer Unemployed	139 (44.8) 73 (23.5) 80 (25.8) 18 (5.8)	23 (33.3) 31 (46.6) 14 (20.5) 0 (0.0)	0.996[a]

Meal frequency per day	≤3 >3	69(22.3) 241 (77.7)	32 (49.2) 33 (50.8)	**<0.0001[b]**
Type of house floor	Cemented/Tile Soil/Mud	204 (65.8) 106 (34.2)	21 (32.3) 44 (67.7)	**<0.0001[b]**
Source of energy for cooking	Electricity Gas Wood/Kerosene	11(3.6) 156 (50.3) 143 (46.1)	3 (4.6) 23 (35.4) 40 (61.5)	**0.030[a]**
Number of baths per week	Daily ≥3 ≤2	175 (56.5) 91 (29.4) 44 (14.2)	3 (4.6) 10 (15.4) 52 (80)	**<0.0001[a]**
Sharing bed	Yes No	87 (28.1) 223 (71.9)	51 (78.5) 14 (21.5)	**<0.0001[b]**
Sharing clothing	Yes No	77 (24.8) 233 (75.2)	57 (87.7) 8 (12.3)	**<0.0001[b]**
Occupants in a bedroom	1 2 >2	208 (67.1) 91 (29.4) 11 (3.5	6 (9.2) 6 (9.2) 53 (81.5)	**<0.0001[a]**
Sharing combs	Yes No	211 (68.1) 99 (31.9)	61 (93.8) 4 (6.2)	**<0.0001[b]**

Data are presented as numbers (percentage) or as median (IQR). *Tinea capitis* (-); children who did not present with TC; *T. capitis* [+], children presenting with *Tinea capitis*. Data are analyzed using [a]Chi square test and [b]Fischer's exact test. Continuous data for weight and height was analyzed using Mann Whitney U test. *P* values < 0.05 have been bolded.

4.3.2 Risk Factors Associated with the Children Participating in the Study

Risk factors associated by the study participants were analyzed. Type of the house floor varied significantly (*P*< 0.0001) between the two groups with the cases having houses with more of soil/mud floors while the *Tinea capitis* negative group having more of cement/tile floors [Table 4.5]. Similarly, the source of energy for cooking differed significantly (*P*=0.030) with the *Tinea capitis* group using more of fire wood and kerosene while the *Tinea capitis* negative using more of gas. The frequency of baths per week also significantly (*P*=0.0001) differed between the groups with the cases less frequently taking a bath compared to the *Tinea capitis* negative [Table 4.5]. Moreover, children presenting clinically with *Tinea capitis* were more likely to share

bedding and clothes ($P< 0.0001$). Likewise, most of the children with *Tinea capitis* had more occupants in the rooms they were sleeping in ($P=0.0001$). Also, children who had TC more likely to share combs unlike the *Tinea capitis* negative [Table 4.5]. All variables describing risk factors associated significantly with *Tinea capitis*.

Table 4.5 Risk factors associated with children participating in the study.

	Category	***T. capitis* Status**		***P***
Variable		*T. capitis* (–) (n=310)	*T. capitis* [+](n=65)	
Age	<8 yrs	219	48	**0.017**[a]
	≥8 yrs	91	17	
Type of house floor	Cement/Tile	204	21	**0.0001**[b]
	Soil/mud	106	44	
Source of energy for cooking	Electricity	11	3	**0.030**[a]
	Gas	156	23	
	Wood/Kerosene	143	40	
Number of baths per week	Daily	175	3	**0.0001**[a]
	≥3	91	10	
	≤2	44	52	
Sharing bed	Yes	87	51	**0.0001**[b]
	No	223	14	
Sharing clothing	Yes	77	57	**0.0001**[b]
	No	233	8	
Occupants in a bedroom	One	208	6	**0.0001**[a]
	Two	91	6	
	More than Two	11	53	
Sharing combs	Yes	211	61	**0.0001**[b]
	No	99	4	

Data are presented as numbers (n). *Tinea capitis* negative is children without *Tinea capitis*; *T. capitis* [+], children presenting with TC. Data are analyzed using the [a]Chi square and [b]Fisher's exact test. *P* values < 0.05 have been bolded.

4.3.3 Association of *Tinea capitis* with Risk Factors

Clinical presentation of *Tinea capitis* was associated with some risk factors. Age was associated with *Tinea capitis* with children aged <8 years being three times at risk (odds ratio 2.793; $P=0.002$) compared to those in the aged >8 years [Table 4.6]. Marital status of the parents did not associate with clinical presentation of *Tinea capitis* (odds ratio 0.466; $P=0.700$). On the contrary, the number of baths was correlated with presentation of *Tinea capitis* were children taking a bath daily were almost five times protected (odds ratio 4.646; $P<0.0001$) [Table 4.6].

Likewise, sharing of beds was associated with clinical presentation of *Tinea capitis* with those sharing beds being two times more likely to present with *Tinea capitis* (odds ratio 1.959; *P*=0.021). Additionally, sharing of combs was strongly correlated with *Tinea capitis*. Children sharing combs were four times more at risk (odds ratio 3.815; *P*<0.0001) [Table 4.6]. The number of occupants also was strongly associated with *Tinea capitis* with children who have a bedroom to themselves being six times protected (odds ratio 6.001; *P*<0.0001).

Table 4.6: Association of *Tinea capitis* with risk factors

Risk	OR	95% CI	*P*
Age			
<8 yrs	2.79	1.43-5.17	**0.002**
≥8 yrs	Ref	-	
Number of baths/week			
<2	4.65	2.03-5.91	**<0.0001**
≥3	Ref	-	
Sharing of bed			
Yes	1.96	1.42-3.74	**0.021**
No	Ref	-	
Sharing of combs			
Yes	3.82	1.93-6.77	**<0.0001**
No	Ref	-	
Sharing clothing			
Yes	1.74	1.34-3.49	**0.033**
No	Ref	-	
Occupants of a bedroom			
>1	6.01	2.01-8.36	**<0.0001**
1	Ref	-	
Type of house floor			
Soil/Mud	1.53	1.23-3.38	**0.045**
Cement/Tile	Ref	-	
Source of energy for cooking			
Wood/Kerosene	1.61	1.16-3.41	**0.031**
Gas/Electricity	Ref	-	

Association of *Tinea capitis* with risk factors. Odds ratios (OR) and 95% confidence intervals (CI) were determined using binary logistic regression controlling for gender. Values in bold are significant *P* values at a cut-off of *P*<0.05.

CHAPTER FIVE

DISCUSSION

5.1 Prevalence of *Tinea capitis* among primary school going children in Kakamega Central Sub-County

The prevalence rate of *Tinea capitis* in school going children in Kakamega Central Sub-County was observed to be 17.3%. The success growth rate of culture was 80% (52/65) of samples; no growth was recorded in 13 samples (20%), this could be attributed to difficulty in sample collection and also it could be samples were collected from dry lesions that were healing from the treatment administered by parents of the affected children (Enendu & Ibe, 2005).

The prevalence rate of this study was found to be higher than some of the previous studies done worldwide including those in Kenya. A study in Cleveland had an estimated prevalence of 13% (Ghannoum *et al.,* 2003), in London, (Hay *et al.,* 2001) observed a prevalence rate of approximately 12%. However, some studies have observed higher prevalence rates than the findings in this study.

A study in Ethiopian School children reported a prevalence rate of 59% **(**Woldeamanuel *et al.,* 2005), in South-Western Nigeria a prevalence of 35% was reported (Oke *et a.,* l2014) and in Madagascar a study found a prevalence of 20.5 % (Contet-Audonneau *et al.,* 2006). Some studies in Kenya have reported much higher prevalences than the current study; In Eldoret a prevalence rate of 33.3% was reported (Ayaya *et al*., 2001). The most recent study in Mathare which is an informal settlement in Nairobi City Kenya, reported significantly higher prevalence of 81.2% (122/150) among school children (Moto *et al.,* 2015). In the recent years, the prevalence of *Tinea capitis* has increased in children worldwide especially in Africa which has a prevalence rate of 14-86% among children (Guerrant *et al*., 2011). The marked difference in prevalence of *Tinea capitis* infection between countries and continents can be attributed to

variation in geographic distribution and occurrence of dermatophytes that causes TC worldwide. In addition, risk factors like endemicity migration, type of animal reservoirs, local climatic conditions can influence the variation of prevalence rates (Soyinka, 1978). Furthermore, previous studies have also found out that , factors like, population growth temperature, relative humidity economic status and close contact among infected children at home and school, and poor personal hygiene are also associated with prevalence of *Tinea capitis* infection in primary school going children (Fathi & al-Samarai, 2000; Ginter-Hanselmayer *et al*., 2007; Moraes *et al.*, 2006). The prevalence of *Tinea capitis* infection was lower in children schooling in urban schools (16.7%) than their counterparts in rural schools (18.7%), though the variation was not significantly different, but this variation is alluded to the fact that, children in urban areas come from a higher socioeconomic status than those from rural schools with a lower socioeconomic status. These findings corroborates with a study done in Gabon which found out that, *Tinea capitis* infection was 20.4% in the urban schools and 26.3% in rural schools (Hogewoning *et al*., 2013).

This study has also observed that, children aged below 10 years are more likely to have *Tinea capitis* than those above 10 years. Low prevalence of TC in children above 10 years appears to be as a result of presence of protective fatty acids in their scalp and also it is attributed to the fact that as the level of education increases , the level of awareness and knowledge of students about health matters also increases hence increasing the level of personal hygiene consequently improving the effectiveness of health behavior (Hibstu & Kebede, 2017). High prevalence in children below 10 years is alluded to some predisposing factors like poor personal hygiene, crowded living conditions, and low socioeconomic status. This is consistent with previous

reports that *Tinea capitis* is mostly exclusive to children and rarely occurs after puberty (Ali-Shtayeh *et al.*, 1998; Oyeka, 1990; Sun *et al*., 2017).

In the contrary, adults are rarely infected and the tendency of scalp ringworm to clear spontaneously at puberty is believed to be due to the change in sebum composition at this age, hence this disease is normally regarded as "disease of the primary school going children". This is corroborated with a study carried out in San Diego California, USA (Chen & Friedlander, 2001) which found out that TC is a common disease in childhood and it is an age-old problem that continues to be a burden to affected families . The prevalence of *Tinea capitis* in boys (50.8 %) and girls (49.2%) was not different. This is contrary to some findings from previous studies that found out a statistical difference in TC infection with gender. For example, a study conducted among primary school children in Amsterdam, Holland (Timen *et al.*, 1999), Tikrit, Iraq (Fathi & al-Samarai, 2000) and Nablus Palestine (Ali-Shtayeh *et al*., 1998). In addition, a more recent study that was done among school children in Kolkata in India (Kundu *et al.*, 2012) found out that the prevalence rate was high among boys than girls, the same was also reported in a study carried out in Eldoret town Kenya (Ayaya *et al*., 2001) which indicated that, there were more male school children in Africa that were infected with *Tinea capitis* than female.

However, just like the present study, a study in Milwaukee USA did not find sex of children to be associated with *Tinea capitis* in univariate and multivariate analysis (Pomeranz *et al*., 1999). In Kenya, gender related studies on the prevalence of ringworm is varied, a study in Kibera slums in Nairobi (Chepchirchir *et al.*, 2009) did not find sex a significant risk factor, but findings of studies done in Eldoret and Mathare slum, an informal settlement in Nairobi indicates that Sex is an associated risk factor to TC infection (Ayaya *et al*., 2001; Moto *et al.*, 2015). Lack of statistical difference of *Tinea capitis* infection in boys and girls in the present study probably

suggests that, the infection is related to personal hygiene and its prevalence can be reduced by adequate health education and good personal hygiene practices.

5.2. Characterization of the fungal species causing *Tinea capitis* in school going children in Kakamega Central Sub-County

Direct microscopy (KOH Preparation) and culture techniques were used to identify etiological agents causing *Tinea capitis*; 39 (60 %) Of the 65 cases collected had yeast cells and or fungal elements in KOH preparation while 26 (40%) had no yeast cells and or fungal elements. Fungal agents were phenotypically identified after culture, 31 (59.6%) isolates were of the genus *Trichophyton* and the most prevalent fungal agent was *Trichophyton tonsurans* which accounted for 51.1% of the fungal agents identified. Predominance *of T. tonsurans* could be attributed to its anthropophilic nature and abundance among human carriers as observed by Kalinowska (2012).

These findings were similar to those obtained from previous studies in Kenya by Ayaya *et al* (2001) in Eldoret town and in the recent study in Mathare slum Nairobi by Moto *et al* (2015). Quite a number of studies in other countries have reported similar findings regarding *T. tonsurans* being a predominant species causing *Tinea capitis* in children. A study in the United Kingdom reported a prevalence range of 50-90% of *Tinea capitis* cases being caused by *T. tonsurans* (Fuller, 2009). This was further observed in another study in Irish pediatric population where *T. tonsurans* accounted for 81.9% of the *Tinea capitis* infection (Nasir *et al.,* 2013). Other fungal species identified in genus *Trichophyton* were: *Trichophyton mentagrophyte* 3 (5.8%) and *Trichophyton rubrum* 2 (3.8%). *Trichophyton mentagrophyte* was the second commonest *Trichophyton spp* isolated in this study, these findings revealed similar results as those previously conducted in other sub-Saharan countries that recorded 7.3–15.7% (Hogewoning *et al*., 2013; Hryncewicz-Gwóźdź *et al.,* 2011) ring worm infection by *Trichophyton*

mentagrophyte. However, among this genus, *T. rubrum* (3.8%), was the least isolated, this result was similar to previous studies that have shown lower than 10% prevalence trend of *T. rubrum* in Kenya and Nigeria. However some studies have reported much higher prevalence of *T. rubrum* than the current study; Gulbarga Hospital in India a study reported *T.rubrum* infection of 46.87% as the predominant fungal etiological agent isolated (Jayanthi *et al.*, 2016).

The other fungal agents identified were of the genus *Microsporum*, which accounted for 23.9% of all the fungal agents. In this genus, *Micropsporum canis* was the most prevalent accounting for 13.5% of the entire fungal agents identified. The other fungal agent in this genus identified was *Micropsporum audouinii* which accounted for 5.8% of all fungal agents identified in study participants. Previous studies have observed that *Tinea capitis* disease is primarily caused by dermatophytes in the genera of *Trichophyton* and *Microsporum* (Burgdorf, 2004). Some Previous studies have reported lower prevalence than the present study, a research Ebony State in Nigeria reported prevalence of 11.9 % of *M. canis*. However, some studies have reported higher prevalence of *M. cans* than the one in present study. A study in Kaduna State in Nigeria 22.7% infection (Dogo *et al.,* 2016). Another study in Brazil, reported a much higher prevalence of 70.5 % (Moraes *et al.,* 2006). *M. canis* infection is attributed to the fact that, being a zoophilic etiologic agent it might have originated from cats, dogs cow, and other animals since people share the residential houses with domestic animals. *Microsporum audouinii* (5.8%) was the third common Species isolated. Some previous study has reported much lower prevalence of 1.1% in Western Europe (Pai *et al*., 2013). However studies that was done in Kenya and Egypt reported higher prevalence of *M. audouinii* (7.8% and 36%) than the present study (Schmeller *et al.*, 1997; Bassyouni *et al.,* 2017). Studies have observed that etiological agents of *Tinea capitis* in a given geographical area can change over time (Pai *et al.,* 2013). For the case of

Microsporum audouinii, previous studies indicates that, it was the predominant etiological agent in North America and Europe until the 1950s (Pai *et al.,* 2013). But currently, *Trichophyton tonsurans* is more common in the USA, and becoming more predominant in Europe and the United Kingdom. The decline in prevalence of *M. audounii* infection in most part of the world is thought to be due to the widespread use of griseofulvin, which is more effective against *M. audounii* than other species like *T. tonsurans* (Ginter-Hanselmayer *et al.,* 2007).

Two species of genus *Aspergillus* were identified; *Aspergillus niger* 3 (5.8%) and *Aspergillus flavus* 1 (1.9%). Isolation of these non-dermatophyte molds is in concurrence with recent etiological and epidemiological studies carried out globally. A retrospective analysis done in a 11 year child in 2004–2014 and etiology of TC in 0–18 year-old children from Bulgaria, revealed surprisingly high incidence of molds majorly *A. niger* and A. *flavus* as etiological agent of *Tinea capitis*. More and more research indicates that not only the main causative agent among separate groups of dermatophytes is different in the different geographical areas throughout the world but also, there is an increasing alteration in etiological subgroups.

Therefore, *A. niger* and *A. flavus* could be a possible new etiopathogenic agents in *Tinea capitis*, and this is alluded to risk factors including; increasing resistance in some species, evolutionary reduction of other causative agents, global alterations in different geographical regions, differences in social-economic factors associated with the patient, the age, and even the gender (Chokoeva *et al*., 2016). These observations suggest non-dermatophyte molds to be new pathogenic etiologic agent for TC in children, especially in patients with poor living conditions or social deprivation.

Additionally, *Epidermophyton flocosum* was also identified accounting for 1.9% of the total fungal agents isolated. Interestingly, 1(1.9%) isolate of *Candida rugosa* was identified among

the fungal species causing TC. Among the children presenting with *Tinea capitis*, 4 (7.7%) had co-infection of two or more fungal agents. According to the studies done globally, *Tinea capitis* is commonly widespread in African countries (Hogewoning *et al.,* 2013; Fulgence *et al*, 2013 & Thakur *et al*., 2013; Pai *et al*., 2013) and in children of Afro-Caribbean extraction, in North America, Central America, and South America.

5.3 Risk factors associated with *Tinea capitis* in school going children in Kakamega Central Sub-County

Tinea capitis is currently a disease of global importance and a public health burden. It is caused by dermatophytes, which attack and grow on dead animal keratin. The predominant clinical forms and causative agents vary from one region of the world to another. This study focused on determining the prevalence, etiological agents and risk factors associated with the infection of *Tinea capitis* in school going children aged between 3 and 14 in primary school going children in Kakamega Central Sub-County. Kakamega County is one the most densely populated Counties in Kenya (KNBS, 2009). Poor socioeconomic status, high population densities, and poor sanitary conditions are some of the factors responsible for the high prevalence of *Tinea capitis* in many developing countries including Kenya.

This study found no statistical difference in the gender and age of study participants. The study participants were therefore homogeneously distributed in terms of age and gender in the clinical groups eliminating any bias based on these two variables. Likewise, the current study did not find significant difference in anthropometric measures of weight and height between the two groups, there is limited information in previous studies about weight and height being factors associated with TC infection in children below 14vyears of age. This present study also observed that majority of the participants were of the Christian faith with the rest being of Muslim faith,

however religion did not vary significantly between the groups and this finding is consistent with other previous studies which did not find any difference in religion among the various study groups. Ethnicity and the age of the caregiver also did not differ between the groups. Kakamega County is predominantly occupied by Bantu of Luhya origin and were the majority of the study participants. It borders Nandi, Siaya and Busia Counties which are occupied by Kalenjin, Luo and Teso ethnic groups respectively hence a number of the study participants were from these ethnic groups. Age of the mother when giving birth to child participating in the study varied significantly between the groups. Children presenting with *Tinea capitis* were from young mothers in age compared to the healthy children suggesting that the age of the mother is a determinant of *Tinea capitis* status. Generally, older mothers are more experienced in child care compared to younger mothers.

This is the most plausible explanation to this finding. Similarly, birth order of the child in the family differed significantly between the two groups. Children presenting with *Tinea capitis* were of a higher birth order compared with the healthy controls suggesting that crowding in a family increases the chance of a child getting *Tinea capitis* infection. Marital status of the mothers or care givers did not differ significantly between healthy controls and cases implying that this socio-demographic factor did not influence *Tinea capitis* status. Their education level of the mothers or care giver varied significantly between the groups. Children presenting with *Tinea capitis* clinically had mothers who had mostly primary or secondary school level of education unlike the healthy controls whose mothers' level of education was mostly secondary and college. This finding concur with study done in Egypt which associated level of education with *Tinea capitis* infection (Bassyouni *et al.*, 2017). However some studies have found contrary results; Turkey (Balci *et al.*, 2014), Nigeria (Dogo *et al.*, 2016) and Kenya (Chepchirchir *et al.*, 2009)

reported that the level of education of parents is not associated with TC infection in school going children. The finding of the present study can be alluded to lack of knowledge on hygienic practices for mothers with a lower level of education and hence high likelihood of their children getting *Tinea capitis* infection. In addition, the income of the mothers and care givers differed significantly between the groups. Children in the *Tinea capitis* group had mothers and or care givers with a low income compared to the healthy controls. This result was supported with the findings in Mathare informal settlement slum in Nairobi Kenya (Moto *et al*., 2015) and in Turkey (Balci *et al.*, 2014). This is alluded to the fact that, parents' income determines the affordability of basic amenities necessary for proper hygiene practices. On the other hand, the number of times the children had a meal in a day varied between the groups. Healthy children seemingly ate more frequently in a day compared to the children presenting with *Tinea capitis*. This study is in agreement with the finding in South Western Nigeria (Olutoyin *et al.*, 2017).

It is alluded to the fact that adequate nutrition and avails the necessary requirements to build a better immunity for the children hence they are better protected from the infection. In the present study, the occupation of the mothers and care givers did not vary between the groups.

Analysis of hygiene practices from the study participants revealed that, there is an association between hygiene practices and prevalence of *Tinea capitis*; number of baths per week PV (0.0001), Sharing of combs PV (0.0001), sharing of clothes PV (0.0001) and sharing of combs PV (0.0001). These finding is corroborated with previous studies which have associated *Tinea capitis* infection with risk factors including hygiene practices. A study in Turkey (Balci *et al.*, 2014) observed that some of the factors that affect the prevalence rate of *Tinea capitis* infection are, geographical differences, poor hygiene and sanitary condition. Some of the dermatophytes causing TC infection vary with geographic location, since some species are widely distributed in

the world whereas others are geographically restricted. Similar findings were found in another study done in Iraq (Fathi & al-Samarai, 2000). Furthermore, the finding of this study is also corroborated with findings in a recent study done in Mathare slums an informal settlement in Nairobi, Kenya which noted that *Tinea capitis* infection is also associated with haircuts especially boys go for shaves in barber shops where they use universal shaving machines and clippers which are not properly cleaned and sterilized accordingly; sharing of combs and the heavy mingling with friends without conscious on personal hygiene are also noted factors associated with TC infection in Mathare slums (Moto *et al*., 2015). Studies in Kibera Slums Nairobi, Kenya (Chepchirchir *et al.*, 2009) and (Nweze and Eke, 2018) in Eastern and Southern part of Africa also found out that poor socioeconomic status, poor sanitary conditions are factors that are equally associated with the spread of *Tinea capitis* infection in primary school children globally.

In relation to gender, there was no significant difference of TC infection. The frequency of baths per week also significantly (P=0.0001) differed between the groups with 80.9% of cases less frequently taking a bath compared to 14.1% of *Tinea capitis* negative that frequently too bath. Moreover, children presenting clinically with *T. capitis* were more likely to share bedding, clothes and combs (P< 0.0001). These findings were in consistence with research done in many part of developing countries including Kenya and Nigeria**,** and some parts of European countries. The prevalence rate of *Tinea capitis* increased with increase in the number of occupants per bedroom in the children's homes, and those sharing items like combs and clothes unlike the *Tinea capitis* negative group. More occupants in a bedroom is associated with a low socioeconomic profile, i.e. low standard of living, poor hygiene and overcrowded living conditions and these facilitate the transmission of *Tinea capitis*

CHAPTER SIX

SUMMARY OF FINDINGS, CONCLUSIONS ANDRECOMMENDATIONS

6.1 Summary of the Findings

This study has established a prevalence of 17.3% *Tinea capitis* infection in Kakamega Central Sub-County. In Africa, the infection rate ranges between 10 and 30% among school-aged children of below 15years, hence this is a public health burden. . *Trichophyton* genus was identified as the most prevalent fungal etiological agent causing *Tinea capitis* among school-going. *T.tonsorans spp* was the most common *species* isolated (51.9%) followed by M. *canis* 13.5% and *T. rubrum*. Additionally, the study established a significant association between *Tinea capitis* disease and poor personal hygiene habits and poor environmental sanitation both in schools and homes.

6.2 Conclusion

1. The prevalence of *Tinea capitis* among primary school going children in Kakamega Central Sub-County is 17.3%.
2. *Trichophyton tonsorans* is the most common etiological agent of *Tinea capitis* among primary school children presenting with *Tinea capitis* in Kakamega Central Sub-County.
3. *Aspergillus niger* and *Aspergillus flavus are* possible new etiopathogenic agents causing *Tinea capitis* pre-pubertal age in Kakamega Central Sub-County.
4. *Tinea capitis* infection among primary school going children in Kakamega Central Sub-County was significantly associated with risk factors like personal hygiene practices including frequency of taking baths, sharing of beds, combs, number of occupants of a bedroom, and environmental sanitation of the children aged 3-14 years.

6.3 Recommendations from the Study

1. Routine surveillance and evaluation of superficial mycoses in primary schools in Kakamega Central Sub-County as a public health measure for asymptomatic carriers of *Tinea capitis* should be carried out and treated, since they are the continuous source of infection.
2. Prophylactic measures on *Trichophyton tonsorans* should be taken since it's the most common fungal etiological agent among children presenting with *Tinea capitis* in Kakamega Central Sub-County.
3. Siblings and playmates of patients should avoid close physical contact and sharing of toys or other personal objects, such as combs and hairbrushes, since organisms can spread from one person to another and infectious agents can be transported to different classrooms within the same or in different schools.

6.4 Recommendations for Future Studies

1. Studies should be carried out to determine the variation in virulence of fungal etiological agents causing *Tinea capitis* in Kakamega Central Sub-County.

2. Study can be done to establish the phylogeny and molecular signatures of the different fungal agents causing *Tinea capitis* in Kakamega Central Sub-County.

REFERENCES

Abd Elmegeed, A. S. M., Ouf, S. A., Moussa, T. A. A., & Eltahlawi, S. M. R. (2015). Dermatophytes and other associated fungi in patients attending to some hospitals in Egypt. *Brazilian Journal of Microbiology*, *46*(3), 799–805. https://doi.org/10.1590/S1517-838246320140615

Adou-Bryn, K. D., Assoumou, A., Haddad, R. N., Aka, B. R., & Ouhon, J. (2004). [Epidemiology of *Tinea capitis* in Abidjan, Cote d'Ivoire]. *Medecine Tropicale: Revue Du Corps De Sante Colonial*, *64*(2), 171–175.

Ali-Shtayeh, M. S., Arda, H. M., & Abu-Ghdeib, S. I. (1998). Epidemiological study of *Tinea capitis* in schoolchildren in the Nablus area (West Bank). *Mycoses*, *41*(5–6), 243–248.

Anosike, J. C., Keke, I. R., Uwaezuoke, J. C., Anozie, J. C., Obiukwu, C. E., Nwoke, B. E. B., & Amajuoyi, O. U. (2005). Prevalence and distribution of ringworm infections in primary school children in parts of Eastern, Nigeria. *Journal of Applied Sciences and Environmental Management*, *9*(3), 21–26. https://doi.org/10.4314/jasem.v9i3.17347

Attal, R. (2016). *Tinea capitis among primary school children: A clinicomycological study in A rural hospital in central india*.

Ayaya, S. O., Kamar, K. K., & Kakai, R. (2001). Aetiology of *Tinea capitis* in school children. *East African Medical Journal*, *78*(10), 531–535.

Balci, E., Gulgun, M., Babacan, O., Karaoglu, A., Kesik, V., Yesilkaya, S., … Nedret Koc, A. (2014). Prevalence and risk factors of *Tinea capitis* and tinea pedis in school children in Turkey. *JPMA. The Journal of the Pakistan Medical Association*, *64*, 514–518.

Barasa, F. M. (2016). State of sanitation and hygiene of public primary schools in Kakamega municipality, western Kenya. https://doi.org/10.4172/2329-6879.C1.029

Bassiri-Jahromi, S., & Khaksari, A. A. (2009). Epidemiological survey of dermatophytosis in Tehran, Iran, from 2000 to 2005. *Indian Journal of Dermatology, Venereology and Leprology*, *75*(2), 142–147.

Bassyouni, R. H., El-Sherbiny, N. A., Abd El Raheem, T. A., & Mohammed, B. H. (2017). Changing in the Epidemiology of *Tinea capitis* among School Children in Egypt. *Annals of Dermatology*, *29*(1), 13–19. https://doi.org/10.5021/ad.2017.29.1.13

Boral, H., Durdu, M., & Ilkit, M. (2018). Majocchi's granuloma: current perspectives. *Infection and Drug Resistance*, *11*, 751. https://doi.org/10.2147/IDR.S145027

Burgdorf, W. H. C. (2004). Fitzpatrick's dermatology in general medicine. 6th edition: Irwin M. Freedberg, MD, Arthur Z. Eisen, MD, Klauss Wolff, MD, K. Frank Austen, MD, Lowell A. Goldsmith, MD, and Stephen I. Katz, MD, PhD, editors, New York, 2003, McGraw-Hill. 2 volumes, 3328 pages. $495.00. ISBN: 0-07-138076-0. *Journal of the American Academy of Dermatology*, *51*(2), 325–326. https://doi.org/10.1016/j.jaad.2003.12.039

Chen, B. K., & Friedlander, S. F. (2001). *Tinea capitis* update: a continuing conflict with an old adversary. *Current Opinion in Pediatrics*, *13*(4), 331–335.

Chepchirchir, A., Bii, C., & Ndinya-Achola, J. O. (2009). Dermatophyte infections in primary school children in Kibera slums of Nairobi. *East African Medical Journal*, *86*(2), 59–68.

Chokoeva, A. A., Zisova, L., Chorleva, K., & Tchernev, G. (2016). *Aspergillus niger* – a possible new etiopathogenic agent in *Tinea capitis*? Presentation of two cases. *The Brazilian Journal of Infectious Diseases*, *20*(3), 303–307. https://doi.org/10.1016/j.bjid.2016.01.002

C**ontet-Audonneau, N., Grosjean, P., Razanakolona, L.-R., Andriantsinjovina, T., & Rapelanoro, R. (2006)**. [*Tinea capitis* in Madagascar: a survey in a primary school in Antsirabe]. *Annales De Dermatologie Et De Venereologie*, *133*(1), 22–25.

Coulibaly, O., L'Ollivier, C., Piarroux, R., & Ranque, S. (2018). Epidemiology of human dermatophytoses in Africa. *Medical Mycology*, *56*(2), 145–161. https://doi.org/10.1093/mmy/myx048

Dogo, J., Afegbua, S. L., & Dung, E. C. (2016). Prevalence of *Tinea capitis* among School Children in Nok Community of Kaduna State, Nigeria. *Journal of Pathogens*, *2016*, 9601717. https://doi.org/10.1155/2016/9601717

Donghi, D., Hauser, V., & Bosshard, P. P. (2011). Microsporum audouinii *Tinea capitis* in a Swiss school: assessment and management of patients and asymptomatic carriers. *Medical Mycology*, *49*(3), 324–328. https://doi.org/10.3109/13693786.2010.522602

Elewski, B. E. (2000). *Tinea capitis*: a current perspective. *Journal of the American Academy of Dermatology*, *42*(1 Pt 1), 1–20; quiz 21–24.

Enendu, N. E., & Ibe, S. N. (2005). Prevalence of *Tinea capitis* among primary school pupils In uli, anambra state, nigeria. *African Journal of Applied Zoology and Environmental Biology*, *7*(1), 1–4. https://doi.org/10.4314/ajazeb.v7i1.41136

Fathi, H. I., & al-Samarai, A. G. (2000). Prevalence of *Tinea capitis* among schoolchildren in Iraq. *Eastern Mediterranean Health Journal = La Revue De Sante De La Mediterranee Orientale = Al-Majallah Al-Sihhiyah Li-Sharq Al-Mutawassit*, *6*(1), 128–137.

Fisher et al, et al. (1978). Fisher Equation - Overview, Formula and Example. Retrieved March 26, 2019, from Corporate Finance Institute website: https://corporatefinanceinstitute.com/resources/knowledge/economics/fisher-equation/

Fulgence, K. K., Abibatou, K., Vincent, D., Henriette, V., Etienne, A. K., Kiki-Barro, P. C., … Hervé Menan, E. I. (2013). *Tinea capitis* in schoolchildren in southern Ivory Coast. *International Journal of Dermatology*, *52*(4), 456–460. https://doi.org/10.1111/j.1365-4632.2012.05733.x

Fuller, L. C. (2009). Changing face of *Tinea capitis* in Europe. *Current Opinion in Infectious Diseases*, *22*(2), 115–118. https://doi.org/10.1097/QCO.0b013e3283293d9b

Ghannoum, M., Isham, N., Hajjeh, R., Cano, M., Al-Hasawi, F., Yearick, D., Elewski, B. (2003). *Tinea capitis* in Cleveland: survey of elementary school students. *Journal of the American Academy of Dermatology*, *48*(2), 189–193. https://doi.org/10.1067/mjd.2003.109

Ginter-Hanselmayer, G., Weger, W., Ilkit, M., & Smolle, J. (2007). Epidemiology of *Tinea capitis* in Europe: current state and changing patterns. *Mycoses*, *50 Suppl 2*, 6–13. https://doi.org/10.1111/j.1439-0507.2007.01424.x

Guerrant, R. L., Walker, D. H., & Weller, P. F. (2011). *Tropical Infectious Diseases: Principles, Pathogens and Practice E-Book*. Elsevier Health Sciences.

Guto, J. A., Bii, C. C., & Denning, D. W. (2016). Estimated burden of fungal infections in Kenya. *Journal of Infection in Developing Countries*, *10*(8), 777–784.

Hay, R. J., Robles, W., Midgley, G., & Moore, M. K. (2001). *Tinea capitis* in Europe: new perspective on an old problem. *Journal of the European Academy of Dermatology and Venereology*, *15*(3), 229–233. https://doi.org/10.1046/j.1468-3083.2001.00214.x

Hibstu, D. T., & Kebede, D. L. (2017). Epidemiology of *Tinea capitis* and Associated Factors among School Age Children in Hawassa Zuria District, Southern Ethiopia, 2016. *Journal of Bacteriology & Parasitology*, *8*(2), 1–5. https://doi.org/10.4172/2155-9597.1000309

Hogewoning, A. A., Adegnika, A. A., Bavinck, J. N. B., Yazdanbakhsh, M., Kremsner, P. G., Raaij-Helmer, E. M. H. van der, … Lavrijsen, A. P. M. (2011). Prevalence and causative fungal species of *Tinea capitis* among schoolchildren in Gabon. *Mycoses*, *54*(5), e354–e359. https://doi.org/10.1111/j.1439-0507.2010.01923.x

Hogewoning, A., Amoah, A., Bavinck, J. N. B., Boakye, D., Yazdanbakhsh, M., Adegnika, A., … Lavrijsen, A. (2013). Skin diseases among schoolchildren in Ghana, Gabon, and Rwanda. *International Journal of Dermatology*, *52*(5), 589–600. https://doi.org/10.1111/j.1365-4632.2012.05822.x

Hryncewicz-Gwóźdź, A., Beck-Jendroschek, V., Brasch, J., Kalinowska, K., & Jagielski, T. (2011). *Tinea capitis* and tinea corporis with a severe inflammatory response due to Trichophyton tonsurans. *Acta Dermato-Venereologica*, *91*(6), 708–710. https://doi.org/10.2340/00015555-1153

J Tietz, H., Czaika, V., M Ulbricht, H., & Sterry, W. (1999). *Tinea capitis* in Germany. A Survey in 1998. *Mycoses*, *42 Suppl 2*, 73–76. https://doi.org/10.1111/j.1439-0507.1999.tb00017.x

Jayanthi, R. S., Nagamani, R., Lavanya, M., & Rao, R. (2016). Incidence and Culture Characteristics of Dermatophytes Isolated at a Tertiary Care Hospital in the Outskirts of Hyderabad, India. *International Journal of Current Microbiology and Applied Sciences*, *5*(8), 372–380. https://doi.org/10.20546/ijcmas.2016.508.039

Khaled, A., Ben Mbarek, L., Kharfi, M., Zeglaoui, F., Bouratbine, A., Fazaa, B., & Ridha Kamoun Barek, M. (2007). *Tinea capitis* favosa due to Trichophyton schoenleinii. *Acta Dermatovenerologica Alpina, Panonica, et Adriatica*, *16*, 34–36.

KNBS. (2009). Kenya National Bureau of Statistics, Nairobi, Kenya. Retrieved July 18, 2018, from Kenya National Bureau of Statistics website: https://www.knbs.or.ke/

Kundu, D., Mandal, L., & Sen, G. (2012). Prevalence of *Tinea capitis* in school going children in Kolkata, West Bengal. *Journal of Natural Science, Biology, and Medicine*, *3*(2), 152–155. https://doi.org/10.4103/0976-9668.101894

Lakshmanan, A., Ganeshkumar, P., Mohan, S. R., Hemamalini, M., & Madhavan, R. (2015). Epidemiological and clinical pattern of dermatomycoses in rural India. *Indian Journal of Medical Microbiology*, *33*(5), 134. https://doi.org/10.4103/0255-0857.150922

Lee, J. Y., & Hsu, M. L. (1992). Pathogenesis of hair infection and black dots in *Tinea capitis* caused by Trichophyton violaceum: a histopathological study. *Journal of Cutaneous Pathology*, *19*(1), 54–58.

Magill, S. S., Manfredi, L., Swiderski, A., Cohen, B., & Merz, W. G. (2007). Isolation of Trichophyton violaceum and Trichophyton soudanense in Baltimore, Maryland. *Journal of Clinical Microbiology*, *45*(2), 461–465. https://doi.org/10.1128/JCM.02033-06

Michaels, B. D., & Del Rosso, J. Q. (2012). *Tinea capitis* in infants: recognition, evaluation, and management suggestions. *The Journal of Clinical and Aesthetic Dermatology*, *5*(2), 49–59.

Moraes, M. S., Godoy-Martínez, P., Alchorne, M. M. A., Boatto, H. F., & Fischman, O. (2006). Incidence of <Emphasis Type="Italic">*Tinea capitis*</Emphasis> in São Paulo, Brazil. *Mycopathologia*, *162*(2), 91–95. https://doi.org/10.1007/s11046-006-0031-z

Moto, J. N., Maingi, J. M., & Nyamache, A. K. (2015). Prevalence of *Tinea capitis* in school going children from Mathare, informal settlement in Nairobi, Kenya. *BMC Research Notes*, *8*, 274. https://doi.org/10.1186/s13104-015-1240-7

Narang, K., Pahwa, M., & Ramesh, V. (2012). *Tinea capitis* in the form of Concentric Rings in an HIV Positive Adult on Antiretroviral Treatment. *Indian Journal of Dermatology*, *57*(4), 288–290. https://doi.org/10.4103/0019-5154.97672

Ndetei, C. J., Opere, A. O., & Mutua, F. M. (). Flood frequency analysis in Lake Victoria basin based on tail behaviour of distributions. 10.

Nweze, E. I., & Eke, I. E. (2017). Dermatophytes and dermatophytosis in the eastern and southern parts of Africa. *Medical Mycology*. https://doi.org/10.1093/mmy/myx025

Ogola, F. O. (2010). *Free education in Kenya's public primary schools: addressing the challenges*. Addis Ababa: Organisation for Social Science Research in Eastern and Southern Africa.

Oke, O. O., Onayemi, O., Olasode, O. A., Omisore, A. G., & Oninla, O. A. (2014). The Prevalence and Pattern of Superficial Fungal Infections among School Children in Ile-Ife, South-Western Nigeria [Research article]. https://doi.org/10.1155/2014/842917

Olutoyin, O. O., Onayemi, O., & Gabriel, A. O. (2017). Risk factors associated with acquiring superficial fungal infections in school children in South Western Nigeria: a comparative study. *African Health Sciences*, *17*(2), 330–336. https://doi.org/10.4314/ahs.v17i2.6

Oyeka, C. A. (1990). *Tinea capitis* in Awka local government area of Anambra State. *West African Journal of Medicine*, *9*(2), 120–123.

Pai, V. V., Hanumanthayya, K., Tophakhane, R. S., Nandihal, N. W., & Kikkeri, N. S. N. (2013). Clinical study of *Tinea capitis* in Northern Karnataka: A three-year experience at a single institute. *Indian Dermatology Online Journal*, *4*(1), 22–26. https://doi.org/10.4103/2229-5178.105461

Philpot, C. M. (1978). Geographical distribution of the dermatophytes: a review. *The Journal of Hygiene*, *80*(2), 301–313.

Pomeranz, A. J., Sabnis, S. S., McGrath, G. J., & Esterly, N. B. (1999). Asymptomatic dermatophyte carriers in the households of children with *Tinea capitis*. *Archives of Pediatrics & Adolescent Medicine*, *153*(5), 483–486.

Pourhoseingholi, M. A., Vahedi, M., & Rahimzadeh, M. (2013). Sample size calculation in medical studies. *Gastroenterology and Hepatology From Bed to Bench*, *6*(1), 14–17.

Rijal, N. (2015, July 5). Sabouraud Dextrose Agar (SDA): Principle, composition, uses and colony morphology. Retrieved May 22, 2019, from Microbeonline website: https://microbeonline.com/sabouraud-dextrose-agar-sda-principle-composition-uses-colony-morphology/

Schmeller, W., Baumgartner, S., & Dzikus, A. (1997). Dermatophytomycoses in children in rural Kenya: The impact of primary health care. *Mycoses*, *40*, 55–63. https://doi.org/10.1111/j.1439-0507.1997.tb00171.x

Soyinka, F. (1978). Epidemiologic study of dermatophyte infections in Nigeria (clinical survey and laboratory investigations). *Mycopathologia*, *63*(2), 99–103. https://doi.org/10.1007/BF00441255

Sun, P.-L., Lin, Y.-C., Wu, Y.-H., Kao, P.-H., Ju, Y.-M., & Fan, Y.-C. (2017). Tinea folliculorum complicating tinea of the glabrous skin: an important yet neglected entity. *Medical Mycology*. https://doi.org/10.1093/mmy/myx086

Tainwala, R., & Sharma, Y. (2011). PATHOGENESIS OF DERMATOPHYTOSES. *Indian Journal of Dermatology*, *56*(3), 259–261. https://doi.org/10.4103/0019-5154.82476

Terragni, L., Lasagni, A., Oriani, A., & Gelmetti, C. (1991). Pityriasis versicolor in the pediatric age. *Pediatric Dermatology*, *8*(1), 9–12.

Timen, A., Bovée, L., Leentvaar-Kuijpers, A., Peerbooms, P. G., & Coutinho, R. A. (1999). [*Tinea capitis* in primary school age children in southeastern Amsterdam: primarily due to Trichophyton tonsurans]. *Nederlands Tijdschrift Voor Geneeskunde*, *143*(1), 24–27.

Woldeamanuel, Y., Leekassa, R., Chryssanthou, E., Menghistu, Y., & Petrini, B. (2005). Prevalence of *Tinea capitis* in Ethiopian schoolchildren. *Mycoses*, *48*(2), 137–141. https://doi.org/10.1111/j.1439-0507.2004.01081.x

APPENDICES

Appendix 1 Informed Consent by parent/guardian of the participants.

(**English Version**)

Consent by---------- of ---------- Primary School.

Title of Research: Fungal *Tinea capitis* and Associated Risk Factor in School going Children Aged 3-14 years in Kakamega Central sub- County

Researcher: Ronald Wamalwa, Masters student, Maseno University

Purpose of the Study

You (parent/guardian of the child participating in the study) are being asked to allow your children to participate in this research entitled above. For them to be able to decide whether to participate in this project, they should understand what the project is about, as well as the possible risks and benefits in order to make an informed decision. This process is known as informed consent. This describes the purpose, procedures, possible benefits, and risks. It also explains how their personal information will be used and protected. Once you have read this form and your questions about the study are answered, you will be asked to sign it. This will allow your children to participation in this study.

Explanation of the study

Tinea capitis is a dermatological disease of the scalp that has caused a lot of psychosocial trauma to primary school going children in Kakamega Central Sub-County. This is due to attached social stigma like, ulceration and irritation around the infected area that hampers pupil's concentration in class.

The results of this study can help County government of Kakamega, to plan on how to curb the risk factors and hygiene practices associated with *Tinea capitis* infection in Kakamega Central Sub-County.

Risks and Benefits

There is minimal discomfort felt when collecting the sample from the affected area of the scalp of the participant when scraping is being done. However it is a bearable process. Once the sample is collected, the participants will each be given a tube of anti-fungal ointment for application at the infected area under the guidance of a Pharmaceutical Technologist.

Confidentiality

The information we get from your children is purposely for research and will not be relayed to anybody. We will keep the confidentiality of every participant by use of serial numbers on the questionnaire. Names will not be used at any point and is of no purpose for this study

Contact Information

If you have any questions regarding this study, please contact Ronald Wamalwa, on phone number 0720469159 or the Secretary MUERC , P.O BOX Private Bag-40105, Maseno, Kenya. Telephone number: +254 057 622, Fax: +254 057 221.

Declaration

Having read and understood the purpose of the study, on behalf of my child, I willingly allow Mr. Ronald Wamalwa to collect samples from my child.

Name---------- Signature ---------- Date----------

Appendix 2 Kibali kilichofahamishwa na mzazi / mlezi wa washiriki.

(Toleo la Kiswahili)

Ruhusa kwa ---------- ya ---------- Shule ya Msingi

Kichwa cha Utafiti**:** Ugomjwa wa mashiling (TC) na Mambo yanayohusiana na Hatari yake katika Shule kwenda Watoto wenye umri wa miaka 3-14 katika kaunti ndogo ya Kakamega Kati

Mtafiti: Ronald Wamalwa , Mwanafunzi wa masters, Chuo kikuu cha Maseno University

Kusudi la Utafiti:

Wewe (mzazi / mlezi wa mtoto anayeshiriki katika utafiti) wanaombwa kuruhusu watoto wako kushiriki katika utafiti huu ulio juu hapo. Kwao kuwa na uwezo wa kuamua kama kushiriki katika mradi huu, wanapaswa kuelewa ni nini mradi huo unahusu,. amoja na uwezekano wa hatari na faida ili kufanya uamuzi sahihi. Utaratibu huu unajulikana kama kibali cha habari. Hii inaelezea kusudi, taratibu, faida iwezekanavyo, na hatari. Pia inafafanua jinsi maelezo yao ya kibinafsi yatatumika na kulindwa. Mara baada ya kusoma fomu hii na maswali yako kuhusu utafiti yanaswaliwa, utaulizwa kuisaini. Hii itawawezesha watoto wako kushiriki katika utafiti huu.

Maelezo ya utafiti

Ugonjwa mashiliiingi ni ugonjwa wa ngozi wa kichwa unaosababisha maumivu mengi ya kisaikolojia kwa watoto wa shule ya msingi kwa kaunti ndogo ya Kakamega ya kati. Hii ni kutokana na unyanyapaa wa kijamii kama vile, ulceration na hasira karibu na eneo la kuambukizwa ambalo huzuia mkusanyiko wa wanafunzi katika darasa. Matokeo ya utafiti huu

yanaweza kusaidia serikali ya kata ya Kakamega, kupanga jinsi ya kukabiliana na sababu za hatari na usafi unaohusishwa na maambukizi ya *Tinea capitis* katika kata ndogo ya Kakamega.

Hatari na Faida:

Kuna usumbufu mdogo waliona wakati wa kukusanya sampuli kutoka eneo lililoathiriwa la kamba la mshiriki wakati uchunguzi unafanyika. Hata hivyo ni mchakato wa kubeba. Mara sampuli itakusanywa, washiriki watapewa kila mmoja tube la mafuta ya kupambana na vimelea kwa ajili ya matumizi katika eneo la kuambukizwa chini ya uongozi wa Teknolojia ya Madawa.

Usiri:

Taarifa tunayopata kutoka kwa watoto wako ni kwa makusudi ya utafiti na haitatumiwa kwa mtu yeyote. Tutaweka siri ya kila mshiriki kwa kutumia namba za serial kwenye swali la maswali. Majina hayatatumiwa wakati wowote na hayana madhumuni ya utafiti huu.

Maelezo ya Mawasiliano:

Ikiwa una maswali yoyote kuhusu utafiti huu, tafadhali wasiliana na Ronald Wamalwa, kwenye namba ya simu 0720469159 au Katibu MUERC, sanduku la posta la kibinafsi -40105, Maseno, Kenya.

Nambari ya simu : +254 057 622, Fax: +254 057 221.

Azimio:

Baada ya kusoma na kuelewa madhumuni ya utafiti, kwa niaba ya mtoto wangu, mimi kwa hiari kuruhusu Mheshimiwa Ronald Wamalwa kukusanya sampuli kutoka kwa mtoto wangu.

Jina ---------- ---- Saini ---------- Tarehe ----------

Appendix 3 Informed Assent for the participants.

Title of Research: Fungal *Tinea capitis* and Associated Risk Factor in School going Children Aged 3-14 years in Kakamega Central sub- County

Researcher: Ronald Wamalwa, Masters Candidate, Maseno University

Purpose of the Study

You are being asked to participate in this research entitled above. For you to be able to decide whether to participate in this project, you should understand what the project is about, as well as the possible risks and benefits in order to make an informed decision. This describes the purpose, procedures, possible benefits, and risks. It also explains how your personal information will be used and protected. Once you have read this form and your questions about the study are answered, you will be asked to sign it. This will allow you to participate in this study.

Explanation of the study

Tinea capitis is a dermatological disease of the scalp that has caused a lot of psychosocial trauma to primary school going children in Kakamega Central Sub-County. This is due to attached social stigma like, ulceration and irritation around the infected area that hampers pupil's concentration in class.

The results of this study can help County government of Kakamega, to plan on how to curb the risk factors and hygiene practices associated with *Tinea capitis* infection in Kakamega Central Sub-County

Risks and Benefits

There is minimal discomfort you will feel when the sample will be collected by scrapping gently from the affected area of the scalp. However it is a bearable process. Once the sample is

collected, you will be given a tube of anti-fungal ointment for application at the infected area under the guidance of a Pharmaceutical Technologist.

Confidentiality

The information we get from your children is purposely for research and will not be relayed to anybody. We will keep the confidentiality of every participant by use of serial numbers on the questionnaire. Names will not be used at any point and is of no purpose for this study

Contact Information

If you have any questions regarding this study, please contact Ronald Wamalwa, on phone number 0720469159 or the Secretary MUERC , P.O BOX Private Bag-40105, Maseno, Kenya. Telephone number: +254 057 622, Fax: +254 057 221.

Declaration

Having read and understood the purpose of the study, I willingly accept to participate in the study

Signature …….. Date ……

Appendix 4 Results for Pre-test of Socio demographic and anthropometric characteristics of children and care givers participating in the study:

Variable	Category	Participants interviewed (n=40)
Gender	Male	24 (60)
	Female	16 (40)
Age	3-8 yrs.	21 (52.5)
	9-11 yrs.	11 (27.5)
	12-14 yrs.	8 (20)
Weight, kg	-	18.5
Height, cm	-	55.0
Religion	Christian	35 (87.5)
	Muslim	5 (12.5)
Ethnicity	Luhya	10 (25)
	Kalenjin	4 (10)
	Luo	24 (60)
	Teso	0 (0)
	Other Bantus	2 (5)
Age of caregiver	20-35 yrs.	26 (65)
	36-45 yrs.	14 (35)
	>45 yrs.	0 (0)
Age of mother when giving birth to the child	<20 yrs.	7 (17.5)
	20-30 yrs.	19 (47.5)
	>30 yrs.	14 (35)
Birth order of the child	≤2	27 (67.5)
	>2	13 (32.5)
Marital status of caregiver	Married	23 (57.5)
	Divorced	5 (12.5)
	Widowed	7 (17.5)
	Unmarried	5 (12.5)
Education level of caregiver	Primary	8 (20)
	Secondary	17 (42.5)
	College and above	15 (37.5)
Income of the caregiver	<5000Kshs	13 (32.5)
	5000-29999Kshs	18 (45)
	>30000Kshs	9 (22.5)
Occupation of the caregiver	Employed	10 (25)
	Self-employed	16 (40)
	Peasant farmer	9 (22.5)
	Unemployed	5 (12.5)
Meal frequency	≤3	15 (37.5)

per day	>3	25 (62.5)
Type of house floor	Cemented/Tile	16 (40)
	Soil/Mud	24 (60)
Source of energy for cooking	Electricity	5 (12.5)
	Gas	10 (25)
	Wood/Kerosene	25 (62.5)
Number of baths per week	Daily	12 (30)
	≥3	21 (52.5)
	≤2	7 (17.5)
Sharing bed	Yes	21 (52.5)
	No	19 (47.5)
Sharing clothing	Yes	17 (42.5)
	No	23 (57.5)
Occupants in a bedroom	1	10 (25)
	2	14 (35)
	>2	16 (40)
Sharing combs	Yes	28 (70)
	No	12 (30)

Data are presented as numbers (percentage) or as median (IQR).

Appendix 5 Semi structured Questionnaire (English version)

Socio-demographic information for school children in ---------- primary school participating in the study.

Semi structured Questionnaire for the Study on socio-demographic information for school going children between ages 3 years to 14 years in Kakamega Sub-County was used.

Participant Study Number:

Tick all answers of respondent (let her/him respond to the question).

1. Date of Birth: (dd/mm/yyyy) ☐☐☐☐☐☐☐☐

2. Sex: Male ☐ Female ☐

3. Religion: Muslim ☐ Catholic ☐ Anglican ☐

SDA ☐ Others *(specify*) ☐

4 .a) Weight in Kg ☐ b) Height in Cm ☐

5. Children's Level of Education: Nursery to class 3 ☐ 4-6 ☐ 7-8 ☐

6. Birth order of the child ≤ 2 ☐ ≥ 2 ☐

7. Does the child have clinical presentation of *Tinea capitis*? Yes ☐ No ☐

8. If yes for 5 above, has child ever been treated on the same disease before? Yes ☐ No ☐

9. Meal frequency per day**: ≤ 3** ☐ **>3** ☐

10. Number of baths per week: Daily ☐ ≥3 ☐ ≤2 ☐

11. Sharing of bed: Yes ☐ No ☐

12. Sharing clothing: Yes ☐ No ☐

13. Sharing combs: Yes ☐ No ☐

14. Occupants in a bed room: One ☐ two ☐ more than two ☐

Socio-demographic information for parents/care giver participating in the study.

1. Age of the parent/caregiver 20-35yrs ☐ 36-45yrs ☐ >45yrs ☐

2. Age of the mother when giving birth < 20yrs ☐ 20-30yrs ☐ <30yrs ☐

3. Marital Status: Married ☐ Widowed ☐ Divorced ☐ unmarried ☐

4. How many children are in primary schools? ☐

5. Approximate monthly income of parents? < 5000 KShs ☐ 5000-29999 KShs ☐

> 30,000 KShs ☐

6. Education level of caregiver: Primary ☐ Secondary ☐ College & above ☐

7. Occupation of caregiver: employed ☐ self employed ☐ peasant farmer ☐

Unemployed ☐

8. Type of house floor: Cement/Tile ☐ Soil/mud ☐

9. Source of energy for cooking: Electricity ☐ Gas ☐ Woo/Kerosene ☐

Thank you for your participation.

Appendix 6 Hojaji funge. (Toleo la Kiswahili)

Habari ya wanafunzi wa shule ya musingi ya---------- waliyo shiriki kwa utafiti

Hojaji funge kutafuta tarifa ya kijamii na idadi ya watu kwa wanafunzi wa shule ya musingi ambao wako kati ya umri wa mwaka 3 hadi 14 kwa kaunti ndogo ya Kakamega Central.

Namba ya mushiriki ……..

1. Tarehe ya kuzaliwa: (siku/mwezi/waka) ☐☐☐☐☐☐☐☐

2. Jinsia: Kiume ☐ Kike ☐

3. Dini: Muisilamu ☐ Mukatoliki ☐ Muangilikan ☐

SDA ☐ ingine*(Taja)* ☐

4. a) Uzito kwa kilo ☐ b) Urefu kwa Sentimita ☐

5. Kiwango cha masomo cha wanafunzi: Chekechea hadi darasa la 3 ☐ 4-6 ☐ 7-8 ☐

6. Mtoto wangapi kwa familia ≤ 2 ☐ ☐ ≥ 2

7. Je, wanafunzi ako na dalili ya ungojwa wa mashilingi (TC)? Ndio ☐ La ☐

8. Kama ndio kwa namba 5 hapo juu, je mwanafunzi, amewai tibiwa ? Ndio ☐ La ☐

9. Mzunguko wa chakula kwa siku**: ≤ 3** ☐ **>3** ☐

10. Uoga mara ngapi kwa wiki? Kila siku ☐ **>3** ☐ **≤2** ☐

11. kugawana kitanda Ndio ☐ La ☐

12. Kushirikiana nguo Ndio ☐ La ☐

13. Kushirikiana Vichana: Ndio ☐ La ☐

14. Idadi ya watoto wanao lala chumba kimoja: Mmoja ☐ wawili ☐ zaidi ya wawili ☐

Maelezo ya jamii na idadi ya watu kwa ajili ya wazazi / mlezi mshiriki katika utafiti.

1. Umri wa mzazi / mlezi 20-35yrs ☐ 36-45yrs ☐ >45yrs ☐

2. Umri wa mama wakati wa kuzaa < 20yrs ☐ 20-30yrs ☐ <30yrs ☐

3. Hali ya ndoa: Alioa ☐ mjane ☐ Talaka ☐ Wasiooa ☐

4. Ni watoto wangapi katika shule za msingi? ☐

5. Mapato ya kila mwezi ya wazazi < 5000 KShs ☐ 5000-29999 KShs ☐

> 30,000 KShs ☐

6. Ngazi ya elimu ya mlez i: Msingi ☐ Upili ☐ chuo na juu ☐

7. Kazi ya mlezi: Walioajiriwa ☐ kazi binafsi ☐ mukulima ☐ Vasio na kazi ☐

8. Aina ya sakafu ya nyumba: Saruji/Tile ☐ udongo / matope ☐

9. chanzo cha nishati kwa kupikia: Umeme ☐ gesi ☐ kuni/mafuta taa ☐

Asante kwa ushiriki wako.

Appendix 7 Ethical approval letter

MASENO UNIVERSITY ETHICS REVIEW COMMITTEE

Tel: +254 057 351 622 Ext: 3050
Fax: +254 057 351 221
Private Bag – 40105, Maseno, Kenya
Email: muerc-secretariate@maseno.ac.ke

FROM: Secretary - MUERC

DATE: 19th November, 2015

TO: Ronald Wamalwa
PG/MSc/00038/2013
Department of Biomedical Science
School of Public Health and Community Development, Maseno University
P. O. Box, Private Bag, Maseno, Kenya

REF: MSU/DRPI/MUERC/00199/15

RE: Determination of Prevalence and Fungal Species causing *Tinea Capitis* in Primary School Going Children Aged 3-14 Years in Kakamega Central Sub County. Proposal Reference Number MSU/DRPI/MUERC/00199/15

This is to inform you that the Maseno University Ethics Review Committee (MUERC) determined that the ethics issues raised at the initial review were adequately addressed in the revised proposal. Consequently, the study is granted approval for implementation effective this 19th day of November, 2015 for a period of one (1) year.

Please note that authorization to conduct this study will automatically expire on 18th November, 2016. If you plan to continue with the study beyond this date, please submit an application for continuation approval to the MUERC Secretariat by 19th October, 2016.

Approval for continuation of the study will be subject to successful submission of an annual progress report that is to reach the MUERC Secretariat by 19th October, 2016.

Please note that any unanticipated problems resulting from the conduct of this study must be reported to MUERC. You are required to submit any proposed changes to this study to MUERC for review and approval prior to initiation. Please advice MUERC when the study is completed or discontinued.

Thank you.

Yours faithfully,

DIRECTORATE OF RESEARCH PUBLICATION & CONSULTANCIES 19 NOV 2015 MASENO UNIVERSITY

Dr. Bonuke Anyona,
Secretary,
Maseno University Ethics Review Committee.

Cc: Chairman,
Maseno University Ethics Review Committee.

MASENO UNIVERSITY IS ISO 9001:2008 CERTIFIED

Appendix 8 Permission letter by Headmaster Mwiyala Primary School

REPUBLIC OF KENYA
MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

The Headmaster,
Mwiyala Primary School,
P.O. Box
Kakamega

Dear Wamalwa,

RE: Permission letter

Following your request to collect samples from children in our school so as to carry a study on fungal agents causing tinea capitis and associated risk factor in school going children aged 3-14 years in Kakamega Central sub-County. We have read and understood the purpose of the study, on behalf of board of management. I hereby allow Mr. Ronald Wamalwa to carry our research in my School by collecting samples from the school children.

Yours faithfully

Appendix 9 Permission letter by Headmaster Mahiakalo Primary School

REPUBLIC OF KENYA
MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

The Headmaster,
Mahiakalo Primary School,
P.O. Box
Kakamega

Dear Ronald,

RE: Permission to carry out research

This is to inform you that following our deliberations with the board of management of Mahiakalo Primary School. We are glad to let you know that you have been allowed to carry out your study **"Fungal agents causing tinea capitis and Associated Risk Factor in School going Children Aged 3-14 years in Kakamega Central sub-County."**

Feel free to ask for any assistance.

Yours faithfully

Appendix 10 Permission letter by Headmaster Elukho Primary School

REPUBLIC OF KENYA
MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

The Headmaster,
Elukho Primary School,
P.O. Box
Kakamega

Dear Wamalwa,

RE: Permission

Your request to carry out a research on our pupils titled "**Fungal agents causing tinea capitis and Associated Risk Factor in School going Children Aged 3-14 years in Kakamega Central sub-County"** has been granted.

Yours sincerely

Mr. Benson Walekhwa
Headmaster Elukho Primary School

Appendix 11 Permission letter by Headmaster Emusala Primary School

REPUBLIC OF KENYA
MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

The Headmaster,
Emusala Primary School,
P.O. Box
Kakamega

Dear Wamalwa,

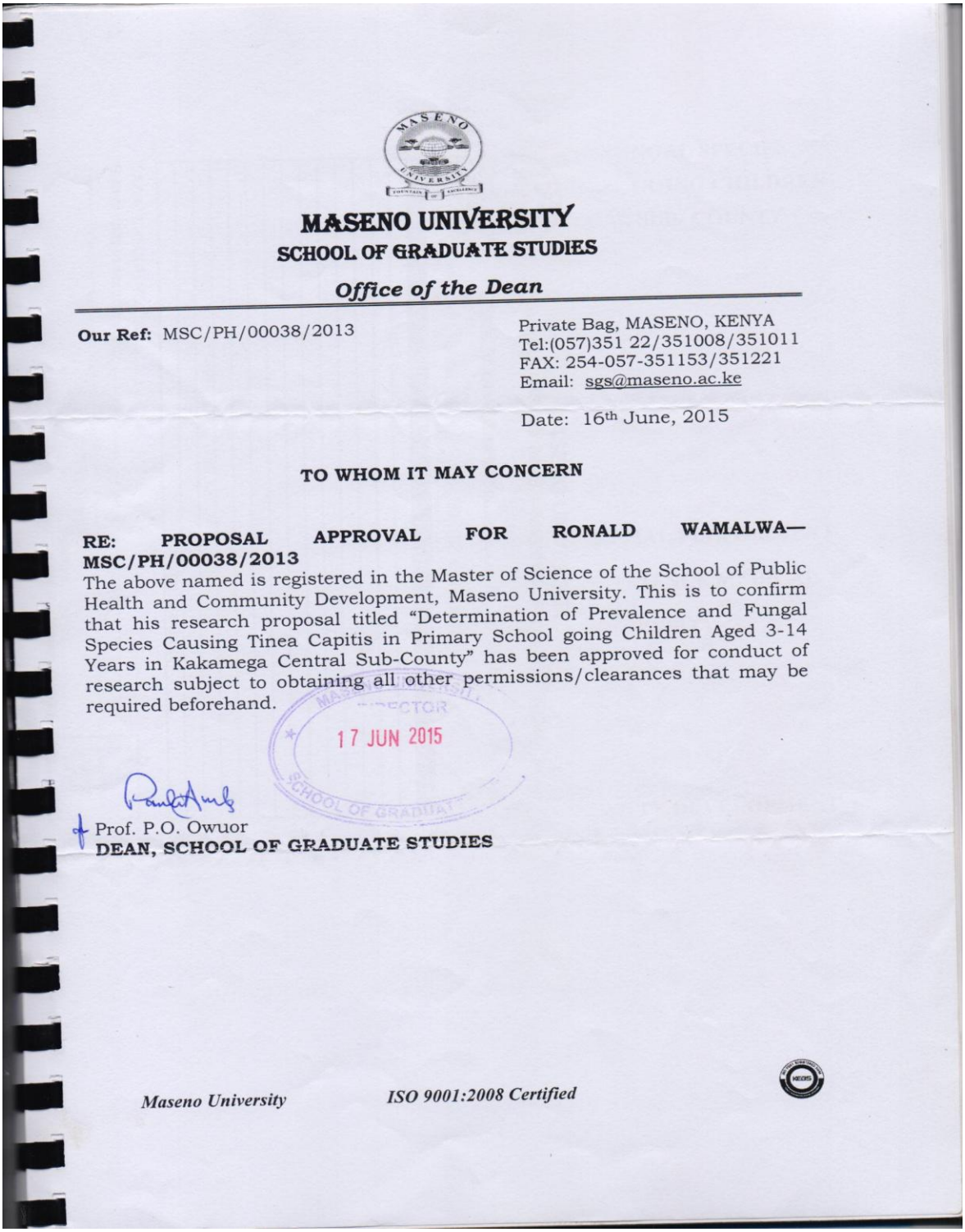
RE: Permission

The board of management of Emusala Primary School wishes to inform you that you have been permitted to carry out your research on our pupils. Kindly make the necessary arrangements with parents of the selected students to sign the consent forms.

Yours sincerely,

Mr. John Nasianda

Appendix 12 SGS proposal approval letter



MASENO UNIVERSITY
SCHOOL OF GRADUATE STUDIES
Office of the Dean

Our Ref: MSC/PH/00038/2013

Private Bag, MASENO, KENYA
Tel:(057)351 22/351008/351011
FAX: 254-057-351153/351221
Email: sgs@maseno.ac.ke

Date: 16th June, 2015

TO WHOM IT MAY CONCERN

RE: PROPOSAL APPROVAL FOR RONALD WAMALWA— MSC/PH/00038/2013

The above named is registered in the Master of Science of the School of Public Health and Community Development, Maseno University. This is to confirm that his research proposal titled "Determination of Prevalence and Fungal Species Causing Tinea Capitis in Primary School going Children Aged 3-14 Years in Kakamega Central Sub-County" has been approved for conduct of research subject to obtaining all other permissions/clearances that may be required beforehand.

17 JUN 2015

Prof. P.O. Owuor
DEAN, SCHOOL OF GRADUATE STUDIES

Maseno University *ISO 9001:2008 Certified*