

**PREVALENCE OF *Trichophyton*, *Microsporum* AND *Epidermophyton* SPECIES
CAUSING *Tinea capitis* IN CHILDREN AGED 3-14 YEARS IN MATHARE
INFORMAL SETTLEMENT, NAIROBI, KENYA**

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DECLARATION

This is my original work and has not been presented for a degree or any other award in any other university or any other institution of higher learning.

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DEDICATION

To the Lord my God, I give the sacrifice of thanks giving. To my beloved husband Mr. Patrick Mulandi, I thank you for your love, moral support, constant encouragement and financial assistance to make this dream come true of pursuing a higher education. To our children Mark Musyoka and Blessing Mutheu who in your tender age needed your mother's love and care and yet very patiently waited for the entire months that I was away from home.

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ABBREVIATIONS AND ACRONYMS

AC	Asymptomatic carrier
APHRC	African Population and Health Research Center
DMSO	Dimethyl Sulfoxide
FDA	Food and Drug Administration
HCP	Health Care Providers
HPA	Health Protection Agency
KOH	Potassium Hydroxide
SPSS	Statistical Package for Social Sciences
TC	<i>Tinea capitis</i>
WHO	World Health Organization

ABSTRACT

Tinea capitis is a worldwide public health problem that affects children below 15 years of age and requires identification of the specific causative fungal agent. The hair and skin of the scalp are associated with symptoms and signs of inflammation and hair loss. Poor hygiene, low standards of living, sharing of hair devices or garment, climate conditions and overcrowding are some of the predisposing factors contributing to frequent transmission of the infection. Several previous studies have concentrated on symptomatic cases of *Tinea capitis* infection with limited studies in Kenya. However, no such study has been done in Mathare informal settlement despite the existence of predisposing factors such as low standards of living of the people in the area. This study therefore aimed at determining the prevalence of *Tinea capitis* infection and its significant risk factors in Mathare informal settlement in both symptomatic and asymptomatic cases. The study also aimed at determining the prevalence of *Trichophyton*, *Epidermophyton* and *Microsporum* species causing *Tinea capitis* infection among school going children in Mathare informal settlement, Nairobi. A total of 150 children were systematically and randomly sampled from five public primary schools in Mathare informal settlement. Skin scrapings specimens were collected and inoculated on potato dextrose agar. Fungal cultural characteristics were observed macroscopically (pigmentation formation), microscopically (microconidia or macroconidia formation) and *Trichophyton* species differentiated by use of biochemical tests. In addition, a structural questionnaire was administered to consenting children's guardians and socio-demographic data collected. In a total of one hundred and fifty (150) children aged between 3-14 years consisting of 89 (59.3 %) males and 61 (40.7 %) females, 123 (82 %) were infected with *Tinea capitis*. The dermatophytes consisted of 61.3 % *Trichophyton*, 13.3 % *Microsporum* and 7.3 % *Epidermophyton* with infections occurring either singly (56 %), duo (38 %) or tripple coinfections (6 %). Males were most affected with socio-economic factors such as employment status of the parents and monthly income levels of the family significantly influencing infections ($p < 0.001$). Other factors that significantly influenced the infection include; knowledge on ways of transmission of *Tinea capitis* ($p < 0.001$), sharing of combs and towels ($p < 0.001$), place of hair shaving ($p = 0.037$) and frequency of hair shaving ($p = 0.02$). The prevalence of the infection was higher in lower age groups than the upper age group of 12-14 years. These findings suggest that prevalence of *Tinea capitis* infection in the informal settlement of Nairobi is high. There is therefore a need to improve personal and community hygiene including the economic status of people living in the informal settlement.

CHAPTER ONE

INTRODUCTION

1.1 Background

Tinea capitis is a disease caused by cutaneous infection of the scalp, eye lashes and eye brows. Several synonyms are used to describe the infection, including ringworm of the scalp and *Tinea tonsurans*. It is caused by dermatophyte species of genera *Trichophyton* and *Microsporum*. The most important causative agents are species which cause an endothrix infection, such as *Trichophyton gourvilli*, *Trichophyton soudanense*, *Trichophyton tonsurans*, *Trichophyton violaceum* and *Trichophyton yaoundei* and species that cause an ectothrix infection such as *Microsporum audouinii*, *Microsporum canis* and *Microsporum gypseum* (Ngwogu *et al.*, 2007). Infections with *Epidermophyton floccosum*, the only species of *epidermophyton* that is pathogenic on man, usually occur on the skin of the torso, limbs, soles of feet or palms of hands and nails, but rarely does it invade the hair (Summerbell *et al.*, 2007). However, a recent study from Brazil suggests that *E. floccosum* may be a possible etiological agent of *Tinea capitis* (Cerqueira *et al.*, 2005).

It is predominantly a disease of preadolescent children. It accounts for up to 92.5 % of dermatophytoses in children younger than 10 years. *Tinea capitis* also occurs in adults, although this is less common (Silverberg *et al.*, 2002; Abdel-Rahman *et al.*, 2005). *Tinea capitis* is considered to be almost exclusive to children and rarely occurs after puberty, probably due to changes in the pH of the scalp and an increase in fatty acids serving a protective role. Consequently, most cases occurring in adults involve women with

hormonal disorders resulting in carryover of *Tinea capitis* from childhood or in patients with severe immunodepression due to leukemia, lymphoma, or treatment with immunosuppressant drugs (Rebollo *et al.*, 2008).

Dermatophytes are considered as group of closely related filamentous keratinophilic fungi belonging to the genera *Trichophyton*, *Epidermophyton* and *Microsporum*. While the genus *Epidermophyton* is represented by a single species (*E. floccosum*), the genera *Microsporum* and *Trichophyton* are complex and consist of many species (Liu *et al.*, 2000). Worldwide, they are among the most common infectious agents for human (Yehia *et al.*, 2010) and prevalence of infections caused by them has dramatically risen to such a level in the last decades that skin mycoses now affect more than 20–25 % of the world's population, which make them one of the most frequent forms of infections (Neji *et al.*, 2008). The distribution of dermatophytes varies among different countries and exhibits geographical and seasonal variations depending on several factors, including life style, type of the population, migration of people and climatic conditions (Asticcioli *et al.*, 2008).

The primary host of *Epidermophyton floccosum*, is man (Larone, 2002). *E. floccosum* is widespread in most countries of the world, accounting for 5 % of all dermatophytes isolated (Summerbell *et al.*, 2007). It is an anthropophilic dermatophyte that is transmitted between individuals by contact, particularly in community swimming pool areas, common showers, and gym facilities (Summerbell *et al.*, 2007).

Tinea capitis infections are classified into three major groups: anthropophilic, zoophilic, and geophilic (H P A, 2007). The anthropophilic infections are parasitic on humans and usually form larger hyphae and spores inside the hair shaft while in zoophilic infections, they are smaller with spores outside the hair shaft. However, in geophilic infections, they are identified by location (H P A, 2007). In immunocompetent individuals, anthropophilic species cause mild lesions with minimal inflammation, but geophilic and zoophilic species may result in extensive lesions secondary to inflammation, leading to abscesses and pustules (Krajewska-Kulak *et al.*, 2003).

Tinea capitis is further divided in terms of invasion of the hair shaft; endothrix and ectothrix. In endothrix, the hair shaft is filled with hyphae and spores. Some causes of endothrix infection are *Trichophyton tonsurans* and *Trichophyton schoenleinii* species (Sarabi, 2008). In the ectothrix types, the hyphae and spores cover the outside of the hair, which results in the destruction of the cuticle. All of the *Microsporum* species and *Trichophyton verrucosum* are involved. *Microsporum* infections (*Microsporum canis*) cause a "gray patch" *Tinea capitis* (Kao, 2006). A very rare and severe form of *Tinea capitis* infection is favus, primarily caused by *T. schoenleinii*. This infection results in a honeycomb-type destruction of the hair follicle, giving the hair a yellowish color (Kao, 2006). Severe scaling of the scalp may result, and due to cuticle breakage, the hair may become brittle which is often seen on the patient (Habif, 2004).

Tinea capitis occurs predominantly in rural or sub urban areas and some of the factors associated with this increased frequency include poor personal hygiene, overcrowding, and low socioeconomic level (Rebollo *et al.*, 2008). These organisms are usually found as

fomites on items such as combs, hats, pillows, and theater seats, where the spores can live for long periods of time, contributing to spread of the disease (Arenas, 2002). Therefore, the prevalence rates of *Tinea capitis* in a particular area depends upon the environmental conditions, personal hygiene and individual susceptibility (Seema *et al.*, 2011).

The isolation of different species of dermatophytes also varies from one ecological niche to another, depending on their primary natural habitat (Seema *et al.*, 2011). Contact in schools is probably the most important independent factor affecting the rapid spread of *Tinea capitis*. Infection in children of school age is usually followed by infection of younger siblings. In addition, progressive migration and climate change, social and economic conditions that affect skin exposure to fungal pathogens, and therapeutic methods are also important (Szepietowski and Baran, 2005). Transmission is increased with decreased personal hygiene and low socioeconomic status. Asymptomatic carriers (AC) are common, making *Tinea capitis* difficult to eradicate (Kawachi *et al.*, 2010).

Anthropophilic dermatophytes such as *T. tonsurans*, *T. violaceum*, and *M. audouinii* have been associated with high rates of asymptomatic carriers (Ginter-Hanselmeyer *et al.*, 2007). These organisms generally produce mild signs of infection. Asymptomatic carriers at home or school are potentially important sources of disease transmission (Ginter-Hanslmeyer *et al.*, 2007). Other studies have determined that carrier rate may increase to as high as 44 % for the siblings of index cases (Chen and Friedlander, 2001). AC should therefore be detected and treated. Increased surveillance in schools would be helpful in prevention of the disease (Ginter-Hanselmeyer *et al.*, 2007). Previous studies have indicated; race, socio economic conditions, cultural patterns and public health measures

as some of the predisposing factors to the infections (Ayanbimpe *et al.*, 2003, Anosike *et al.*, 2005, Bassiri and Khaksar, 2006). The emergence of *T. tonsurans* infection in developed countries has been attributed to low socioeconomic status, crowded living conditions, and the sharing of combs (Fuller *et al.*, 2003).

Tinea capitis disease has been recognized as an important public health problem in the United States with 13 % of school children, especially those of African-American descent, testing positive for the dermatophytes (Ghannoum *et al.*, 2003). *Tinea capitis* has decreased in developed countries, while it presents a high prevalence in developing countries (Caputo *et al.*, 2001).

In Kenya, limited studies have been done on *Tinea capitis* infection. In a study done in school going children in Kibera informal settlement, Nairobi, the prevalence of dermatophyte infections was found to be 11.2 % with *Tinea capitis* infection being the most prevalent (Chepchirchir *et al.*, 2009). In the study *T. violaceum* was the most common with 72.9 % dermatophyte species isolated.

In other studies done in a rural school in Kisumu and an urban school in Eldoret in Kenya, the prevalence of *Tinea capitis* infection was found to be 10.1 % and 33.3 % respectively (Schmeller *et al.*, 1997, Ayaya *et al.*, 2001). *Trichophyton tonsurans* was the most prevalent (77.8 %) in Eldoret urban school (Ayaya *et al.*, 2001) while in Kisumu rural school, *Microsporum audouinii* was the most prevalent with 62 % of the dermatophyte species isolated (Schmeller *et al.*, 1997). Presence of healthy asymptomatic carriers is one of the greatest challenges in eradication of dermatophytosis and therefore

asymptomatic carriers should be identified and treated in order to prevent transmission of the infection.

1.2 Statement of the problem and justification

Tinea capitis causes hair loss, scaling, erythema, and impetigo-like lesions. It is the most common dermatophyte infection found in children under the age of 12 years (Sarabi, 2008). Most of dermatophyte infections of the hair (*Tinea capitis*) are caused by species of genera *Trichophyton* and *Microsporum* leading to itching and hair loss. These fungi are highly adapted to nonliving keratinized tissues of the hair (Kao, 2006). The source of infection may be humans, animals, or soil since various dermatophyte species have both ecologic and geographic differences in their occurrence.

Although no specific preventive measures like vaccine exist, dermatophyte infection can be prevented by observing simple general hygiene measures. Epidemiological studies of *Tinea capitis* have however demonstrated that poor hygiene, low standards of living, climate conditions and overcrowding are interrelated and all contribute to frequent transmission of the infection. *Tinea capitis* is a cause of concern because of its contagious nature and its cause of social stigma in children.

Contact among children is more frequent between the school ages of 4-14 years than in early childhood and therefore this age group is at greater risk of contracting infectious diseases (Fathi and Al-Samarai, 2000). For this reason conducting school surveys is the best way of measuring the magnitude of the problem in order to enable designing of

programmes to meet the needs of those mostly infected by *Tinea capitis* and also develop appropriate preventive and control measures.

There is inadequate information on the causative agent of *Tinea capitis* in Kenya (Ayaya *et al.*, 2001). Previous studies carried out in Kenyan primary school children in Eldoret, Kisumu and Kibera informal settlement considered only symptomatic cases of dermatophytosis. However, no such studies have been carried out in Mathare informal settlement despite the availability of predisposing factors of the infection such as low socio-economic levels of the people living in the area. Existence asymptomatic carriers among children may lead to high rates transmission of the infection making it difficult to be eradicated.

Identification of dermatological agents causing *Tinea capitis* in both symptomatic and asymptomatic individuals would therefore help in determining the actual prevalence rates of the infection in an area in order to reduce the risk of transmission of the infection. The causative agents of *Tinea capitis* infection in asymptomatic carriers can therefore be identified and treated to reduce its prevalence rates among the children. Isolation and identification of specific causative agent of *Tinea capitis* would help in the right choice of chemotherapy hence reducing the prevalence of the infection among children.

1.3 Research questions

- i) Are *Trichophyton*, *Microsporum* and *Epidermophyton* species present in all the hair samples collected from children in Mathare informal settlement, Nairobi?
- ii) Is there variation in prevalence of *Trichophyton*, *Microsporum* and *Epidermophyton* species isolated from the specimen collected?
- iii) Is there a relationship between the prevalence of *Tinea capitis* and the socio-economic background, age and gender of the children?

1.4 Research Hypotheses

- i) *Trichophyton*, *Microsporum* and *Epidermophyton* species are not present in most of the hair samples collected from children in Mathare informal settlement, Nairobi.
- ii) There is no significant difference between the prevalence of the isolates.
- iii) There is no significant relationship between the socio-economic background, age and gender and the prevalence of *Tinea capitis* in children aged between 3-14 years in Mathare informal settlement, Nairobi.

1.5 Objectives of the study

1.5.1 General objective

The prevalence of *Trichophyton*, *Microsporum* and *Epidermophyton* species causing *Tinea capitis* infection among children aged between 3-14 years in Mathare informal settlement, Nairobi.

1.5.2 Specific objectives

- i) To determine the prevalence of *Tinea* infection.
- ii) To determine the relationship between socio-economic back ground, age, and gender of children and the prevalence rates of *Tinea capitis* in Mathare informal settlement dwellers.
- iii) To isolate and identify dermatological agents causing *Tinea capitis* infection from hair samples collected from children in the age bracket of 3-14 years in Mathare informal settlement.

CHAPTER TWO

LITERATURE REVIEW

2.1 Etiology of *Tinea capitis*

The predominance of specific pathogens causing *Tinea capitis* varies with geography, environments, climates, occupations, ethnic groups and life styles. The dermatophytes that cause *Tinea capitis* can invade other parts of the body such as the nails and the body, but rarely the feet or groins. Children or adults who have neither signs nor symptoms of infection, but from whose scalps causative fungi can be grown are described as “carriers” (H P A, 2007).

The disease is caused by species of genera *Trichophyton* and *Microsporum* (Emele and Oyeka, 2008). The most important causative agents are species, which cause an endothrix infection, such as *Trichophyton gourvilli*, *Trichophyton soudanense*, *Trichophyton tonsurans*, *Trichophyton violaceum* and *Trichophyton yaoundei* and species that cause an ectothrix infection such as *Microsporum audouinii*, *Microsporum canis* and *Microsporum gypseum* (Ngwogu and Otokunefor, 2007). Ecto-endothrix invasion of the hair is often associated with *M. audouinii*, *M. canis*, *M. distortum*, *M. ferrugineum*, *M. gypseum*, *M. nanum*, and *T. verrucosum*. Some of these cause fluorescence under Wood light (Rebollo *et al.*, 2008).

The organism that commonly causes *Tinea capitis* in the Western world is *Trichophyton tonsurans* while there is inadequate information on the actual causative agent in Kenya (Ayaya *et al.*, 2001). In poor African countries, the most common causative organisms are

Trichophyton soudanense and *Microsporum audouinii* (Havlickova *et al.*, 2008). Infection by *M. audouinii* is of historical interest in many parts of the world because it was responsible for epidemics in Europe in the 19th century before arriving in the Americas and then finally almost disappearing 50 years ago (Arenas, 2008).

2.2 Clinical Manifestations

TC has three clinical forms: TC superficial (non-inflammatory), TC profunda (inflammatory) and TC favosa (favus). Inflammatory TC presents with painful, inflammatory, indurated, and postulated mass that can be accompanied by regional lymphadenopathy (Aktas *et al.*, 2009). Massive follicular destruction and big nodules presenting with pustule and sinus tractions can rarely occur. This acute inflammatory nodule is called kerion celci which occur as a result of intense hypersensitivity reaction to dermatophyte infections (Aktas *et al.*, 2009). If the zoophilic dermatophytes are the causative agent, pustules and deep indurations can occur (Corting, 2009).

The clinical presentation of TC is determined by the form of invasion of the hair by the pathogenic fungi (ectothrix or endothrix), the size of the inoculum, and the immune status of the host (Rebollo *et al.*, 2008). A wide variety of presentations have been described, ranging from asymptomatic carriers, diffuse scaling similar to seborrheic dermatitis, areas of alopecia without inflammation, alopecia with black dots, and if the causative agent is zoophilic or geophilic, a variable inflammatory response is triggered in the host and is clinically manifested as folliculitis or kerion (Rebollo *et al.*, 2008) . It is also common to

encounter enlargement of the auricular and posterior occipital lymph nodes, and this can be the primary manifestation of the disease (Elewski, 2000).

Genetic immunological predispositions and also genetic differences of keratins affect the ability of a fungus to attach to the stratum corneum (Joshi *et al.*, 2011). Dermatophytes have the ability to form molecular attachments to keratin and use it as a source of nutrients allowing them to colonize keratinized tissues, including the stratum corneum of the epidermis, hair, nails (Kemal *et al.*, 2013). Resistance factors to the colonization of fungi are composed of UV light, variation in temperature and moisture, and fungistatic fatty acids and sphingosines produced by keratinocytes (Kemal *et al.*, 2013).

2.3 Transmission of *Tinea capitis*

The etiologic agents originate from different sources based on host preference and natural habitat. The natural reservoir of dermatophytes can be humans (anthropophilic dermatophytes), animals (zoophilic dermatophytes), or soil (geophilic dermatophytes) (Adamski and Batura-Gabryel, 2007).

Transmission requires contact with intact or detached hair. Human-to-human transmission usually requires close contact with infected subject or person because dermatophytes are of low infectivity and virulence. In most cases transmission takes place within families or in situations involving direct contact with detached hair; for example in barber shops.

The source of infection of zoophilic dermatophytes in children and adults are mostly domestic animals – cats, dogs, hamsters, guinea pigs, rabbits or even some birds. Farmers also often suffer from dermatomycoses transmitted from breeding cattle, pigs, sheep, horses and goats (Adamski and Batura-Gabryel 2007). Infection with geophilic dermatophytes usually happens as a result of contact with soil and it is common among people who cultivate the soil (gardeners, farmers) (Kalinowska, 2012). The disease more often affects males than females working without protective gloves and unsuitable hygiene is conducive for transmission of pathogen. Infection through direct contact with ill people occurs rather rarely (Kalinowska, 2012).

Occasionally, dermatophytes infection may become chronic and wide spread. This progression has been related to both host and organism factors (Fathi and Al-Samarai, 2000). Approximately half of these patients have underlying diseases affecting their immune response or are receiving treatments which compromise T-lymphocyte function. On the basis of the type of hair invasion, dermatophytes are also classified as endothrix, ectothrix or favus. In endothrix infection the fungus grows completely within the hair shaft, the hyphae are converted to arthroconidia (spores) within the hair while the cuticle surface of the hair remains intact (Fuller *et al.*, 2003).

In ectothrix infection hair invasion develops in a manner similar to endothrix except that the hyphae destroy the hair cuticle and grow around the exterior of the hair shaft. Arthroconidia may develop both within and outside the hair shaft. Elongated hyphae, parallel to the long axis of the hair, persist within the hair. Favus is a rare type of TC

characterized by typical honey-colored, cup-shaped, follicular crusts called scutula (Brajesh and Mahadeva, 2013). Ectothrix anthropophilic infections potentially spread rapidly whereas endothrix and favic infections are less contagious (Rebollo, *et al.*, 2008). Fungal conidia are shed in the air, and may remain viable for long periods on combs, brushes, blankets and telephones (Habif *et al.*, 2005).

These dermatophytes can be transmitted from person to person and through fomites (Panasitti *et al.*, 2006). The clinical presentation of the disease varies depending on the etiological agent and type of hair invasion, the level of host resistance and the degree of inflammatory host response (Liu *et al.*, 2000). Asymptomatic carriage (AC) seems to be organism specific. Anthropophilic dermatophytes such as *T. tonsurans*, *T. violaceum*, and *M. audouinii* have been associated with high rates of AC (Ginter-Hanselmeyer *et al.*, 2007). These organisms generally produce mild signs of infection. Asymptomatic carriers at home or school are potentially important sources of disease transmission (Ginter-Hanslmeyer *et al.*, 2007). Other studies have determined that carrier rate may increase to as high as 44 % for the siblings of index cases (Chen and Friedlander, 2001).

Dermatophytes are keratinophilic fungi, which parasitize on corneous structures, such as stratum corneum, hair or nails (Kalinowska *et al.*, 2012). Of great importance may also be some specific anatomic regions of the skin, greatly facilitating the colonization by fungi. Scalp hair can therefore arrest arthrospores spread by air. Similarly, spores are arrested in the hyponychium under or in the interdigital spaces, or in the folds of the skin where additionally occlusion helps them to develop (Dworacka-Kaszak, 2004). The

spores are particularly resistant to environmental conditions, such as variable temperature and drying (Hryniewicz-Gwozdz *et al.*, 2005). In addition to the progressive migration and climate change, social and economic conditions that affect skin exposure to fungal pathogens, and therapeutic methods are also important (Szepietowski and Baran, 2005). Transmission is increased with decreased personal hygiene and low socioeconomic status. Asymptomatic carriers are common, making TC difficult to eradicate (Kawachi *et al.*, 2010).

2.4 Epidemiology of *Tinea capitis*

The epidemiology of TC has changed with the advent of griseofulvin and the sensitivity of *M. audouinii* to this antifungal medication (Elewski, 2000). Since the 1970's, there has been a progressive spread of infections caused by *Trichophyton tonsurans* through inner city areas of much of the USA and more recently in the UK and other European cities. By contrast *Trichophyton schoenleinii*, which causes a characteristic scalp infection, favus, is becoming less common, partly because it's striking clinical appearances and the tendency to scar are recognized even in remote communities. Patients with favus, or their parents, are more likely to present for treatment (H P A, 2007).

Trichophyton tonsurans arrived in the Americas with the Spanish conquistadores and currently, in Mexico, this organism accounts for between 15 % and 28 % of cases (Arenas, 2002). In the United States of America, it is the predominant causative organism of TC (98 %), whereas the dermatophyte *Microsporum canis* is more common in some parts of Europe, Arab countries, Iran, Brazil, Mexico, and the Dominican Republic

(Arenas, 2002). The Countries with the highest incidence are Italy and other Mediterranean countries, although other nearby countries such as Austria, Hungary, Germany, and Poland also has high incidences (Ginter-Hanselmayer *et al.*, 2007). The increase in anthropophilic dermatophytes is due to *Trichophyton tonsurans*, mainly in the United Kingdom and to *Trichophyton soudanense* and *Microsporum audouinii* in France (Panasiti *et al.*, 2007).

The commonest cause of this infection in the UK is *Microsporum canis*. Its geographic range is, however, worldwide as it is spread from cats or dogs. In many parts of the UK, *Microsporum canis* infections are infrequent but still the commonest forms of TC in those locations. *Microsporum canis* infections are also seen in children who do not have a history of exposure to cats or dogs (H P A, 2007). The likely explanation is that they have acquired the infection from a contaminated environment. In addition, other anthropophilic fungi such as *T. violaceum*, *T. soudanense* and *M. audouinii* are seen in cities. A dramatic increase in *T. tonsurans* infections has been reported in the USA (Nelson *et al.*, 2003). Additionally, *T. tonsurans* had become the most common cause and today more than 95 % of *Tinea capitis* cases are caused by *T. tonsurans* (Foster *et al.*, 2004).

In the USA *T. tonsurans* is also the most frequent isolate; it appears to be common in urban populations, particularly black American children, than in other cultural or ethnic groups. Little is known about the risk factors for anthropophilic infection (HPA, 2007). Previous studies have indicated; race, socio economic conditions, cultural patterns and

public health measures as some of the predisposing factors to the infections (Ayanbimpe *et al.*, 2003, Anosike *et al.*, 2005, Bassiri and Khaksar, 2006). The emergence of *T. tonsurans* infection in developed countries has been attributed to low socioeconomic status, crowded living conditions, and the sharing of combs (Fuller *et al.*, 2003).

In a recent US survey, TC was found in 6.6 % of the population (Fungal Research Trust, 2011). However an infection range from 0 % to 19.4 % is more common in deprived areas and black children, suggesting a global prevalence of 200 million cases (Fungal Research Trust, 2011). In Germany, before World War II, *Microsporum audouinii* and *Epidermophyton floccosum* occupied the top of the list of causative organisms by frequency, but from the 1950s onwards *T. rubrum* (80 % to 90 %) has been the predominant dermatophyte at all sites apart from the head (Seebacher *et al.*, 2008).

In Africa, however, TC continues to be an important public health problem, where it has been reported to affect 10 % to 30 % of school-aged children (Sidat *et al.*, 2007). Hair infection (*Tinea capitis*) is most common among children, often resulting in bald patches with psychological consequences. Although TC, like other dermatophytoses, is of public health importance, it is not a notifiable disease and as a result, the actual prevalence figures are unknown in many endemic areas (Ayaya *et al.*, 2001; Ameh and Okolo, 2004; Anosike *et al.*, 2005).

In the Netherlands, Sweden, and Belgium, there have been increases in *M. canis* TC, but there are also increases of anthropophilic TC caused by *T. violaceum*, *T. soudanense*, and

T. tonsurans, which is a reflection of immigration patterns, particularly from East Africa (Kolivras *et al.*, 2003; Hallgren *et al.*, 2004). The most common species responsible for TC in Australia and New Zealand are *M. canis* and *T. Tonsurans* (Ameen, 2010). However, since the early 1990s, *T. soudanense*, *T. violaceum*, and *M. audouinii* TC have been increasingly reported in children who have immigrated from East Africa, in particular, with evidence for transmission of these agents to local populations (Mc Pherson *et al.*, 2008).

In Nigeria, the head is affected in 13.7 % of cases and the most common causative organisms are *Trichophyton soudanense* (30.6 %), *Microsporum ferrugineum* (7.7 %), and *Microsporum audouinii* (7.7 %), with cases involving *Trichophyton tonsurans* occurring less frequently (Ayanbimpe *et al.*, 2008). In Mozambique, the prevalence of TC is 9.6 %, due mainly to *Microsporum audouinii*, *Trichophyton violaceum*, and *Trichophyton mentagrophytes* (Sidat *et al.*, 2007). There is limited data on TC infections in Kenya. However, for those that have evaluated the prevalence of TC among school going children, have shown 33.3 % infection rates with the prevalence of *T. tonsurans* being 77.8 % and 4 % for *T. rubrum* (Ayaya *et al.*, 2001).

The distribution of dermatophyte infections and their causative agents varies with geographical region. It is influenced by a wide range of factors, such as type of population, climatic factors, lifestyle, migration of people, cultural practices and socioeconomic conditions (Havlickova *et al.*, 2008; Ameen, 2010). Some dermatophyte species appear to be homogeneously distributed worldwide whereas others show a

geographic restriction (Havlickova *et al.*, 2008). In recent decades, an ever-growing etiological role of some anthropophilic dermatophytes has become evident all over the world (Jankowska-Konsur *et al.*, 2011).

2.5 Diagnosis of *Tinea capitis*

Apart from cultural characteristics for identification of dermatophytes, clinically TC agents such as *M. audouinii* and *M. canis*, can mimic impetigo and pediculosis or psoriasis and seborrhea, respectively. However, for impetigo, the pain is generally more severe and individual hairs do not appear to be broken. In psoriasis, the scales on the scalp are thicker, but the hair is not broken off (Johnson and Nunley, 2000). *Alopecia areata* also causes hair loss and may mimic *T. tonsurans* infections, but does not cause scaling of the scalp (Sarabi, 2008). TC is diagnosed by several methods.

A Wood's lamp examination may show hairs that turn blue-green. A potassium hydroxide test on the hair or scalp may show fungi under the microscope. A fungal culture of the hair or scalp may show what type of fungus is causing the infection (Mounsey and Reed, 2009). Clinical diagnosis can also be applied. However, dependence on the clinical diagnosis of TC is unreliable and has a low specificity even though certain signs such as lymphadenopathy are useful predictors of the infection. For this reason, wherever possible, the diagnosis should be confirmed by appropriate laboratory tests.

2.5.1 Wood's lamp examination

The Wood's lamp produces invisible long-wave ultraviolet light (340-450 nm wave length). Filtered ultraviolet (Wood's) light elicits a green fluorescence from some dermatophyte fungi, mainly *Microsporum* species, in hair infections. Exposure to Wood's light is a useful screening procedure for taking specimens from *Microsporum* infections (H P A, 2007). The first use of Wood's lamp for the detection of TC was based on the fact that some dermatophyte species produce characteristic fluorescence under UV light. The chemical responsible for the fluorescence is pteridine. Wood's lamp is helpful in the diagnosis and treatment of an individual patient as well as for mass screening and control of epidemics in schools. It can also be helpful in assessing the length and response to treatment; the end point being emergence of non-fluorescent hair. Dermatophytes that cause fluorescence are generally members of the *Microsporum* genus. However, the absence of fluorescence does not necessarily rule out TC as most *Trichophyton* species, with the exception of *T. schoenleinii*, are non-fluorescent (Gupta and Singhi, 2004).

Wood's light fluorescence is helpful but not diagnostic as it is only positive if the responsible organism fluoresces and fluorescence is sometimes seen for other reasons. The diagnosis of TC should be confirmed by microscopy and culture of skin scrapings and hair pulled out by the roots (Higgins *et al.*, 2000). However, with TC infections that are caused by the *Trichophyton* species, the fungal spores form on the inside of the hair shaft (endothrix), and there is no fluorescence (Fuller *et al.*, 2003). Therefore, the Wood's light examination is not a reliable method for diagnosing TC caused by the *Trichophyton* species because this species does not fluoresce.

2.5.2 Direct microscopy

Microscopic examination and/or fungal culture should be used to confirm the clinical diagnosis of TC because of the extended nature of most treatment regimens (Ali *et al.*, 2007). Microscopic examination consists of scraping the scales of the lesions onto a slide and viewing the sample, which is prepared with a 20 % potassium hydroxide (KOH) solution, under the microscope to look for the presence of hyphae (Chen and Friedlander, 2001). This test may be difficult to interpret or may be falsely negative with early or inflammatory lesions. Therefore, the final diagnosis of TC should be made by culture.

2.5.3 Mycological culture

Culture documentation of the infection is a crucial component to treatment of TC (Roberts and Friedlander, 2005). Plucked hair fragments and skin scrapings are placed directly in culture media. The most commonly used media is Sabourand's agar. Chloramphenicol and Cycloheximide are used to inhibit bacteria and saprobic fungi. Cultures are incubated at 25°C for 3-4 weeks and if *T. verrucosum*, *T. violaceum* or *T. soudanense* are suspected, they are incubated for 6 weeks. Fungal identification is based on macroscopic (pigmentation formation) and microscopic morphology (macroconidia or microconidia formation).

2.6 Identification of dermatological agents causing *Tinea capitis*

Like a number of fungi, dermatophytes may exhibit two phases in their life cycle: the anamorph state (imperfect or asexual phase), which is isolated in the laboratory; and the teleomorph state (perfect or sexual phase) (Enany *et al.*, 2013). Not all of the teleomorph

dermatophyte species have been identified (Mukherjee *et al*, 2011). Anamorphic states of dermatophytes include genera *Epidermophyton*, *Microsporum* and *Trichophyton* and belong to the class Hyphomycetes and phylum Deuteromycota (Enany *et al.*, 2013). Teleomorphic states include majority of geophilic and zoophilic species of *Microsporum* and *Trichophyton*. They are classified in the teleomorphic genus *Arthroderma*, order Onygenales, phylum Ascomycota, and are usually found in their anamorphic state (Molina, 2011).

There are 3 major genera of Dermatophytes. These are *Epidermophyton*, *Microsporum* and *Trichophyton*. *Epidermophyton* are characterised by large thin-walled, multicellular, club-shaped and clustered bunches of macroconidia (Ayorinde *et al.*, 2013). No Microconidia are produced. However, *Microsporum* produces both microconidia and macroconidia (Ayorinde *et al.*, 2013). Macroconidia are multiseptate, with echinulations on the cell wall. The thickness of the cell wall and shape varies depending on the species (Simpanya, 2000). *Trichophyton* produces smooth walled macroconidia. Macroconidia are thin walled and cigar-shaped (Centre for Food Security and Public Health, 2005).

Microsporum canis grow on culture media to form white cotton radiated colony, golden yellow on reverse (Marques *et al.*, 2005). Macroconidia are fusoid, thick and rough-walled with curved apex with greater than 6 cells (Mcdonald, 2000). *Epidermophyton floccosum* grow with khaki pigmentation on front and yellow brown reverse (Ellis *et al.*, 2007). The macroconidia are similar to those of *Microsporum* except that they are smooth thin walled, club shaped and they occur in clusters and appear to be directly growing

from the hyphae (McDonald, 2000) but with no microconidia.

The cultural morphology and microscopic characteristics for *Trichophyton* species include; numerous smooth walled and clavate to pyriform microconidia. Macroconidia are less distinctive and often absent in this genus (McDonald, 2000). *Trichophyton tonsurans* show dark-brown pigmentation with reddish brown to mahogany reverse after 21 days. In microscopy it reveals numerous microconidia of varying sizes and shape which appear to be formed at right angle to the hypha (Ellis *et al.*, 2007).

Trichophyton mentagrophytes produce a flat, white to cream and a powdery appearance in potato dextrose agar with a pinkish brown reverse. The microscopy show single-celled spherical microconidia and spiral hyphae. *T. rubrum* produce white to cream flat colony with yellow-brown reverse after 21 days. On microscopy, numerous pyriform microconidia are observed (Ellis *et al.*, 2007). *T. mentagrophytes* is urease positive after 7 days while *T. rubrum* is urease negative after 7 days (McDonald, 2000). The Colony of *T. verrucosum* grows slowly in potato dextrose agar. It is small, button or disc-shaped, white to cream-coloured, with a suede-like to velvety surface, a raised centre, and flat periphery with a yellow reverse. On microscopy, it is observed to produce clavate to pyriform microconidia borne singly along the hyphae (Ellis *et al.*, 2007).

Traditionally, most commercially available identification systems of dermatophytes are based on physiological (growth temperature), nutritional (sugar assimilation and/or fermentation, enzyme production profiles) and morphological characteristics (Elsayed *et*

al., 2010). *Tinea capitis* is generally identified by the presence of branching hyphae and spores on KOH microscopy (Ayorinde *et al.*, 2013). If hyphae and spores are not visualized, Wood's lamp examination can be performed. If KOH microscopy and Wood's lamp examinations are negative, fungal culture may be considered when *Tinea capitis* is strongly suspected (Barry and Hainer, 2003).

Laboratory diagnosis is routinely performed by direct microscopic examination of a clinical specimen followed by sample culture in specific agars (Côbo *et al.*, 2010). This combination of techniques is time-consuming and notoriously low in sensitivity (Uchida *et al.*, 2009). Furthermore, sample cultures on agar have a high risk of contamination by non-dermatophytic moulds and yeasts (Arabtzis *et al.*, 2007). The final diagnosis must be made based on isolation of the organism from affected tissues and visualization of tissue invasion by organisms with compatible morphology (Arabtzis *et al.*, 2007).

PCR-based techniques used in dermatophytes diagnosis, are highly specific and sensitive methodologies but demand well-equipped laboratories, expensive reagents, laboratory personnel expertise and protocol standardization, so, actually, molecular techniques for dermatophytes diagnosis are far from being routinely used and need more studies before implementation (Garg *et al.*, 2009). Some associations with other techniques, such as histology, are proposed to increase diagnosis sensitivity (Karimzadegan-Nia *et al.*, 2007) but this would bring more difficulties in the routine, demanding professionals, equipments and more time (Côbo *et al.*, 2010).

2.7 Standard therapy

Griseofulvin was first approved by the U.S. Food and Drug Administration (FDA) for systemic treatment of TC in 1958. Before then, the only available treatments were shaving the head, applying mercury/sulfur to the scalp, or resorting to high-fat diets (Möhrenschlager *et al.*, 2005). However, griseofulvin quickly became the mainstay of treatment and the use of terbinafine and itraconazole in patients allergic to griseofulvin were also successful (Trivino-Duran *et al.*, 2005). In a meta-analysis study, Fleece *et al.* (2004) showed terbinafine treatment for up to four weeks to be as effective in treating *Trichophyton* spp. as 8 weeks of griseofulvin treatment. Griseofulvin is a mitotic inhibitor and interferes with nucleic acid, protein, and cell wall synthesis of replicating dermatophyte cells (Brendan, 2012). There is also evidence that griseofulvin has an anti-inflammatory effect, which is unique among the systemic antifungal agents (Brendan, 2012). A recent extensive review quoted mycologic cure rates of 80 % to 95 % and effective therapy rates of 88 % to 100 % for griseofulvin (Gupta and Cooper, 2008).

In 2007, terbinafine became the second FDA-approved drug to treat TC in children. The drug is an allyl-amine whose antifungal effect is due to inhibition of squalene epoxidase (Brendan, 2012). However the responses of *Microsporum* species to terbinafine are generally slower than those of *Trichophyton* and in some patients there is treatment failure (Caceres-Rios *et al.*, 2000). However higher doses of terbinafine, more than 6 mg/kg per day, appear to produce good responses (Devliotou-Panagiotidou and Koussidou-Eremondi, 2004).

Itraconazole has both fungistatic and fungicidal activity, depending on its tissue concentration, unlike other azoles, its principal mechanism of action is fungistatic, through depletion of ergosterol in the cell membrane, leading to alteration of membrane permeability (Rebollo *et al.*, 2008). It is highly lipophilic and keratinophilic, and it persists in the stratum corneum for 3 to 4 weeks after suspension of treatment, allowing it to be used in pulses of 1 week separated by periods of 2 weeks without treatment (Higgins *et al.*, 2000).

Currently, the recommended therapy for TC is a 6 to 8 week course of oral griseofulvin. Griseofulvin has a long-standing history of safety and efficacy when used to treat fungal scalp infections in children (Bennet *et al.*, 2000). Griseofulvin is effective when treating *Microsporum*, *Epidermophyton*, and *Trichophyton* (Chan and Friedlander, 2004). When compared to other treatments in *Trichophyton* infections, griseofulvin and terbinafine are equally effective, but griseofulvin is most effective against *Microsporum* infections (Fuller *et al.*, 2001). Despite the existence of antifungal agents effective on dermatophytes, there is need to search for alternatives (Tra Bi *et al.*, 2005). The relatively high cost and constraints due to the length of the modern treatment curb the control of the dermatomycoses in developing countries (Tra Bi *et al.*, 2005). Resource-poor people from remote areas still use traditional medicine for the treatment of various diseases of microbial and non microbial origin (Kone *et al.*, 2002).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study area and population

The study was carried out in Mathare valley informal settlement in Nairobi. Mathare valley is situated five kilometers northeast of Nairobi's city center. As one of the largest slums in East Africa and the oldest in Nairobi, Mathare is divided into different villages. The area is comprised of 13 villages: Mashimoni, Mabatini, Village No. 10, Village 2, Kosovo, 3A, 3B, 3C, 4A, 4B, Gitathuru, Kiamutisya, and Kwa Kariuki (Crow and Odaba, 2010). The 2009 Kenyan Census reported 80,309 residents in the 13 Mathare villages.

The settlement sits within a valley of the Mathare and Gitathuru. Mathare Valley is enclosed by Pangani on the West. On the north, it is enclosed by the police depot, Mathare primary school, and Mathare Mental Hospital. Juja Road borders Mathare on the south, separating it from Eastleigh, an estate dominated by Somali immigrants and entrepreneurs. To the east, it borders Huruma estate (Fig. 3.1). It stretches out for about 3 kilometres along side Juja road (APHRC, 2002). Water quality and reliability is inconsistent, with frequent contamination from vandalized pipes and 90 % of residents lacking access to in-home piped water. The sanitary infrastructure in Mathare is equally bad and in many cases worse than the water. The sewerage pipe system is in total disrepair, and there is limited or no solid waste management.

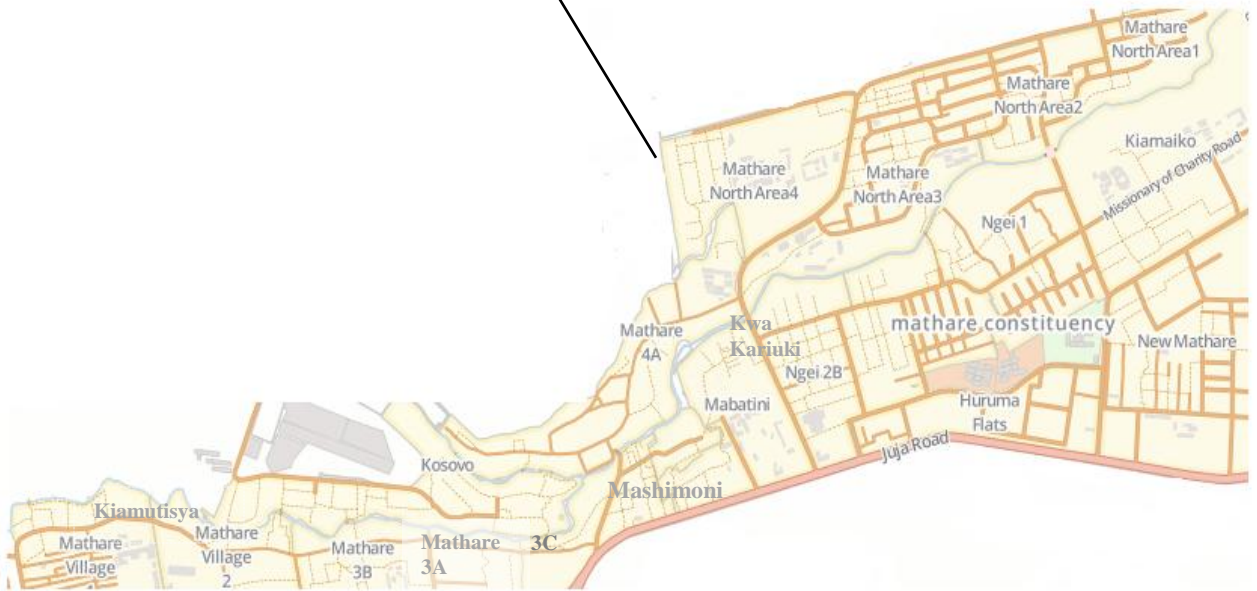


Figure 3.1: A map showing Mathare informal settlement, Nairobi (www.openstreetmap.com).

3.2 Structured questionnaires

A structured questionnaire (Appendix 1) was administered among the children's guardians and socio-economical and demographic data collected. The questionnaires were administered to the parents/ guardians of the children who were selected for the study after the collection of the specimen. The questionnaires were divided into two parts. The first section was on socio demographic data of the study subjects while the second part was on knowledge on hygienic practices in relation to TC infection. The questionnaires were personally administered to the children's parents/guardians by the researcher. All the five public primary schools in Mathare informal settlement were involved in the study. The schools involved include; Mathare 4A, Mathare north primary school, Kiboro primary school, St. Teresa's and Muthaiga primary school.

3.3 Study design

This was a cross-sectional study. The study subjects were randomly selected from the five public primary schools in Mathare informal settlement. Systematic random sampling method was used to select the subjects. The desired sample size (n) was 150 while the study population (p) was 2250. The interval of study subjects' selection was given by p/n ($2250/150$) which was 15. Every 15th pupil was therefore selected for the study. Sampling from each school was done considering the total pupil population: Mathare 4A 477, Mathare north 480, Kiboro primary 410, St.Teresa's 420 and Muthaiga 463. The average population in each school was given by study population/number of schools ($2250/5$) which was 450. Therefore, thirty pupils ($450/5$) were randomly selected from each of the five public primary schools. The children were grouped in age groups of year 3-5, 6-8, 9-

11 and 12-14. Samples were collected and questionnaires were personally administered by the researcher to the subjects through their guardians/ parents. Inclusion and exclusion criteria were used in this study.

3.3.1 Inclusion criteria

All pupils aged between 3-14 years in Mathare informal settlement who were present in school at the period of study, whose parents consented as well as those who assented to participate in the study were included for the study. This included the children without clinical symptoms (asymptomatic) of TC and the ones with clinical symptoms (symptomatic).

3.3.2 Exclusion criteria

Children whose parents did not consent to their children's participation in the study were excluded from the study.

3.4 Sample size determination

Sample size was calculated from the sample size formula:-

$$n = Z^2 p (1-p)/d^2 \text{ (Daniel, 1999), and a confidence level of 95 \%}$$

where, n = sample size,

Z = Z statistic for a level of confidence,

P = expected prevalence or proportion,

d = precision

The prevalence of dermatophytosis in school going children in Kibera informal settlement is 11.2 % (Chepchirchir *et al.*, 2009).

Therefore, $p = 0.11$

$d = 0.05$ (half of p).

$z = 1.96$ (For the level of confidence of 95 %, which is conventional, Z value is 1.96).

Therefore,

$$n = 1.96^2 * 0.11(1-0.11) / 0.05^2 = 150.437 = 150.$$

3.5 Specimen collection

Scalp skin scrapping/hair stubs were collected from school going children in the selected primary schools. The scalp was first sterilized with 70 % alcohol and skin scrapped by sterile surgical blades and hair stubs collected into dry Petri dishes. The samples were then wrapped with sterile parafilm and transported to Kenyatta University laboratory for analysis.

3.6 Examination of the specimen

3.6.1 Direct microscopy

Some of the samples were inoculated onto the media while the other treated with 10 % Potassium hydroxide (KOH) + 36 % dimethyl sulfoxide (DMSO) without vigorous squashing of the specimen on the slide. The slide was gently heated and viewed under light microscope (Robbert and Pihet, 2008). Hair samples were examined within 30 minutes to allow softening and digestion of the specimen (HPA, 2007). Slides were evaluated for the presence of fungal elements under a microscope (x100, x200 and x400) magnification. The presence of fungal hyphae and/or spores within (endothrix) and/or around (ectothrix) hair shafts was considered to be a positive test.

3.6.2 Mycological culture

Plucked hair fragments and skin scrapings were placed directly on culture media. Potato dextrose agar was used as culture media. 0.1g/L Chloramphenicol and 0.1g/L cycloheximide were added to inhibit bacterial and saprobic fungal contamination. The cultures were incubated at 25°C to ensure that the media does not dry up and the growth was examined regularly for 3–4 weeks. Fungal identification was carried out based on macroscopic (growth characteristics, pigment formation) as well as microscopic morphology (formation of macro conidia and micro conidia or other typical elements). Identification was carried out by the gross colony morphology and microscopically by lacto phenol cotton blue mounts and slide cultures (Roberts and Friedlander, 2005). The identification was done according to mycological identification of dermatophytes by McDonald *et al.* (2000) and Ellis *et al.* (2007).

3.6.3 Screening for *Trichophyton* and *Microsporum* species

The cultures were macroscopically screened twice a week for signs of fungal growth. Change in colony pigmentation on both reverse and front of the plate was also recorded. Additionally biochemical tests were performed. This included urease activity (Betty *et al.*, 2007) in order to differentiate between the members of *Trichophyton* species.

3.7 Data analysis

All the field data were collected and stored in Microsoft Excel Software package. The scalp scrapings /hair stubs data and questionnaire data were then exported to SPSS 16 for

analysis. Chi- square test was used for comparing prevalence of the infection by sex, age and to determine significant predisposing factors of *Tinea capitis* infection. $P < 0.05$ was considered significant. The results were then presented in descriptive statistics using frequency tables, cross tabulation and bar charts.

3.8 Ethical consideration

Authority to carry out research was sought from Kenyatta University Graduate School. Kenyatta University Ethics Review Committee gave the approval. National commission for science, technology and innovation gave the permit. Consenting parents and children signed an informed consent form to allow participation of their children in the study.

CHAPTER FOUR

RESULTS

4.1 Demographic profile

A total of 150 children aged 3-14 years from the five public primary schools in Mathare informal settlement were examined for *Tinea capitis* infection. Both symptomatic and asymptomatic cases were considered whereby the asymptomatic and symptomatic cases picked at random were 48 (32 %) and 102 (68 %) respectively. All the 102 (68 %) symptomatic cases were positive for *Tinea capitis* infection. Of the 48(32 %) asymptomatic cases only 21 (43.75 %) were positive for *Tinea capitis* infection. In the other 27 (56.52 %) samples no dermatological agent was isolated. The study population comprised of 89 (59.3 %) males and 61 (40.7 %) females. The mean average age was 8.5 ± 1.86 . The number of children selected at random comprised of 47 children between the ages of 3-5, 72 children between the ages of 6-8, 20 children between the ages of 9-11 and 11 children between the ages of 12-14. The overall prevalence of the three genera of dermatological agents causing *Tinea capitis* infections was 61.3 %, 13.3 % and 7.3 % for *Trichophyton*, *Microsporum* and *Epidermophyton*, respectively (Table 4.1).

4.1.1 Prevalence of *Tinea capitis* infection in children aged 3-14 years in Mathare informal settlement

Of the 150 children examined, 123 (82 %) were infected with either one of three dermatophytes. These were; *Trichophyton* (61.3 %), *Microsporum* (13.3 %) and *Epidermophyton* (7.3 %). There was a significant difference between the prevalence of the three dermatological agents isolated ($\chi^2 = 6.602$, $df = 1$, $p = 0.026$). According to sex, males were significantly infected compared to females (45.3 % versus 36.7 %, $\chi^2 = 7.142$,

df = 1, p = 0.009). The prevalence of *Trichophyton* species was 62.9 % in males versus 59.0 % in females. There was a significant difference in the prevalence of *Trichophyton* species between sexes ($\chi^2 = 5.673$, df =1, p = 0.020). The prevalence of *Microsporum* species was 35.3 % in males versus 22.9 % in females. The prevalence of *Microsporum* species differed significantly between sexes ($\chi^2 = 7.503$), df = 1, p = 0.006).

By age the levels of infection were different in the age groups 6-8 years ($\chi^2 = 4.236$, df = 1, p = 0.049), for *Trichophyton* in the age category 9-11 years ($\chi^2 = 4.738$, df = 1, P = 0.031) and *Microsporum* in the age category 6-8 years ($\chi^2 = 5.438$, df = 1, P = 0.021) (Table 4.1). The highest infection prevalence was observed in males. In the age category 12-14 years there was a significant difference between males and females. Males had higher prevalence of 66.7 % compared to 33.3 % for females. ($\chi^2 = 5.438$. df = 1, P = 0.020).

Table 4.1 Prevalence of *Tinea capitis* infections among the study subjects in Mathare informal settlement

Age (years)	Sex	Number examined(N)	<i>Trichophyton</i> species	<i>Microsporum</i> species	<i>Epidermophyton</i> species	overall
3-5	Male	25	22(91.6)*	1(4.2)	0(0)	23(95.8)
	Female	22	15(65.2)	4(17.4)	1(4.3)	20(87.0)
	Total	47	37(78.7)	5(10.6)	1(2.1)	43(91.4)
6-8	Male	44	26(61.9)	3(7.1)	5(11.9)	34(81.0)
	Female	28	14(46.7)	6(20.0)	2(6.7)	22(73.3)
	Total	72	40(55.6)	9(12.5)*	7(9.7)	56(77.8)*
9-11	Male	12	8(57.1)	4(42.9)	0(0)	12(100)*
	Female	8	4(60.0)	1(10.0)	2(20)	7(90)
	Total	20	10(58.8)*	4(23.5)	2(11.8)	16(94.10)
12-14	Male	8	4(66.7)	0(0)	1(16.7)	5(83.3)
	Female	3	1(33.3)	2(66.7)	0(0)	3(100)
	Total	11	5(55.6)	2(22.2)	1(11.1)	8(88.9)
All	Male	89	56(62.9)*	7(7.9)*	5(5.6)	68(76.4)*
	Female	61	36(59.0)	13(21.3)	6(9.8)	55(90.2)
	Total	150	92(61.3)	20(13.3)	11(7.3)	123(82.0)

*5% or less significant difference in prevalence of dermatological agents causing *Tinea capitis*

The highest prevalence of *Microsporum* species infection was found in the age category 9-11 years followed by age group 6-8 years. In the age category 9-11 years, males had significantly higher infections than females ($\chi^2 = 4.591$, $df = 1$, $P = 0.032$) (Table 4.1). Among the *Trichophyton* species, *Trichophyton tonsurans* (33.3 %) was the most prevalent followed by *Trichophyton mentagrophytes* (10.7 %) and *Trichophyton verrucosum* and *Trichophyton rubrum* as the least (8.0 %) (Figure 4.1).

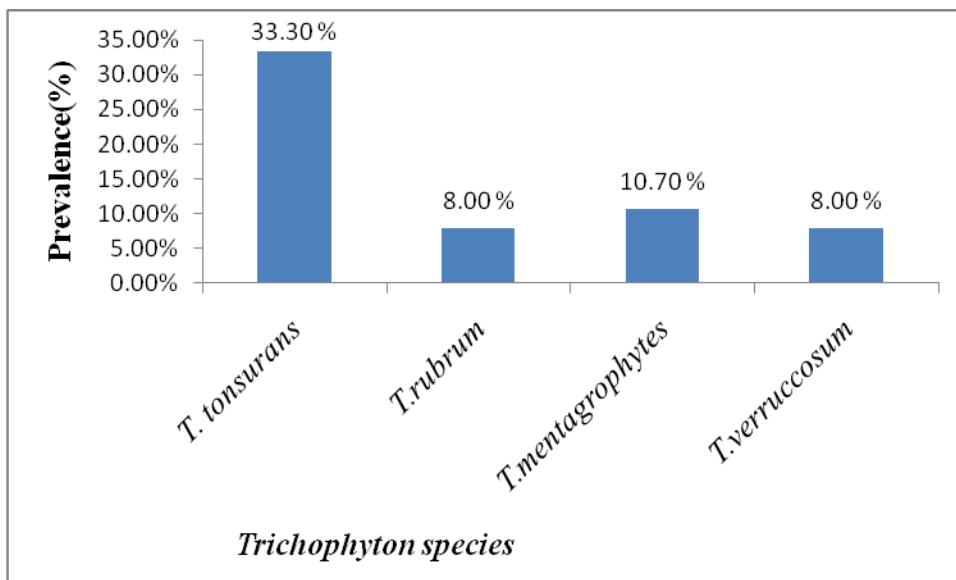


Figure 4.1 Prevalence of *Trichophyton* species isolated from the scalp samples of the 150 children of Mathare informal settlement

Key: N; Total number of samples collected (150), n; frequency of *Trichophyton* species identified, percentage (prevalence) = $(n/N) * 100$.

Of the 150 hair and scalp scrapings examined from the children, 11 (7.3 %) were positive for *Epidermophyton* infections with children of the age group 6-8 years and males most affected ($\chi^2 = 0.948$, $df = 1$, $p = 0.330$). Only a few children in the age group 12-14 and 3-5 years were found positive for *Epidermophyton* species (Table 4.1). The only *Epidermophyton* species isolated from the hair samples was *Epidermophyton floccosum*. The most prevalent species of *Microsporum* was *Microsporum gypseum* (7.3 %) followed by *Microsporum canis* (6.0 %) (Table 4.2).

Table 4.2 Prevalence of *Microsporum* species isolated from the 150 samples collected from children in Mathare informal settlement

<i>Microsporum</i> species	Frequency (n)	Percentage (n/N)*100
<i>Microsporum canis</i>	9	6.0
<i>Microsporum gypseum</i>	11	7.3
Total	20	13.3

Key: N; Total number of samples collected (150), n; Frequency of dermatophytes isolated.

4.2 Multiple infections with dermatological agents causing *Tinea capitis* among the study subjects in Mathare informal settlement

Some dermatological agents occurred singly whereas others occurred in a multiple fashion (Figure 4.2). Among 56 % who had only one infection, *Trichophyton* occurred singly at the highest rate of 30 % followed by *Microsporum* at 22 % while the least single infection was by *Epidermophyton* (4 %).

The dermatological agents also co-occurred at the rate of 38 % of all the cases observed. *Trichophyton* and *Microsporum* species co-occurred most at the rate of 30 %, followed by *Trichophyton* and *Epidermophyton* combination at the rate of 6 % and the least occurring combination was *Microsporum* species with *Epidermophyton* species at the rate of 2 %. Triple infections with all the three dermatological agents observed in this study occurred at a very small rate of 6 % (Figure 4.2).

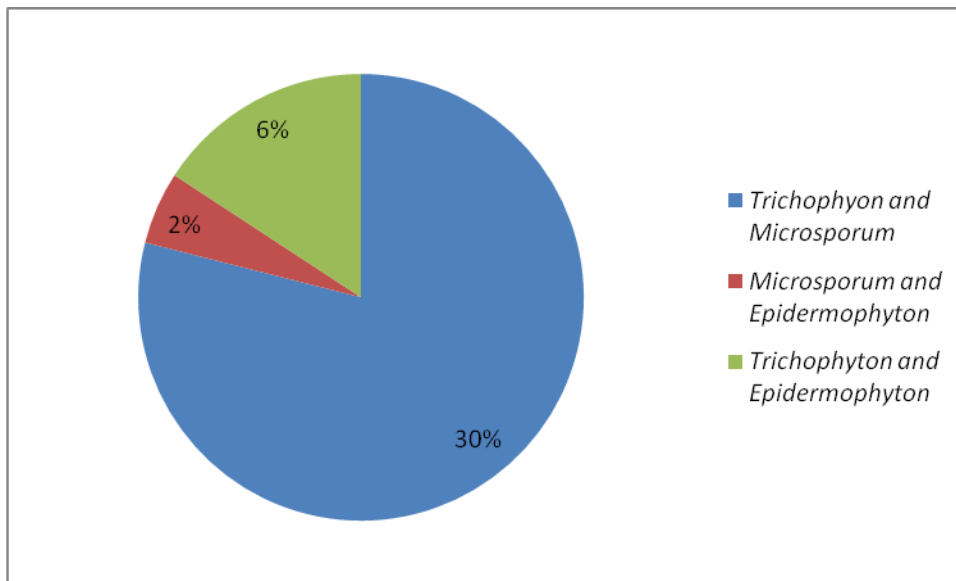


Figure 4.2: Multiple infections with dermatological agents causing *Tinea capitis* among the study subjects in Mathare informal settlement

4.3 Significant pre-disposing factors for *Tinea capitis* infections in children aged 3-14 years in Mathare informal settlement

The demographic characteristics of the study subjects included; the socio economic status of the family, number of children in a family and practice of personal hygiene (Table 4.3). Practice of personal hygiene among the children was demonstrated by frequency and place of hair shaving, sharing of personal effects such as combs and towels and knowledge on ways of transmission of *Tinea capitis*.

4.3.1 Social economic status of the children

The socio economic status of the children included the employment status of the parents and the monthly income of the family. Most of children came from families whose both parents were unemployed and earned less than 5,000 Kenya shillings per month (Table 4.3).

4.3.1.1 Employment status of the father and prevalence of *Tinea capitis* in children aged 3-14 years in Mathare informal settlement

In a total of 34 children whose parents were employed, 7 (20.6 %) had *Tinea capitis* infections while among self-employed, unemployed and retired the percentages of children infected were 92.6 %, 96.9 % and 95.8 % respectively (Table 4.3). The highest prevalence was therefore observed among children whose parents were unemployed 63/65 (96.9 %). The employment status of the father was found to have a significant influence on the prevalence rates of *Tinea capitis* among the study subjects ($\chi^2 = 102.287$, $df = 3$, $P < 0.001$).

Table 4.3 socio-demographic characteristics of the study subjects and prevalence of *Tinea capitis* infection in Mathare informal settlement

	No. of Participants (N)	Frequency with <i>Tinea</i> infection (n)	% of participants Infected (n/N) %	Pvalue
Father's employment status				
Employed	34	7	20.6	p < 0.001
self-employed	27	27	92.6	
unemployed	65	65	96.9	
retired	24	24	95.5	
Mother's employment status				
Employed	23	9	39.1	p < 0.001
Self-employed	27	19	70.1	
Unemployed	67	66	98.5	
retired	33	28	84.8	
Family Monthly income				
Below 5,000	82	76	92.7	p < 0.001
5,000-10,000	30	26	86.7	
10,000-15,000	21	11	52.4	
15,000-20,000	12	4	33.3	
Above 20,000	5	0	0	
Number of children in a family				
1-4	42	1	2	p = 0.210
5-8	50	11	22	
>8	68	52	76.5	
Respondents' source information				
Teachers	54	2	3.7	p = 0.727
Friends	22	15	68.2	
HCP	24	17	70.8	
Parents	27	19	70.4	
Others	23	12	52.2	
Knowledge on ways of transmission				
Have knowledge	21	12	57.1	p < 0.001
Have no knowledge	129	114	88.4	
Sharing of combs and towels				
Yes	92	85	92.4	p < 0.001
No	58	38	65.5	
Frequency of hair shaving				
Weekly	30	19	63.3	p = 0.02
After two weeks	42	36	85.7	
Monthly	78	68	87.2	
Place of hair shaving				
Home	47	33	70.2	p = 0.037
Barber shop	68	65	95	
Both home and barber shop	35	25	71.4	

4.3.1.2 Employment status of the mother and prevalence of *Tinea capitis* in children aged 3-14 years in Mathare informal settlement

Of the 150 children examined, 9/23 (39.1 %) children whose mothers were employed were positive for *Tinea* infection (Table 4.3). Of the 27 children whose mothers were self-employed, 19 (70.1 %) were positive for *Tinea capitis* while 28 out of 33 (84.8 %) were observed in children whose mothers were retired. However the highest prevalence of *Tinea capitis* (66/67) was observed in children whose mothers were unemployed. The employment status of the mother was found to be a significant risk factor to *Tinea capitis* infections in the children ($\chi^2 = 52.056$, $df = 3$, $P < 0.001$).

4.3.1.3 Approximate monthly income levels of the family in Kenya shillings (Ksh) and prevalence of *Tinea capitis* in children aged 3-14 years in Mathare informal settlement

Monthly income levels of the family had a significant influence on the prevalence rates of *Tinea capitis* in children ($\chi^2 = 237.170$, $df = 4$, $p < 0.001$) (Table 4.3). The greatest percentage of the families 82 (54.7 %) reported to have an income of less than Ksh 5,000 per month, 30 (20 %) earn an income of more than Ksh 5,000 but less than Ksh 10,000 per month while 21 (14 %) earn an income of between Ksh 10,000 and 15,000 per month. Only 12 (8.0 %) of the families earn more than Ksh 15,000 but less than Ksh 20,000 while very few 5 (3.3 %) of the families gets an income of more than Ksh 20,000 per month. However the highest prevalence (92.7 %) was observed in children whose family income levels was below Ksh 5,000.

4.3.2 Number of children in a family and prevalence of *Tinea capitis* in children aged 3-14 years in Mathare informal settlement

The largest number of children who were positive for *Tinea capitis* (76.5 %) came from families with more than eight children (Table 4.3). The other 22 % and 2 % were from families with a total number of children between 5-8 and 1-4 respectively. However the number of children in a family was not a significant risk factor to the infection among the study subjects ($\chi^2 = 3.123$, $df = 2$, $P = 0.210$).

4.3.3 Respondents' source of information on personal hygiene and prevalence of *Tinea capitis* in children aged 3-14 in Mathare informal settlement

The study showed that 36 % (54/150) of the respondents aged between 6 and 14 obtain information on personal hygiene from their teachers with majority 78 % being within the age category of 12-14 years (Table 4.3). Of the 54 respondents whose source of information was teachers, only 2 (3.7 %) were infected with *Tinea capitis*. There was no significant difference between teachers as source of information and age group of children with 78% of those whose source of information were teachers being those aged between 12-14 years mostly in standard 6-8 ($\chi^2 = 7.934$, $df = 3$, $P = 0.47$).

Other sources of information were friends (14.7 %), Health care providers (HCP) (16 %) and parents (18 %). There was no significant difference between parents as source of information and sex of children with 64 % of those whose source of information were parents being girls ($\chi^2 = 2.965$; $df = 1$; $p = 0.85$). Other sources of information accounted for 15.3 %. The source of information had no significant influence on the prevalence rates of *Tinea capitis* among the study subjects ($\chi^2 = 2.049$, $df = 4$, $P = 0.727$). However

the highest prevalence of *Tinea capitis* (70.8 %) was observed in children whose source of information was HCP.

4.3.4 Knowledge of the children on ways of transmission of *Tinea capitis* and its prevalence among the study subjects in Mathare informal settlement

With regard to transmission of *Tinea capitis*, the majority 129 (86 %) had no knowledge on the ways in which they can be infected with the ring worms of the scalp and only 21 (14%) had knowledge on how they can be infected (Table 4.3). Out of the 129 children who had no knowledge on the ways of transmission of *Tinea capitis*, 114 (88.4 %) were infected with *Tinea capitis*. Only 12 (57.1 %) out of 21 who reported to have knowledge on the ways of transmission of *Tinea capitis* were infected.

Children in the age group 12-14 accounted for 84 % of the respondents with knowledge on ways of transmission of *Tinea capitis*, the other 16 % were from age group 9-11. There was no significant difference between the knowledge on transmission of *Tinea capitis* and sex of children ($\chi^2 = 0.477$, $df = 1$, $p = 0.490$). The prevalence of *Tinea capitis* was significantly high in children who had no knowledge on ways of transmission of the infection ($\chi^2 = 21.820$, $df = 1$, $P < 0.001$).

4.3.5 Relationship between sharing of combs and towels with the prevalence of *Tinea capitis* in children aged 3-14 years in Mathare informal settlement

This study shows that 92 (61.3 %) of the respondents shared combs and bathing towels while 58 (38.7 %) did not share. Among those who shared combs and towels, 85 (92.4 %) were infected with *Tinea capitis* while 38 (65.5 %) were among those who did not share

(Table 4.3). Sharing of combs and towels was observed to be a significant risk factor to *Tinea capitis* infection among the study subjects ($\chi^2 = 18.187$, $df = 1$, $P < 0.001$).

4.3.6 Frequency of hair shaving and prevalence of *Tinea capitis* in children aged 3-14 years in Mathare informal settlement

Out of the 150 children, only 30 (20 %) of them had their hair shaved weekly, 42 (28 %) had their hair shaved after two weeks and 78 (52 %) had their hair shaved monthly (Table 4.3). Out of 30 children who shaved their hair weekly, only 19 (63.3 %) were found to be *Tinea* infected. Of the 42 who shaved their hair after two weeks, 36 (85.7 %) were infected. The highest infection 68/78 (87.2 %) was observed in children whose hair was shaved monthly. The frequency of hair shaving was found to be a significant risk factor to *Tinea capitis* infection among the study subjects ($\chi^2 = 9.876$, $df = 3$, $P = 0.020$).

4.3.7 Place of hair shaving and prevalence of *Tinea capitis* in children aged 3-14 years in Mathare informal settlement

Out of the 150 children whose samples were examined, the majority 68 (45.3 %) had their hair shaved in barber shops, 47 (31.3 %) had their hair shaved at home while 35 (23.4 %) had their hair shaving done at both home and barber shops (Table 4.3). However, the highest prevalence of *Tinea capitis* was observed in children whose place of hair shaving was barber shop (92.4 %), followed by those who shaved their hair at both barber shop and home (71.4 %). The lowest prevalence was observed in children who did their hair shaving at home (70.2 %). The place of hair shaving was found to have significant influence on the prevalence rates of the infection ($\chi^2 = 6.604$, $df = 2$, $P = 0.037$).

4.3.8 Level of knowledge of the children on ways of transmission of *Tinea capitis* and its prevalence among the study subjects in Mathare informal settlement

The findings show that, of the 21 children who reported to have knowledge on ways of transmission 6 (28.7 %) mentioned at least 3 correct methods of transmission of *Tinea capitis*. These were ranked highly knowledgeable (Table 4.4). About 13 (61.9 %) mentioned at least two correct ways of transmission and were ranked as average while only 2 (9.4 %) mentioned only one correct answer and therefore were ranked as low.

Table 4.4: Level of knowledge of the children on ways of transmission of *Tinea capitis*

Level of knowledge	Frequency	Percentage
High	6	28.7
Average	13	61.9
Low	2	9.4
Total	21	100

4.4 Dermatological agents causing *Tinea capitis* in children aged 3-14 years in Mathare informal settlement

The three genera of dermatological agents; *Microsporum*, *Trichophyton* and *Epidermophyton* were isolated and identified from the hair samples collected from the 150 children (Plate 4.1 - 4.7). Based on the colony morphology and microscopic observations, seven different species were identified. *Trichophyton tonsurans* (Plate 4.1)

grew on potato dextrose agar to produce dark-brown pigmentation with reddish brown/mahogany reverse after 14 days. In microscopy it revealed numerous microconidia of varying sizes and shapes which appeared to be formed at right angle to the hypha.

Trichophyton rubrum (Plate 4.2) produced white flat velvet colony with yellow-brown reverse after 14 days. On microscopy, numerous small pyriform microconidia were observed. *Trichophyton mentagrophytes* (Plate 4.3) grew to produce flat, white to cream and a powdery appearance with a pinkish brown reverse and single-celled spherical microconidia under microscope on the tenth day of growth. *Trichophyton mentagrophytes* was urease positive after 7 days.

The Colony of *Trichophyton verrucosum* (Plate 4.4) was identified by its slow growth in potato dextrose agar. The colony appeared small, button or disc-shaped, cream-coloured, with a suede-like to velvety surface, a raised centre, and flat periphery with a yellow reverse on the twenty first day of growth. On microscopy, it was observed to produce clavate to pyriform microconidia borne singly along the hyphae. *Microsporum gypseum* (Plate 4.5) was identified by production of a colony which was powdery with tawny buff surface and yellow brown on reverse side of the medium. On microscopy, abundant, thin and smooth walled macroconidia with 4-6 septa were observed.

Microsporum canis (Plate 4.6) produced flat, white colored with a dense cottony surface and golden yellow on reverse side of the medium after 10 days of growth. Under microscope, spindle shaped, rough and thick walled macroconidia were observed.

Epidermophyton floccosum (Plate 4.7) grew with khaki pigmentation on front and yellow brown reverse. On microscopy, large thin-walled, multicellular, club-shaped and clustered bunches of macro conidia were observed.

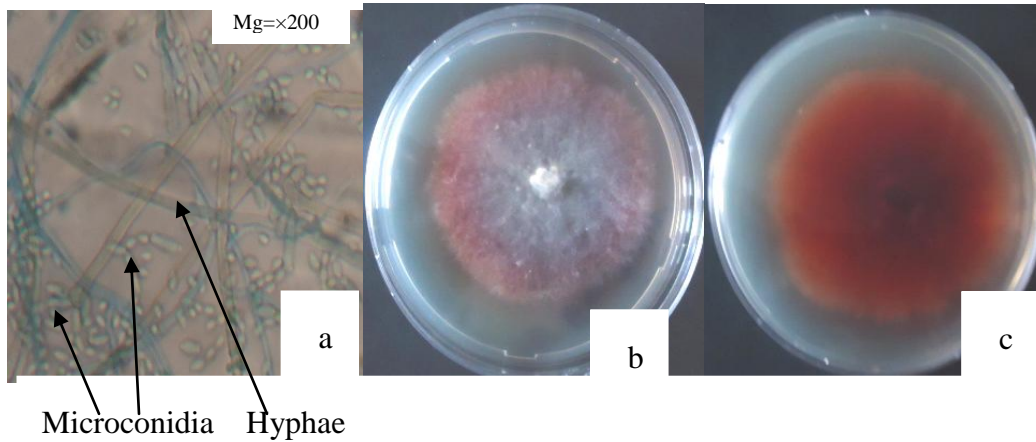


Plate 4.1: *Trichophyton tonsurans*, a; microscopy, *T. tonsurans* in culture media, b; front and c; reverse

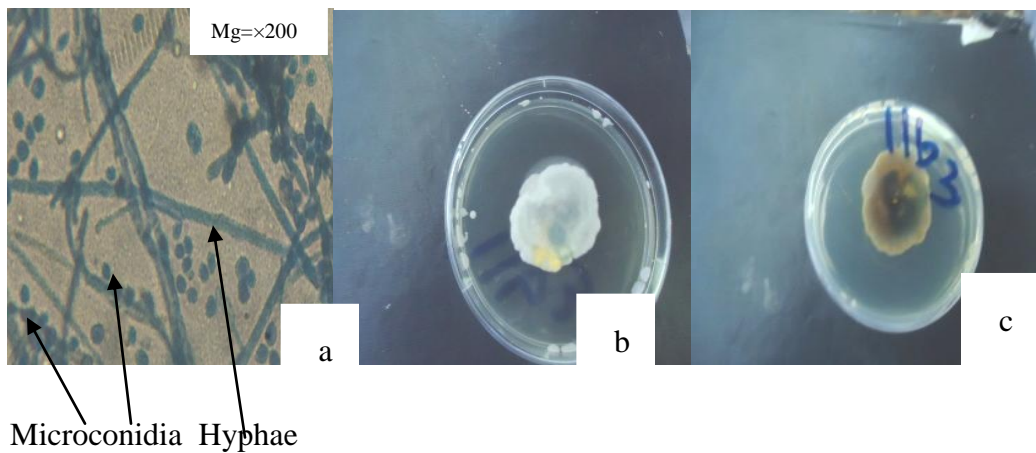


Plate 4.2: *Trichophyton rubrum*, a; microscopy, *T. rubrum* in culture media, b; front and c; reverse

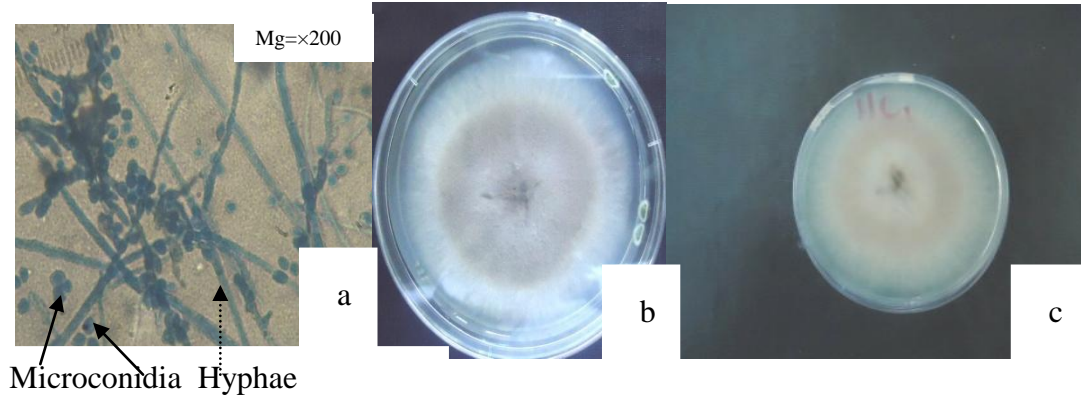


Plate 4.3: *Trichophyton mentagrophytes*, a; microscopy, *T. mentagrophytes* in culture media, b; front and c; reverse, d; urease test for *T. mentagrophytes*

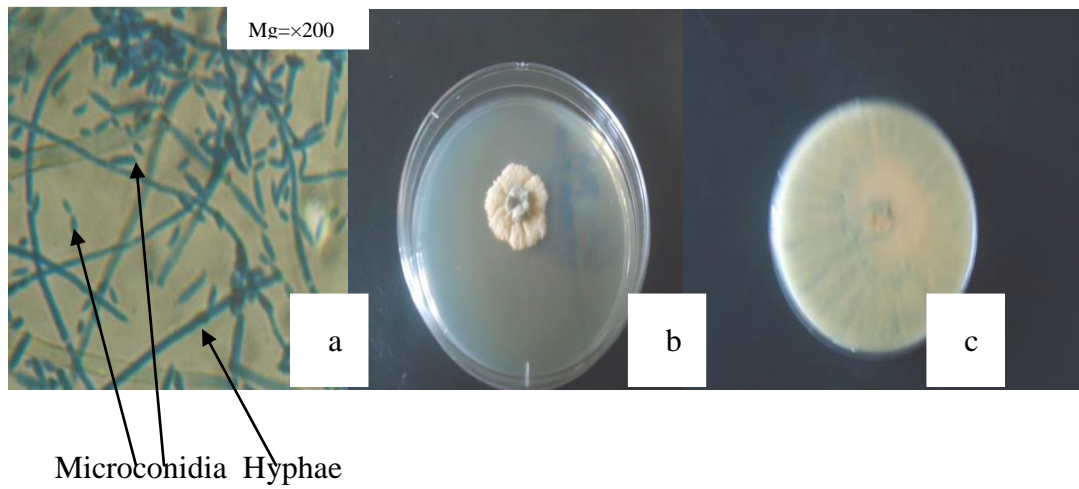


Plate 4.4: *Trichophyton verrucosum*, a; microscopy, *T. verrucosum* in culture media, b; front, c; reverse

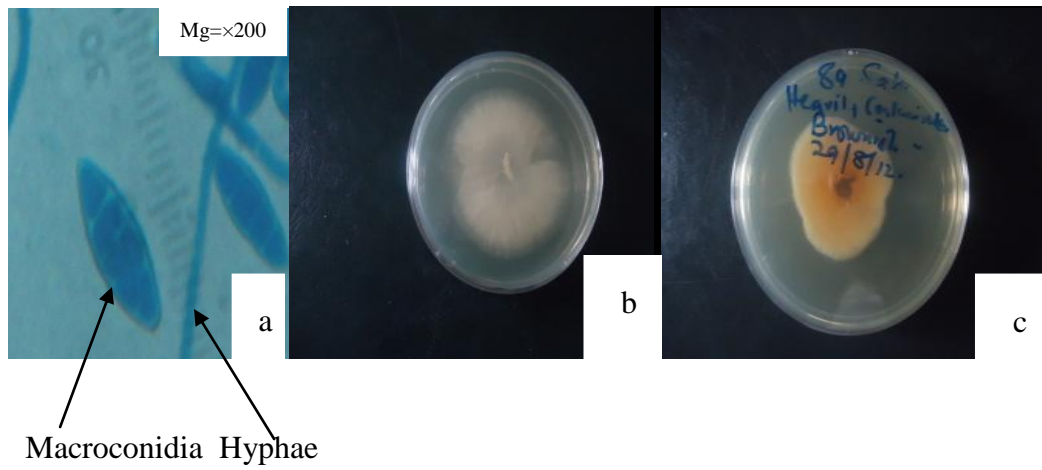


Plate 4.5: *Microsporium gypseum*, a; microscopy, *M. gypseum* in culture media, b; front and c; reverse

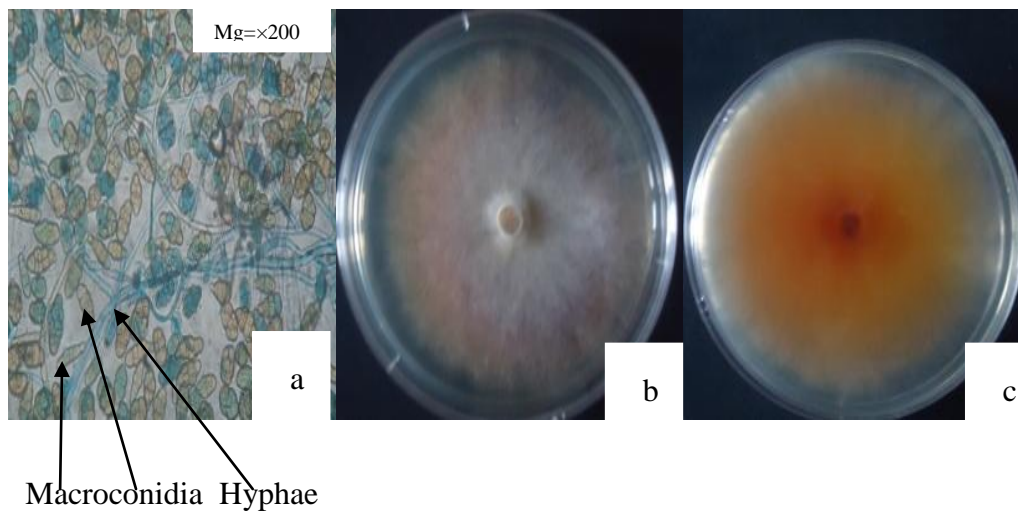


Plate 4.6: *Microsporium canis*, a; microscopy, *M. canis* in culture media, b; front and c; reverse

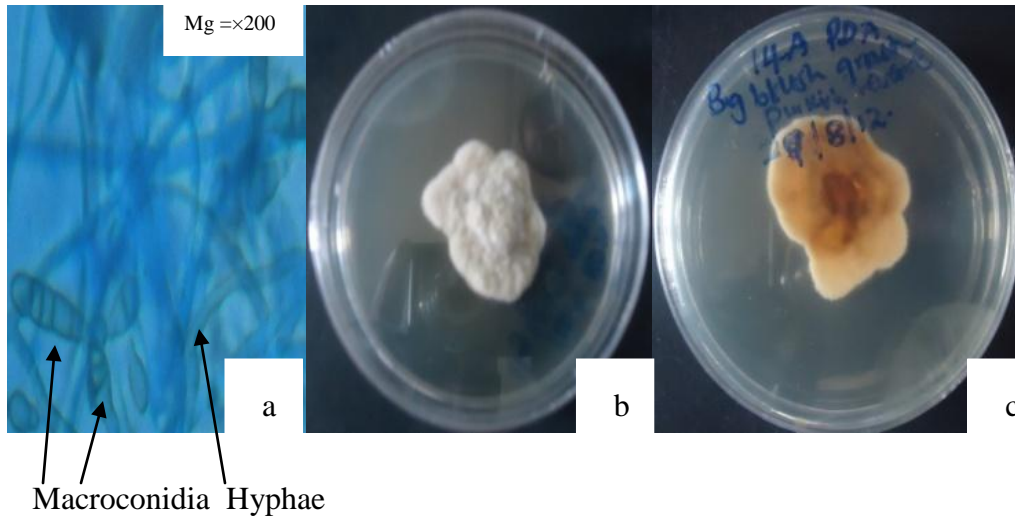


Plate 4.7: *Epidermophyton floccosum*, a; microscopy, *E. floccosum* in culture media, b; front and c; reverse

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Etiological agents of *Tinea capitis*

This study identified three genera of dermatological agents causing *Tinea capitis*. These species included; *Trichophyton tonsurans*, *Trichophyton mentagrophytes*, *Trichophyton verrucosum*, *Trichophyton rubrum*, *Microsporum gypseum*, *Microsporum canis* and *Epidermophyton floccosum*. These dermatological agents detected in this study have also been detected in previous studies carried out in Western Kenya, Libya and Nigeria on *Tinea capitis* infection (Ayaya *et al.*, 2001; Ellabib *et al.*, 2002; Enemour and Amendu, 2009).

Isolation of different species of dermatophytes varies from one ecological niche to another (Sajjan and Mangalgi, 2012). *Trichophyton tonsurans* was the most predominant species isolated in this study. This observation was also made in the previous studies carried out in Madagascar, Jamaica, Iraq and Kenya (Ayaya *et al.*, 2001; Audonneau *et al.*, 2006; East-Innis *et al.*, 2006; Al Samarai, 2007; Garg *et al.*, 2009). The reason why this dermatophyte is commonly isolated could be due to its resistance to adverse effects of environmental conditions and therefore it can stay for a long time on surfaces making it easily transferred by asymptomatic carriers. These results do not match with previous studies carried out in Pakistan, Nepal, Ethiopia, Egypt, India and Kenya (Ahmed *et al.*, 2006; Jha *et al.*, 2006; Woldeamanuel *et al.*, 2005; Chepchirchir *et al.*, 2009; Azab *et al.*, 2012; Grover *et al.*, 2012) in which *T. violaceum* was the most frequent species isolated.

T. soudanense was predominant in studies carried out in Nigeria and Gabon (Ayanbimpe *et al.*, 2008 and Hogewoning *et al.*, 2011). This difference in dermatophyte species isolated could be due to difference in geographical location and changes in climatic conditions. *M. audonii* was the most prevalent species noted in India and Nigeria (Avasn *et al.*, 2008 and Emele and Oyeka, 2008). *M. canis*, as the frequent isolate has been reported in Egypt (Amer *et al.*, 2007) while *T. mentagrophytes* and *T. verroccusum* were common in studies conducted in India and Iran (Yazdanfar, 2010; Bose *et al.*, 2011).

The etiological agents of *Tinea capitis* vary from one geographical location to another. In Sub-Saharan West Africa, *Microsporum audouinii* and *Trichophyton soudanense* have been isolated (Ayanbimpe *et al.*, 2003; Anosikke *et al.*, 2005) In the Western regions of the world, *Trichophyton tonsurans* has emerged the predominant cause of tinea (Hay *et al.*, 1996; Warnock and Campbell, 1996; Gupta *et al.*, 1998; Timen *et al.*, 1999; Ghannoum *et al.*, 2003,). In a previous study conducted in Kisumu in Western part of Kenya, the etiological agents isolated were *T. violeceum*, *M. audonii* and *M. canis* which are zoophilic organisms (Schmeller, 1998).

T. tonsurans was the most commonly isolated organism in this study and this is similar to the findings in the Western regions of the world and previous study conducted in Kenyan school children in Eldoret (Elewski, 2000; Ayaya *et al.*, 2001). This distribution pattern of dermatophytes infection in different parts of the world has been attributed to factors such as climate, life-style, and prevalence of immunodeficiency diseases in the community and also the reluctance of patients to seek treatment because of

embarrassment or minor nature of disease unless the condition becomes sufficiently serious to affect the quality of life (Hashem al sheikh, 2009).

5.1.2 Prevalence of dermatological agents causing *Tinea capitis* in children aged 3-14 years

The prevalence of *Tinea capitis* in a particular area depends upon the environmental conditions, personal hygiene and individual susceptibility. The isolation of different species of dermatophytes also varies from one ecological niche to another, depending on their primary natural habitat (Alsamaria, 2007). Findings from this study showed that *Trichophyton* species, *Microsporum* species and *Epidermophyton* species were endemic in the study area with varied prevalence. A trend that is similar to those previously observed from other communities in tropical Africa (Enweani *et al.*, 1996; Ayaya *et al.*, 2001; Hogewoning *et al.*, 2013).

The prevalence of *Tinea capitis* (82 %) was higher than those obtained among Ethiopian primary school children (59 %) (Woldeamanuel *et al.*, 2005); Tanzania (4 %) (WHO, 2005) and (33.3 %) Kenya (Ayaya *et al.*, 2001). The observed high prevalence could be due to the fact that, the current study considered both symptomatic and asymptomatic cases and also could be associated with high population growth hence frequent contact with infected individuals coupled with low income levels of the people in the informal settlement. The prevalence varied with sex and age. Males were highly infected compared to girls. The high rates of hair cuts by boys from non specific barber shops and frequent use of combs that are often shared and the heavy mingling with friends without being conscious of personal hygiene are some of the factors that could be associated with

high infection rates contrary to girls (Menan *et al.*, 2002; Adou-Bryn *et al.*, 2004; Ezeronye, 2005; Enendu and Ibe, 2005). The low prevalence rates in girls could be associated with the fact that most of the girls especially older than 13 years prefer to plait their hair rather than visiting barber shops. This could also be associated with the fact that girls practice better hair, general personal hygiene and many do carry their own weaving equipment hence reducing chances of possible contact with infective agents on hair dresser's hand (Ajao and Akintunde, 2005). These findings were contrary to those obtained in Egypt and Nigeria that showed high prevalence rates among girls than boys, a difference that was not statistically significant (Omar, 2000; Anosike *et al.*, 2005). This could be associated with the fact that contrary to Kenyan girls who practiced high levels of personal hygiene, there was high prevalence of pediculosis among the females in Egypt that was an indication of poor health habits and poor hygiene among the girls than boys (Omar, 2000).

In relation to age, 3-5 and 6-8 had highest prevalence. Among the age group 6-8 years, the prevalence (77.8 %) was similar to those obtained from previous studies in Kenya and other sub-Saharan countries of 69 % to 78 % (Robertson and Wright, 1990; Ayaya *et al.*, 2001) (Table 4.1). This could be associated with poor hygiene at this age as well as the absence of saturated fatty acids that provide a natural protective mechanism against dermatophytoses (Chepchirchir *et al.*, 2009). The low number of children in the age category 12-14 who participated in the study could be associated with the fact that most of them refused to go for skin scraping despite their parents' consent.

The study also showed different prevalence of the species causing *Tinea capitis* among the study subjects in the study area. *Trichophyton* species had the highest prevalence of 61.3 %, which could be due to the fact that most of the *Trichophyton* species are anthropophilic and therefore their occurrence is high in human carriers. The *Trichophyton* species which was observed to have the highest prevalence was *Trichophyton tonsurans* (33.3 %). This could be explained by the fact that this dermatophyte is resistant to the adverse impact of external conditions and asymptomatic carriers (Kalinowska, 2012) transfer it. This rate was similar to that obtained in Nigeria (30.6 %) (Ayambimpe *et al.*, 2008) but contrarily lower than that previously obtained in Kenya (77.8 %) (Ayaya *et al.*, 2001).

For *Trichophyton mentagrophytes* (10.7 %), the findings were similar to those previously obtained in studies in other sub-Saharan countries of 7.3 % - 15.7 % (Ayambimpe *et al.*, 2008; Emele and Oyeka, 2008). However, among this genus, *Trichophyton verrucosum* and *Trichophyton rubrum* (8 %), were least isolated. These findings were similar to previous studies that have shown a lowly maintained prevalence trend of this species in Kenya and Nigeria ranging between 4 % and 9 % (Oyeka, 1990, and Ayaya *et al.*, 2001). The low prevalence of *Trichophyton verrucosum* among the children could be associated with low rates of interaction with cattle which are the reservoirs for the dermatophyte (Kalinowska, 2012) since these children mainly live in urban areas where cattle rearing is rare. The low prevalence of *Trichophyton rubrum* can be explained by the fact that *Tinea capitis* caused by *Trichophyton rubrum* is a rare event worldwide (Ziemer *et al.*, 2005).

The *Microsporum* species; *Microsporum gypseum* and *Microsporum canis* were isolated in this study. These species had a prevalence of 7.3 % and 6.0 % respectively that was similar to those previously obtained in Nigeria of 6.9 % and 7.3 % respectively (Ayambimpe *et al.*, 2008). A low prevalence of *Epidermophyton floccosum* (7.3 %) was also detected in this study. The observed rate was close to those previously obtained in Nigeria and Libya of 4.3 % and 7.0 % respectively (Enweani *et al.*, 1996; Ellabib *et al.*, 2002). *Epidermophyton floccosum* has been shown to cause sporadic cases of *Tinea capitis* (Sberna *et al.*, 1993) and asymptomatic carriage (Cuetara *et al.*, 1998). It has been further shown that changes in geographical distribution over time may be related to increasing mobility of the population hence leading to the difference in prevalence of the infection (Singal *et al.*, 2001). The existence of multiple infections in this study population could be associated with poor personal hygiene, suboptimal treatment, poor drug adherence and abject poverty that predispose one to tinea infections (Alsamaria, 2007; Magill *et al.*, 2007; Panackal *et al.*, 2009).

5.1.3 Relationship between prevalence of *Tinea capitis* and various risk factors

One of the greatest problem hindering eradication and prevention of *Tinea capitis* is the presence of healthy asymptomatic dermatophyte carriers. In this study, 43.7 % (21/48) of the children without clinical symptoms of *Tinea capitis* were healthy carriers. However, the difference among asymptomatic carriers varies highly between studies (Navarrete *et al.*, 2001). To evaluate the impact of employment status, socioeconomic status, income and number of children in the family on *Tinea capitis* infection, a comparative study was done. Employment status of the parents/ guardians was observed to have significant influence on infection rates with children from unemployed parents being highly infected.

This showed that a low socioeconomic standard could be a risk factor to *Tinea capitis* infections. The low prevalence rates among the children whose parents were employed could probably be because these parents can afford to buy their own barber machines and therefore the children do their hair shaving at home to avoid infection from nonspecific barber shops. This finding concurred with previous studies (Figuroa *et al.*, 1997; Havlickova *et al.*, 2004; Anosike *et al.*, 2005; Ogunbiyi *et al.*, 2005; Enemour and Amendu, 2009; David *et al.*, 2010; Nweke, 2010).

In this study, the number of children in a family was found to have no significant influence on prevalence rates of *Tinea capitis* ($p = 0.210$). The association with overcrowding probably stems from infectious nature of dermatophytes and sharing of towel, combs, pillows and hats leading to an increased risk of interfamilial transmission (Fathi and Al-samaria, 2000). In the current study, the prevalence of *Tinea capitis* among the study subjects was significantly related ($p < 0.001$) to the sharing of personal effects which might have largely contributed to high prevalence of the infection in children aged 3-14 years in Mathare informal settlement.

The study found knowledge on personal hygiene to be a significant risk factor ($p < 0.001$) to prevalence of *Tinea capitis* among the study subjects. This was similar to a previous study that found an association between the presence of dermatophytosis infection and the habit of hygiene (Metintas *et al.*, 2004). Majority (73.6 %) of the children did not have access to information on personal hygiene that could have highly contributed to the

infection. Children brought up in clean environments with less crowding and reliable water supply tend to suffer less from dermatophytes (Mark *et al.*, 1999).

5.2 Conclusions

- i) Based on the findings from this study, it shows that there is a very high prevalence (82%) of *Tinea capitis* infections due to *Trichophyton*, *Microsporum* and *Epidermophyton* species among school going children in informal settlement of Mathare with *Trichophyton* species being the most prevalent among the dermatological agents.
- ii) Low socio-economic background and poor personal hygiene were significant predisposing factors of *Tinea capitis* among the study subjects with communal hair shaving being the most significant risk factor to infection among boys.
- iii) The prevalence of the infection was higher in lower age groups than the upper age group of 12-14 years.
- iv) The prevalence of the infection was higher in males than in females.
- v) All the three dermatological agents causing *Tinea capitis* infection were isolated from the samples collected from both symptomatic and asymptomatic subjects.

5.3 Recommendations

- i) There is need for public awareness on the modes of spread and simple preventive measures to reduce the prevalence of *Tinea capitis* in the informal settlement.
- ii) There is a need for enforcing proper hygienic practices and education among school going children and their parents/guardian to reduce the current trend of infection in schools and by extension, the larger population.

- iii) There is need to improve the living standards of people living in informal settlement as one way to reduce the incidence of the infections in these areas.
- iv) There is need for public health personnel to check antiseptic procedures used by the barbers and advise them on the correct procedures to use in order to reduce transmission of the infection.
- v) There is need for adoption of mycological culture as the diagnostic procedure for *Tinea capitis* in hospitals, health centres and schools for both symptomatic and asymptomatic cases in order to determine the specific causative agent of *Tinea capitis* and prevent transmission due to asymptomatic carriage.

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APPENDICES

Appendix I

Questionnaire

This research is made for academic purpose. It is geared towards assessing the prevalence of ring worms of the scalp in children aged 3-14 years in Mathare informal settlements of Nairobi. The outcome will help in advising the policy makers and relevant disease control programmes on the appropriate preventive measures to undertake to prevent the infection in the area. It will also help in knowledge of the specific causal organism so as to help therapists to administer the right type of therapy. You are kindly requested to provide answers to these questions as honestly and precisely as possible. Response to these questions will be treated as confidential and your identity will not be revealed to anyone.

Thank you.

PART A: PATIENT DEMOGRAPHIC CHARACTERISTICS

(Please don't write your name)

SECTION 1(tick where appropriate)

1. AGE:

Between 3-5 years

Between 6-8 years

Between 9-11 years

Between 12-14 years

2. SEX: MALE

FEMALE

3. Class: _____

4. School: _____

5. Division: _____

6. EMPLOYMENT STATUS OF FATHER

Employed

Self employed

Unemployed

Retired

INCOME OF THE FATHER IN KSHS PER MONTH

KSH _____

7. EMPLOYMENT STATUS OF THE MOTHER

Employed

Self employed

Unemployed

Retired

INCOME OF THE MOTHER IN KSHS PER MONTH

KSH _____

8. Number of children in your family

**PART B: KNOWLEDGE ON HYGIENIC PRACTICES IN RELATION TO
TINEA CAPITIS (RINGWORM) INFECTION.**

QUESTIONS

1. Do you ever obtain information on personal hygiene? (Yes/No)

2. If yes, then where do you mostly obtain the information? (Parents, Teachers, Friends, health care providers.)(Other specify)

3. Do you share combs with your friends/siblings?(Yes/No)

4. Do you share bathing towel with your friends/ siblings?(Yes/No)

5. Where do you normally have your hair shaving?
Barber shop
Home
Both

6. How often do you shave your hair?
Weekly
After two weeks
Monthly

7. Are you aware of ways through which ringworms can infect you?(Yes/No)

8. If the answer is yes, then which methods?

Appendix II Ethical approval



KENYATTA UNIVERSITY
ETHICS REVIEW COMMITTEE

Fax: 8711242/8711575
Email: kuerc.chairman@ku.ac.ke
kuerc.secretary@ku.ac.ke
Website: www.ku.ac.ke

P. O. Box 43844
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Tel: 8710901/12

Our Ref: KU/R/COMM/51/249

Date: 30th October, 2013

Moto Jedidah Ndunge
Kenyatta University,
Department of Plants and Microbial Sciences,
P.O. Box 43844 00100-Nairobi

Dear Ms. Ndunge

APPLICATION NUMBER PKU/140/I 123 – “PREVALENCE OF TRICHOPHYTON, EPIDERMPHYTON AND MICROSPORUM SPECIES CAUSING TINEA CAPITIS IN CHILDREN AGED 3 – 14 YEARS IN MATHARE INFORMAL SETTLEMENT, NAIROBI KENYA.”- Version 2

1. IDENTIFICATION OF PROTOCOL

The application before the committee is with a research topic “Prevalence of trichophyton, epidermphyton and microsporum species causing tinea capitis in children aged 3 – 14 years in Mathare informal settlement, Nairobi Kenya” dated 25th October, 2013.

2. APPLICANT

Moto Jedidah Ndunge
Kenyatta University,
P.O. Box 43844 00100-Nairobi

3. SITE

Mathare informal settlement, Nairobi Kenya

4. DECISION

The committee has considered the research protocol in accordance with the Kenyatta University Research Policy (section 7.2.1.3) and the Kenyatta University Ethics Review Committee Guidelines, and is of the view that against the following elements of review,

- (i) Scientific design and conduct of study,
- (ii) Recruitment of research participant,
- (iii) Care and protection of research participants,
- (iv) Protection of research participant’s confidentiality,
- (v) Informed consent process,
- (vi) Community considerations.

AND APPROVED that the research may proceed for a period of ONE year from 30th October, 2013

ADVICE/CONDITIONS

- i. Progress reports are submitted to the KU-ERC every six months and a full report is submitted at the end of the study.
- ii. Serious and unexpected adverse events related to the conduct of the study are reported to this board immediately they occur.
- iii. Notify the Kenyatta University Ethics Committee of any amendments to the protocol.
- iv. Submit an electronic copy of the protocol to KUERC.
- v. Biological material obtained from participants for purposes of this study should not be transported out of the country.

When replying, kindly quote the application number above.


If you accept the decision reached and advice and conditions given please sign in the space provided below and return to KU-ERC a copy of the letter.



PROF. NICHOLAS K. GIKONYO
CHAIRMAN ETHICS REVIEW COMMITTEE



I Jedidah Ndunge Moto..... accept the advice given and will fulfill the conditions therein.

Signature.....  Dated this day of 26th November 2013.

cc. Vice-Chancellor
 Director: Institute for Research Science and Technology