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Prevalence and causative fungal species of tinea capitis among school children in Marigat, Baringo County, Kenya

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Abstract
Ringworm of the scalp (Tinea capitis) is a superficial fungal infection primarily caused by dermatophytes that invade the hair shaft. Effective elimination of the fungi is dependent on the identification of the species associated to achieve the greatest treatment of the disease. This study investigated the occurrence of dermatophytes species causing head Tinea capitis. A total of 267 pupils were sampled from nursery level to standard five (<5years to 14 years) in Marigat in Baringo County and examined for the presence of scalp disease. Infected specimens were collected from head scalps of infected children. Using sterile scalpels and forceps, infected epilated hair was cut around the scalp region, collected aseptically and wrapped in sterile aluminum foil paper. The collected samples were transported to the Kenya Medical Research Institute laboratory, Nairobi, for isolation and identification. The data on the demographic features was collected using a structured questionnaire. The data were analyzed using parametric tests employing analysis of variance test and correlation analysis. The prevalence of tinea capitis among the pupils in Marigat was 39.4%, which was found to significantly vary (p<0.05) with gender, age, class and previous history of antifungal treatments. There were significant differences in the prevalence of the fungal species causing tinea capitis among the pupils (χ^2 = 11.285, df = 3, p = 0.0027). The most predominant dermatophyte species causing tinea capitis was *Trichophyton tonsurans* (48.3%) followed by *Trichophyton mentagrophytes* (37.1%) while, *Nannizia gysea* (29.2%) was the least prevalent among the species. It is clearly indicated that there is high occurrence of tinea capitis caused by three dermatophyte species. Therefore, there is need to device mechanisms to manage tinea capitis in this area.

Keywords: Tinea capitis, prevalence, dermatophyte, causative agent, Kenya

Introduction
Fungal infections among humans are a common problem in the world and cause diseases to approximately 1.2 billion people which are estimated at 20% of the world's population Ryan *et al*. 2014 [42]. The situation is worse in the tropical areas where they are recognized as the causative agents of some of the most serious tropical diseases in both humans and animals (Guerrant *et al*. 2011) [17]. Tinea capitis is a cutaneous fungal infection (Dermatophytosis) of the scalp. The disease is primarily caused by dermatophytes in the *Trichophyton* and *Nannizzia* (ex *Microsporum*) genera that invade the hair shaft. The clinical presentation is typically single or multiple patches of hair loss, sometimes with a 'black dot' pattern (often with broken-off hairs), that may be accompanied by inflammation, scaling, pustules, and itching Freedberg, *et al*. 2003 [13]. Several species of dermatophytes are associated with tinea capitis. In Kenya, the annual cost for importing antifungals to treat fungal infections including TC is very high (Guto *et al*. 2016; Mwangi 2009) [19, 29]. This makes the problem of tinea capitis in Kenya serious. Olutoyin *et al*. (2017) [30]; Philpot, (1978) [33] have associated Tinea capitis infections with a number of factors such as virulence of the species, environmental conditions coupled with geographical region and socio-demographic. The major antropophilic tinea capitis fungal agents like *Microsporum audouinii*, *Trichophyton tonsurans* and *Violaceum sudanense* have been reported as the most prevalent in the tropics (Michaels and Del Rosso, 2012; Fuller, 2009) [27, 15].

Trichophyton tonsurans followed by *Trichophyton rubrum* infection have been reported by various researchers as the most common cause of Tinea capitis in children because of its ability to infect inside the hair follicles. In Africa Tinea capitisoccurs in the range of 10-70% of children (Coulibaly *et al*. 2018) [9].

In Kenya several reports have shown the prevalence of Tinea capitis among different children population with varying prevalence levels (Rotich 2010) [34]. Schmeller *et al*. (1997) [36] reported a prevalence of 7.8% which was associated with *Microsporum audouinii*, *Trichophyton violaceum* and *Microsporum canis* in Kisumu. In Eldoret an infection prevalence of 33.3% (Ayaya *et al*. 2001) [7], 11.2% in Kibera, Nairobi (Chepchirchir *et al*. 2009) [8], but a higher prevalence of 81.2% in Mathare an informal settlement in Nairobi (Moto *et al*. 2015) [28]. Wamalwa (2019) [38] established a Tinea capitis infection prevalence of 17.4% in Kakamega Central Sub-County which was associated with *T. tonsurans* followed by *Microsporum canis*, *Microsporum auduoinii*, *T. mentagrophytes*, *T. rubrum*, and *Epidermophyton floccosum*. The study of the causative agents of superficial mycoses in Kenya needs a further intensity because of its direct effect on the development of adequate patient diagnosis and disease control. Furthermore, prevalence and occurrence of the causative agent vary according to geographical and seasonal variation, endemicity of the disease, changes in immigration patterns and travels. The study therefore focused in establishing the prevalence and causative dermatophytic agent for Tinea capitis in primary school children in Marigat division, Kenya.

Materials and Methods

Collection and isolation of the fungal species

The specimens used for the biological evaluation were obtained from school going children in Marigat town (0° 28′ 12″ N, 35° 58′ 48″ E) of Baringo County. All the children from nursery level (4-5 years old) to standard five (14 years old) were sampled. Specimens were collected from head scalps of children.

The affected area was disinfected with 70% alcohol and left to dry. Skin scrapings from the borders of scalp lesions, were collected aseptically using sterile scalpels. Each sample was wrapped in sterile aluminum foil paper. The collected samples were transported to the Kenya Medical Research Institute (KEMRI) laboratory, Nairobi for culturing, isolation and identification of fungal species.

The fungal scrapings were immersed into 20% potassium hydroxide (KOH) for direct microscopic examination of fungal spores. Culturing was done as described by Smith and Onions (1994) [37] using Sabouraud dextrose agar (SDA) added with chloramphenicol 0.05g/mL antibiotic as described by Chepchirchir (2009) [8] and incubated at 25 °C for 48 hours. The fungal isolates were sub-cultured into Potato Dextrose agar from the primary culture and incubated at 25±2 °C for 48 hours.

Identification of tinea capitis causing fungi

For the identification of the different isolates, the isolates were inoculated onto pre-prepared potato dextrose broth medium and incubated for 3-4 weeks at room temperature (25 ± 2 °C). A thin preparation of the fungal culture was made with a drop of lactophenol cotton blue solution on a glass slide and observed under a microscope. Dermatophytes were identified using the keys of Larone (1995); Kern (1985) [25]; Frey *et al*., (1981) [14] based on macroscopic (growth characteristics and pigmentation) and microscopic morphology of conidia as visualized in microscope (x10) and (x40) objectives.

Results

Characteristics of the study population and prevalence of tinea capitis among children in Marigat division

The pupils with tinea capitis infections were clearly visible from the infection on their scalps compared with the health colleagues (Plate 1). Among the 267 pupils sampled in Marigat schools, (105) 39.4% showed infection of the scalp. From these children showing mycological symptoms, male pupils were 58.1% and female were 39.9%, the prevalence of tinea capitis was found to differ significantly ($p < 0.05$) with gender, age, class and use of antifungal treatments. The diagnosis of tinea capitis among the infected pupils showed that the male pupils (46.4%) had higher prevalence than female (30.3%). On the other hand, tinea capitis appeared to decline with age of the pupil. The highest prevalence of 619% was observed in children below 5years, while lowest was recorded in pupils above 14 years. In regard to the level of class the prevalence of the diagnosed tinea capitis infection among the nursery school pupils was significantly (47.6%) compared to other classes. It was further noted that size of the family had no significant difference ($p < 0.05$) in the prevalence of tinea capitis. Overwhelmingly the number of pupils' not using antifungal treatments had the highest prevalence (79.7%) of tinea capitis among the sample subjects whereas, 19.7% of the pupils with infection reported a previous history of antifungal agents use (Table 1).

Plate 1: a) Back side of infected head, and (b) uninfected child's head of non-inflammatory scalp ringworm in Marigat.

Table 1: Prevalence of tinea capitis among children of different ages and sex

Parameter Category		Number of pupils infected	Prevalence (%)	χ^2	p-value
Gender	Male	26	46.4	14.443	0.0004
	Female	10	30.3		
Age (yrs)	<5	13	61.9	25.442	0.0000
	5-10	13	31.0		
	10-14	5	33.3		
	>14	2	26.1		
Class	Nursery	10	47.6	22.265	0.0043
	1	7	53.8		
	2	5	45.5		
	3	7	33.3		
	4	8	25.8		
	5	3	30.0		
	6	1	33.3		
Family size	< 2	4	44.4	4.236	0.0922
	2-5	13	27.7		
	6-10	8	36.4		
	>10	5	45.5		
Use antifungal drugs	Yes	2	16.7	115.442	0.0000
	No	46	59.7		

Prevalence of fungal species responsible for tinea capitis infection in Marigat

Trichophyton mentagrophytes, *Trichophyton tonsurans* and *Nannizia gypsea* were the three fungal species isolated from children attending primary school Marigat division. There were significant differences in the prevalence of the fungal species causing tinea capitis among the pupils (χ^2 = 11.285, df = 3, p = 0.0027). The most prevalent species causing tinea capitis was *T. tonsurans* (48.3%) followed by *T. mentagrophytes* (37.1%) while *N. gypsea* was the least prevalent among the species found (29.2%) (Fig.1). *T. mentagrophytes* was a rapid grower compared to the other fungi isolated. The morphological characteristics varied from fluffy white, velvety white and buff to cinnamon for *T. mentagrophytes*, *T. tonsurans* and *N. gypsea*, respectively. Microconidia were abundant in all the isolates, though with varying morphological structures.

Table 2: Characteristics of the identified species of fungi causing tinea capitis

Fungal species isolated	Growth rate	Colony morphology		Microscopy	
		Surface	Underside	Macroconidia	Microconidia
T. mentagrophytes	Rapid	Fluffy white becoming yellow	Pink turning reddish brown	Cylindrical and few	Small and round along hyphae
T. tonsurans	Moderate	Velvety white, raised folds	Yellow to brown	None	Numerous, irregular size. Some attached to branched conidiophores
N. gypsea	Moderate to rapid	Buff to cinnamon, sometimes pink	Buff to pinkish buff	Abundant, elliptical with thin, roughened walls and 4 -6 septa, with terminal filament	Usually sparse, clu-shaped, born along the sides of the hyphae.

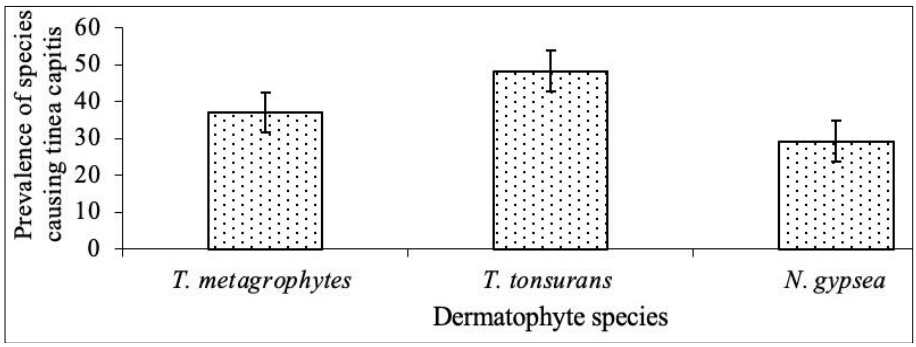

Fig 1: The prevalence of tinea capitis species among children attending Marigat division

The age wise prevalence of dermatophytes infecting children in Marigat

Trichophyton tonsurans was most prevalent across all the age bracket under investigation but was highest in the ages less than 5 years, followed by ages between 10 and 14 years old (Fig. 2). *T. mentagrophytes* and *N. gypsea* were not present in children over 14 years, but *T. mentagrophytes* occurred at the highest frequency in children aged 5 to 10 years.

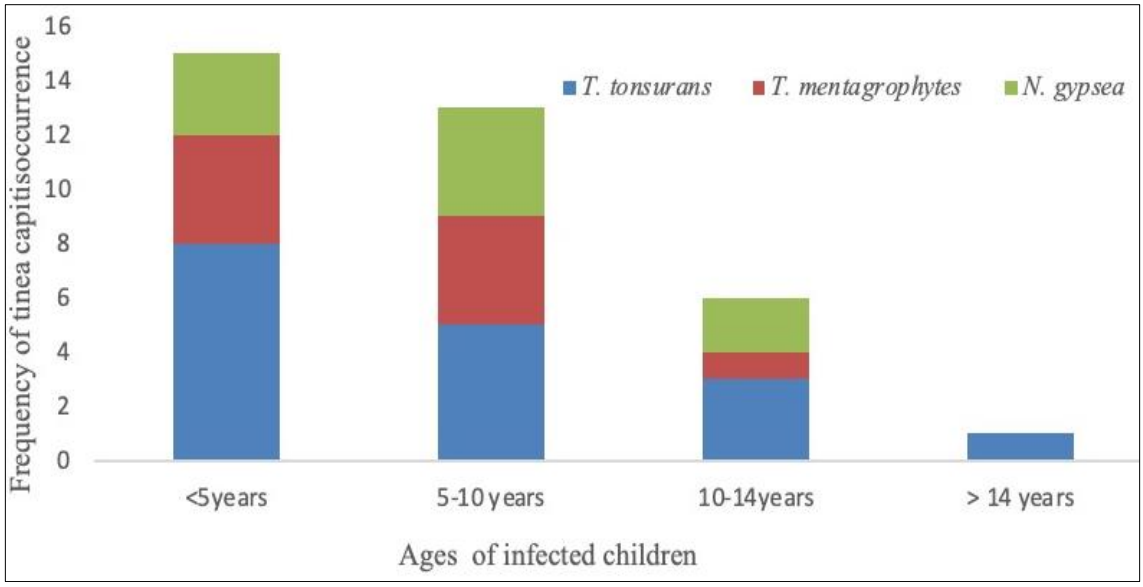

Fig 2: The age wise distribution of dermatophytic pathogens infecting children in Marigat

When the sex was considered against the occurrence of individual taenia capitis causal agent, *T. mentagrophytes* was found occurring equally in both sexes, however there was a significant difference in the occurrence of *T. tonsurans* between the two sexes, being more prevalent in males, and similar results were also observed in the case of *N. gypsea* as shown in Figure 3 below.

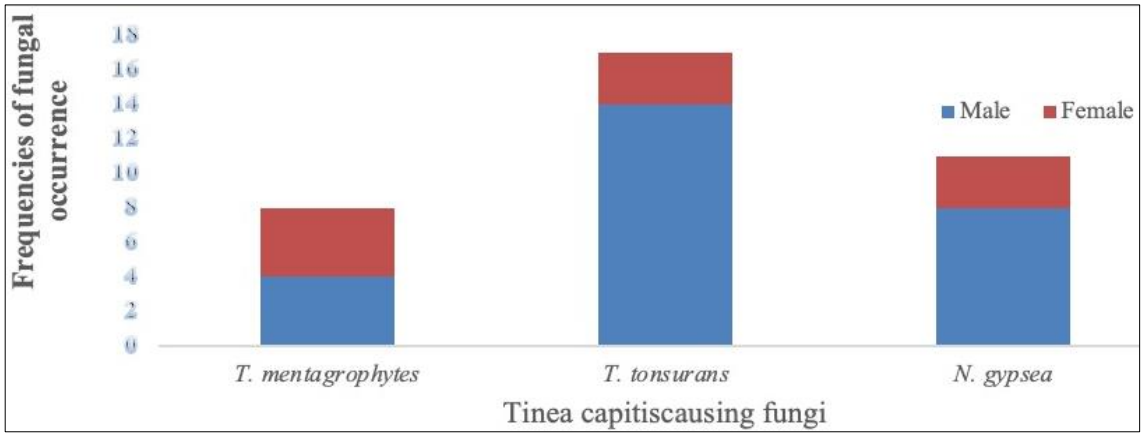

Fig 3: The distribution of dermatophytic pathogens infecting children in Marigat according to sex

Discussion

The overall prevalence of tinea capitis identified among the children in Marigat was found to be higher than the prevalence reported in some other areas in Kenya such as Kibera (Chepchirchir *et al*. 2009) [8], but lower than Mathare (Moto *et al*. 2015) [28] and Kakamega (17.4%) (Wamalwa 2019). However, it was found to be lower than those obtained in Ethiopia (59%) (Woldeamanuel *et al*. 2005) [41] and higher than Tanzania (4%) (WHO 2005) and previous findings in Kenya (33.3%) (Ayaya *et al*. 2001) [7]. This prevalence of tinea infection was also higher than what was reported in rural parts of Nigeria (Adefemi *et al*. 2011) [1], but lower than 45% reported in Nok community of Nigeria (Dogo *et al*. 2016) [11] and 59% reported by Oluwabunmi *et al*. (2019) in Osogbo in Nigeria. The high prevalence of tinea capitis in Marigat may be associated with low hygienic standards among school age pupils, aggravated by the relatively high temperatures in the study area as also observed by Dogo *et al*. (2016) [11], and the tendency of pupils to play in the soils where they acquire the fungus causing ringworm infections such as *N. gypsea* could have aggravated the high prevalence noted. This agrees with findings of Adou-Bryn *et al*. (2004) [3] in Ivory Coast, but was different from the reports of Anosike *et al*. (2005) [5] and Omar (2000) [31] in Nigeria and Egypt, respectively. However, higher prevalence than other areas in Sub-Saharan Africa may also indicate lack of medical checkups and treatments among these pupils. This was partially confirmed by the results obtained where an overwhelming number of pupils' not using antifungal treatments had the highest prevalence of tinea capitis among the sample respondents while a lower number of the pupils using antifungal agents were less infected with tinea capitis.

The prevalence of tinea capitis was found to differ significantly with gender, age, class and use of antifungal treatments. From the study the affected age bracket was between less than 5years to 14 years as shown elsewhere (Al Aboud and Crane 2021) [4]. Hay (2017) [20] reported that the tinea capitis causal fungi vary depending on the human sex type, they reported that *Trichophyton* infections affects both sexes equally during the childhood than at adult age, but reported that *Microsporum canis* affects boys than girls. Male pupils had higher prevalence of tinea capitis than females which concurs with two previous studies in Nigeria

(Adefemi *et al*. 2011) [1] and could be related to the nature of games practiced by both gender as boys are tend to prefer to play more in the soils. Boys usually cut their hair and therefore expose their heads to the fungus causing tinea capitis both from the environment and from the hair cutting equipment. On the other hand, girls had low prevalence probably due to the fact that they are more cognizant of their appearances; and as a result, they care more about personal hygiene and hair that promotes health than males (Hibstu and Kebede 2017) [21]. However, these findings were contrary to those obtained in Egypt and Nigeria where girls had high prevalence rates of infection than boys (Anosike *et al*. 2005; Omar 2000) [5, 31]. Further it differed with Moto *et al*. (2015) [28] who showed that there was no difference across the age groups in relation to infection. Tinea capitis appeared to decline with age of the pupils probably due to the less exposure of the children to the soils and other fungal agents as the children at increasing age, limit what they play with, similarly also at older ages the level of hygiene is higher than the young children.

T. mentagrophytes, *T. tonsurans* and *N. gypsea* were the three species of fungi causing tinea capitis among school going children in Marigat. *T. tonsurans* was the most prevalent species followed by *T. metagrophyte*, while *N. gypsea* was the least among the species isolated. *T. tonsurans* being the most predominant dermatophyte in this region could be due its anthropophilic nature and abundance in humans and their potential carriers as explained by Kalinowska (2012) [24]; Hogewoning *et al*. (2013) [22]; Hryncewicz-Gwóźdź *et al*. (2011) [23]. Wamalwa (2019) [38] also reported a similar trend in Kakamega, Kenya. Dei-Cas *et al*. (2019) [10], reported that tinea capitis is caused primarily by Microsporum and Trichophyton dermatophic species. There was however higher presence of *T. mentagrophytes* compared to the previous reports from Kenya which could be attributed to nature of the livelihoods of the community of Marigat, being pastoralists and children tend to assist in animal rearing exposing to close proximity with these livestock, thereby may acquire this zoophilic dermatophyte. This is collaborated with reports of the ease of the dermatophyte transmission to humans from animals and preference to young children (Gnat *et al*., 2019; Guo *et al*., 2020) [16, 18]. However, the prevalence levels of the *T. mentagrophytes* in Marigat was lower than previous reports of Ayanlowo *et al*. (2014) [6] in Nigeria. Similarly, the findings of P´erez-Tanoira *et al*. (2017) [32] in Ethiopia appear to agree with the present results, but partially agrees with Moto *et al*. (2015) [28] as a mixed infection of *Trichophyton* and *Microsporum* species, and Adesiji *et al*. (2019) [2] in Osogbo in Nigeria who reported that *T. rubrum* was the most prevalent. *T. rubrum* was not found among the infecting dermatophytic fungi in children of Marigat in the study period similar to *Epidermophyton* species.

Conclusion

The prevalence of tinea capitis among the pupils in Marigat division was 39.4%, which was found to significantly vary with gender, age, class and antifungal treatments. *T. mentagrophytes*, *T. tonsurans* and *N. gypsea* were the three species of fungi reported to cause tinea capitis in Marigat division. *T. tonsurans* was more prevalent compared to the other two species. Researchers and medical health personnel need to device mechanisms to manage tinea capitis in areas in Marigat because of its prevalence in Marigat Kenya.

Acknowledgments

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Ethical considerations

Permission to access the children with visible head ringworms (tinea capitis) was requested and granted by the Ministry of Education through the Head teacher. Who then notified their parents or guardians of the pupils falling in the sampling criterion and signed an acceptance consent. Ethical certification was obtained from the local Medical Officer of Health through the ethical review committee for consideration of the research ethics. Further the permission of the pupils was then sought through verbal explanation, who then volunteered for sampling. Details of the pupils concerning extend of tinea capitis infection, treatment, history and their levels of hygiene were kept confidential only between the research subjects and the investigators.

Data Availability

The data used to generate this information and findings are readily available with the author and can easily be accessed on request.

Conflict of Interest

The authors categorically declares that the work does not have financial and/or non-financial conflicting or competing interest. Therefore, no conflict of interest in this publication whatsoever. All the work was funded by the authors and hence fully owned by the authors.

Authors contribution

The present study was fully conducted by the authors, Kugui participated in data collection, isolation, analysis and manuscript development. Kipsumbai participated in data collection, identification and manuscript development, Chemoiwa participated in data collections, analysis and manuscript development while Kiprop participated in identification and manuscript development and editing.

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