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REVIEW ARTICLE

Estimation of the burden of tinea capitis among children in Africa

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Abstract

Tinea capitis is a common and endemic dermatophytosis among school age children in Africa. However, the true burden of the disease is unknown in Africa. We aimed to estimate the burden of tinea capitis among children <18 years of age in Africa. A systematic review was performed using Embase, MEDLINE and the Cochrane Library of Systematic Reviews to identify articles on tinea capitis among children in Africa published between January 1990 and October 2020. The United Nation's Population data (2019) were used to identify the number of children at risk of tinea capitis in each African country. Using the pooled prevalence, the country-specific and total burden of tinea capitis was calculated. Forty studies involving a total of 229,086 children from 17/54 African countries were identified and included in the analysis. The pooled prevalence of tinea capitis was 23% (95% CI, 17%–29%) mostly caused by *Trichophyton* species. With a population of 600 million (46%) children, the total number of cases of tinea capitis in Africa was estimated at 138.1 (95% CI, 102.0–174.1) million cases. Over 96% (132.6 million) cases occur in sub-Saharan Africa alone. Nigeria and Ethiopia with the highest population of children contributed 16.4% (*n* = 98.7 million) and 8.5% (*n* = 52.2 million) of cases, respectively. Majority of the participants were primary school children with a mean age of 10 years. Cases are mostly diagnosed clinically. There was a large discrepancy between the clinical and mycological diagnosis. About one in every five children in Africa has tinea capitis making it one of the most common childhood conditions in the region. A precise quantification of the burden of this neglected tropical disease is required to inform clinical and public health intervention strategies.

KEYWORDS

aetiology, Africa, children, dermatomycoses, prevalence, tinea capitis

JEL CLASSIFICATION

D03

PROSPERO Registration Number: CRD4202018972

1 | INTRODUCTION

Tinea capitis, also known as scalp ringworm, is a highly contagious superficial fungal infection of the scalp and its associated hair follicles, occurring predominantly in children under 12 years of age.[1,2] Tinea capitis occurrence is not recorded by global or public health agencies; hence, the true burden is unknown.[3]

Majority of the cases reported are of children, and the mean age of onset is in patients aged between 3 and 7 years living in Africa or of sub-Saharan African descent living abroad.[4,5] It is highly neglected and under-reported in Africa. Determinants of the presence of tinea capitis include low socio-economic status, high population densities and poor health practices.[3]

Dermatophytes causing tinea capitis are classified as anthropophilic, zoophilic and geophilic dermatophytes depending on whether they are transmitted from one infected human to another, acquired through contact with infected animals or contracted from contaminated soil or fomites, respectively.[6] Anthropophilic dermatophytes are associated with endemic infections, while zoophilic and geophilic dermatophytes are more sporadic.[6] A clear understanding of how tinea capitis is transmitted is essential in preventing the disease.

While an earlier study showed that dermatophytosis occurs in between 10% and 70% of children throughout Africa, with tinea capitis being the most common presentation,[7] an accurate estimate of the true burden in Africa remains unknown. A precise quantification of the burden of this neglected tropical disease is required to inform clinical and public health intervention strategies. This study aimed at determining the prevalence and aetiology of tinea capitis in Africa.

2 | MATERIALS AND METHODS

2.1 | Study design

This was a systematic review and meta-analysis whose protocol was developed in accordance with recommendations by Meta-analyses Of Observational Studies in Epidemiology (MOOSE)[8] and The Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) checklists.[9] The protocol for this systematic review and meta-analysis was registered by PROSPERO database (CRD42020189727) and published in a peer-reviewed journal.[10]

2.2 | Search Strategy

The search was conducted by systemically identifying articles published from January 1990 to October 2020. We explored databases such Embase, MEDLINE and the Cochrane Library of systematic review for eligible studies. We restricted the languages to English and French since they are the main national languages in most African countries. Age for children was restricted to zero (0) to 17 years. We identified and refined MeSH (Medical Subject Headlines used for indexing articles in PubMed) search terms such as "tinea capitis," "dermatophytes," "dermatophytosis," "scalp infections," "scalp ringworms," "*Trichophyton*," "*Microsporum*," "*Epidermophyton*," "*Nannizzia*," "*Arthroderma*," "burden," "prevalence," "incidence," AND "children," OR "age <18 years" AND "Africa" or each of the individual 54 countries of Africa. The search terms were translated into French and then further refined to facilitate search in other databases.

Authors of eligible articles that only had abstracts provided were contacted. A bilingual scientist translated all the eligible French articles into English for review and data extraction. Furthermore, we performed a manual literature search on all citations that met the inclusion criteria for our study.

2.3 | Study selection and inclusion criteria

The research studies were run through Healthcare Databases Advanced Search (National Institute for Health and Care Excellence, UK) programme in order to remove duplicate research articles. Initially, two reviewers (FB and LR) independently screened the titles and abstracts to rule out articles that were irrelevant to the study purpose. Thereafter, the full texts of potentially eligible papers were retrieved and discussed by the authors. Any disagreements about eligibility of the articles for the study were resolved by consensus-based discussion among the authors.

The MOOSE criteria for searching and selecting observational studies were used: The following inclusion criteria were applied to identify acceptable studies:

1. Observational studies published in a peer-reviewed journal from January 1990 to October 2020 and in the English and French languages.
2. Designed as retrospective, cross-sectional or prospective observational study.
3. Among children (<18 years old) in African countries.
4. Reporting the prevalence or incidence of tinea capitis.

The following studies were excluded:

1. Case reports, case series with subjects <10, opinion papers, qualitative research, letters to the editor, comments, conference proceedings, policy papers, reviews and meta-analyses, study protocols without baseline data and animal studies.
2. Studies reporting other scalp infections.

2.4 | Data extraction and management

Data extraction was done by two independent reviewers, and the data were coded. We used a data extraction form prepared using

Microsoft Excel 2016 to collect information from all eligible studies such as year of publication, first author's name, country, sample size, population studied, study design, age range, gender distribution, incidence, prevalence, aetiology, clinical vs laboratory diagnosis and risk factors of tinea capitis. When the required data were not readily available from published articles, we requested raw data from the authors. Data extracted were reviewed by two other independent reviewers (R.O and L.N), and any disagreements were resolved by discussion.

2.5 | Study outcomes

2.5.1 | Primary outcome

Pooled prevalence of tinea capitis among children in Africa.

2.5.2 | Secondary outcome

1. Country-specific and the total number of cases (prevalence) of tinea capitis in Africa.
2. Culture-proven aetiology, reported to at least genus level.

2.6 | Quality assessment

Two authors (FB and RO) independently assessed the risk of bias in the selected studies using a modified New Castle-Ottawa scores. The reviewers assessed different components of each study such as the study design, selection bias, measurement of outcomes and the study findings. The overall study and the individual components of each study were graded into categories of low, moderate or high risk of bias. The overall grade was derived as an average of the individual components. Controversies between two reviewers were resolved through consensus or a third reviewer.

2.7 | Data synthesis and analysis

STATA V.16.0 (StataCorp LLC) software was used for data analysis. A random-effect model meta-analysis was performed using meta command for in STATA and presented as prevalence, 95% confidence intervals (CIs) and weights. A forest plot was used to present the results of the meta-analysis. Sub-group meta-analysis was also performed to assess the effect of diagnostic modalities on the pooled prevalence. A systematic descriptive synthesis was performed appropriately to complete the meta-analysis.

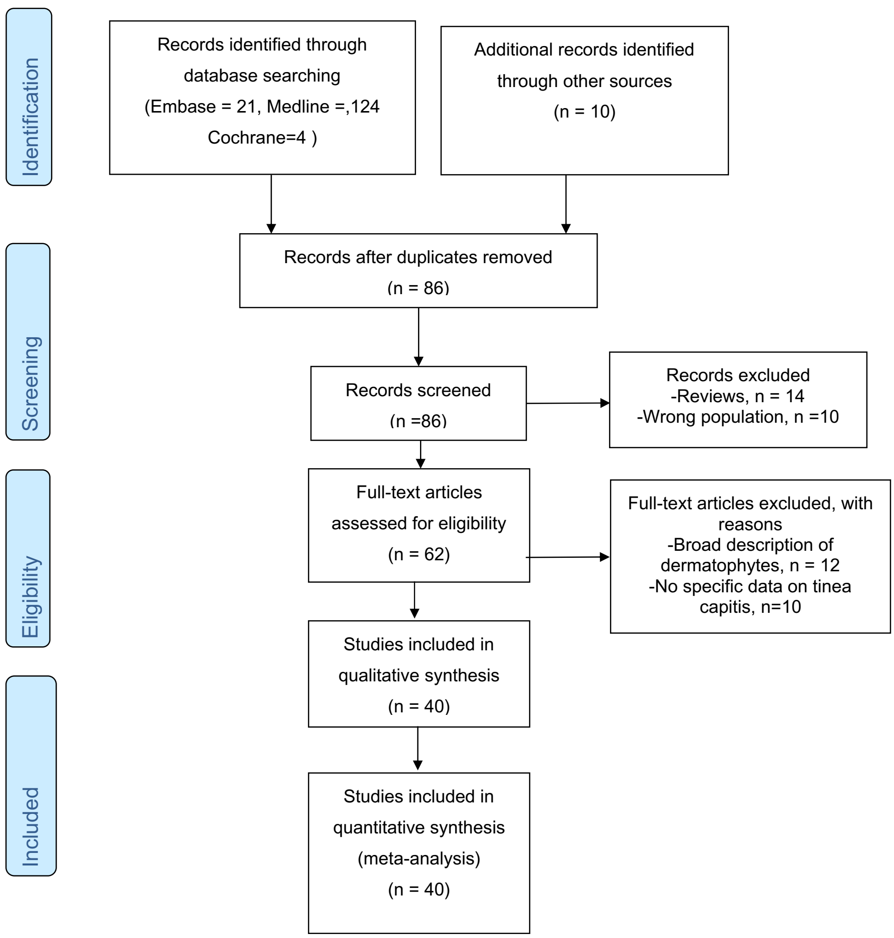

FIGURE 1 PRISMA flow diagram

TABLE 1 Selected characteristics of the 40 studies reporting the prevalence of tinea capitis in Africa

Serial number	First author (reference)	Year of publication	Country	Study design	Study period	Study population	Age	N (229,086)	Clinical diagnosis of TC; n (%)	Mycological diagnosis of TC; n (%)
1	Amiri[2]	2020	Tanzania	Cross-sectional	2013	Children from orphanage centres	Median: 11 (SD: 3.7)	144	—	115 (79.9)
2	Chikoi[13]	2018	Tanzania	Cross-sectional	2017	Primary school children	Mean: 9.92 (SD: 1.13)	500	86 (17.2)	—
3	Farag[14]	2018	Egypt	Cross-sectional	2015–2016	Primary school children	Mean: 9.88 (SD: 2.37) Range: 6–14	3464	35 (1)	31 (0.9)
4	Bassyouni[15]	2017	Egypt	Cross-sectional	2013–2014	Primary school children	Mean: 8.4 (SD: 1.8) Range: 5.5–12	12,128	49 (0.4)	25 (0.2)
5	Coulibaly[16]	2016	Mali	Cross-sectional	2010–2012	Primary school children	Mean: 9.7 (6–15)	590	232 (39.3)	189 (32)
6	Leiva-Salinas[17]	2015	Ethiopia	Cross-sectional	2012	Primary school children	Mean: 10 (SD:2.4, Range: 4–14)	647	159 (24.6)	—
7	Moto[18]	2015	Kenya	Cross-sectional	2013	Primary school children	Mean: 8.5 (SD: 1.86, Range: 3–14)	150	102 (68)	122 (81.3)
8	Ayanlowo[19]	2014	Nigeria	Cross-sectional	—	Primary school children	Mean: 8.1 (SD:3.1, Range: 20–17)	604	201 (33.3)	29 (4.8)
9	Kechia[20]	2014	Cameroon	Cross-sectional	2011–2012	Primary school children	Mean: 10.7 (SD: 0.16, 4–15)	4601	377 (8.2)	354 (7.7)
10	Oke[21]	2014	Nigeria	Cross-sectional	2011	Primary school children	Mean: 9.42 (SD: 2.00, 5–16)	800	215 (26.9)	96 (12)
11	Fulgence[22]	2013	Ivory Coast	Prospective	2008–2009	Primary school children	Range 4–16	17,745	2645 (14.9)	2458 (13.9)
12	Halim[23]	2012	Morocco	Retrospective	2002–2011	Children attended to at a hospital	Mean: 12.7	1418	260 (18.3)	229 (16.1)
13	Adefemi[24]	2011	Nigeria	Cross-sectional	2005	Primary school children	5–16	602	—	137 (22.8)
14	Hogewoning[25]	2011	Gabon	Cross-sectional	2005	Primary school children	4–17	454	105 (23.1)	74 (16.3)
15	Hogewoning[25]	2011	Ghana	Cross-sectional	2004	Primary school children	4–16	463	39 (8.4)	31 (6.7)
16	Hogewoning[25]	2011	Ghana	Cross-sectional	2007	Primary school children	4–20	1394	121 (8.7)	—
17	Hogewoning[25]	2011	Rwanda	Cross-sectional	2007	Primary school children	4–20	2528	522 (20.6)	—
18	Ali[26]	2009	Ethiopia	Cross-sectional		Primary school children	Median: 10 (5–15)	372	—	87 (23.4)
19	Nzenze-Afene[27]	2009	Gabon	Cross-sectional	2004	Primary school children	Mean: 10.6 (3–17)	794	185 (23.3)	124 (15.6)
20	Wokoma[28]	2009	Nigeria	Cross-sectional	—	Primary school children	5–13	1320	73 (5.5)	—

(Continues)

TABLE 1 (Continued)

Serial number	First author (reference)	Year of publication	Country	Study design	Study period	Study population	Age	*N* (229,086)	Clinical diagnosis of TC; *n* (%)	Mycological diagnosis of TC; *n* (%)
21	Wokoma[29]	2009	Nigeria	Cross-sectional	2007	Primary school children	6–10	1441	176 (12.2)	—
22	Ayanbimpe[30]	2008	Nigeria	Cross-sectional	2004	Primary school children	3–16	28,505	796 (2.8)	248 (0.9)
23	Emele[31]	2008	Nigeria	Cross-sectional	2002–2005	Primary school children	2.5–15	47,723	4498 (9.4)	502 (58.9)
24	Benmously-Mlika[32]	2007	Tunisia	Retrospective	2000–2006	Children attended to at a hospital	<18	71,586	—	204 (0.3)
25	Nnoruka[33]	2007	Nigeria	Cross-sectional	2005	Primary school children	Mean: 8.4 (SD: 1.3, 4–17)	287	139 (48.4)	206 (71.8)
26	Sidat[34]	2007	Mozambique	Cross-sectional	2001	Primary school children		1149	110 (9.6)	100 (8.7)
27	Contet-Audonneau[35]	2006	Madagascar	Cross-sectional	2002	Primary school children	6–14	210	83 (39.5)	17 (8.1)
28	Sidat[36]	2006	Mozambique	Cross-sectional	2001	Primary school children		685	67 (9.8)	66 (9.6)
29	Woldeamanuel[37]	2005	Ethiopia	Cross-sectional	2000	Primary school children		948	578 (61)	—
30	Woldeamanuel[38]	2005	Ethiopia	Cross-sectional	2001	Children living on an island	4–15	171	104 (60.8)	—
31	Bamba[39]	2003	Ivory Coast	Cross-sectional	2001	Primary school children	5–15	535	146 (27.3)	144 (26.9)
32	Menan[40]	2002	Ivory Coast	Cross-sectional	1998–1999	Primary school children	Mean: 9.8 (SD: 3.8, 4–15)	1913	227 (11.9)	217 (11.3)
33	Ayaya[41]	2001	Kenya	Cross-sectional	—	Primary school children	Mean: 9.6 (6–14)	164	68 (41.5)	52 (31.7)
34	Maiga[42]	2001	Mali	Cross-sectional	—	Primary school children	Mean: 10 (SD: 2.3, 5–20)	15,553	—	515 (3.3)
35	Vandemeulebroucke[43]	1999	Mali	Cross-sectional	1998	Primary school children	5–16	371	46 (12.4)	90 (24.3)
36	Figueroa[44]	1997	Ethiopia	Cross-sectional	1995	Primary school children	Median: 10 (5–15)	219	63 (28.8)	35 (16)
37	Figueroa[45]	1996	Ethiopia	Cross-sectional	1992	Primary school children	Mean: 8.9 (5–16)	112	—	10 (8.9)
38	N'Dir[46]	1994	Senegal	Cross-sectional	—	Children in the community		4537	255 (5.6)	140 (3.1)
39	Oyeka[47]	1990	Nigeria	Cross-sectional	1984	Primary school children	4–18	1555	300 (19.3)	158 (10.2)
40	Robertson[48]	1990	Zimbabwe	Cross-sectional	—	Primary school children		704	204 (29)	175 (24.9)

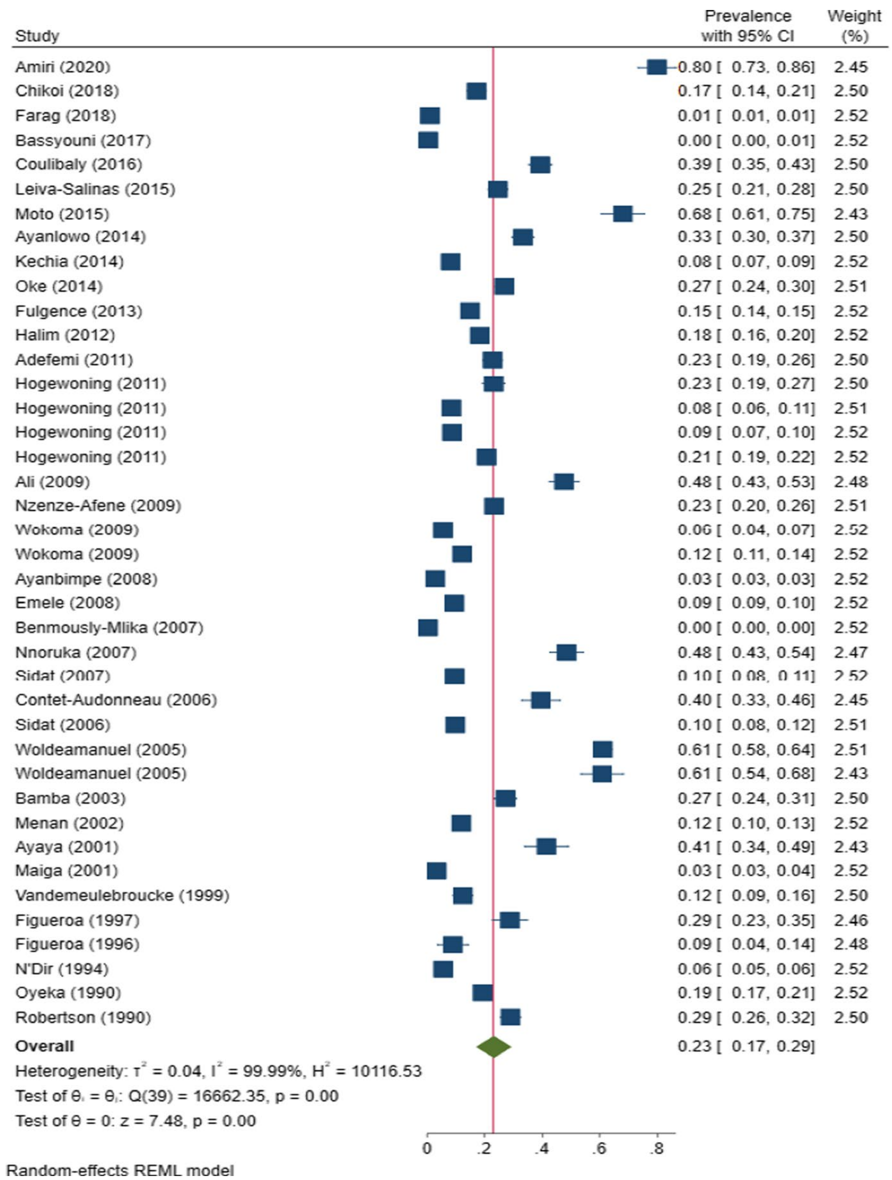

FIGURE 2 Meta-analyses of the pooled prevalence of tinea capitis among children in Africa

Heterogeneity of studies was assessed using *Q* statistics; I^2 and *p*-value were used to report heterogeneity between studies. Bias secondary to small study effects was investigated using funnel plots and the Egger test. A $p < .05$ was considered statistically significant.

2.8 | Burden of tinea capitis in Africa

Using individual country population estimates from the United Nations Development Programme database (2019),[11,12] the burden of tinea capitis was estimated by determining the population of children (ages <18 years) in each of the 54 countries within Africa (at risk population). This was then multiplied by the pooled prevalence of tinea capitis derived from the meta-analysis, and sensitivity analysis was done at 95% CIs of the pooled prevalence.

2.9 | Ethics statement

No ethical approval was required for this study as the underlying data were retrieved from publicly available sources.

3 | RESULTS

3.1 | Study characteristics

Forty studies involving a total of 229,086 individuals from 17 countries of Africa were included in the analysis (Figure 1). The median number of participants per study was 749 (range 112–71,586) children. Majority (66.0%, $n = 151{,}230$) of the participants were primary school children with a mean age of 10 ± 1 years (Table 1).

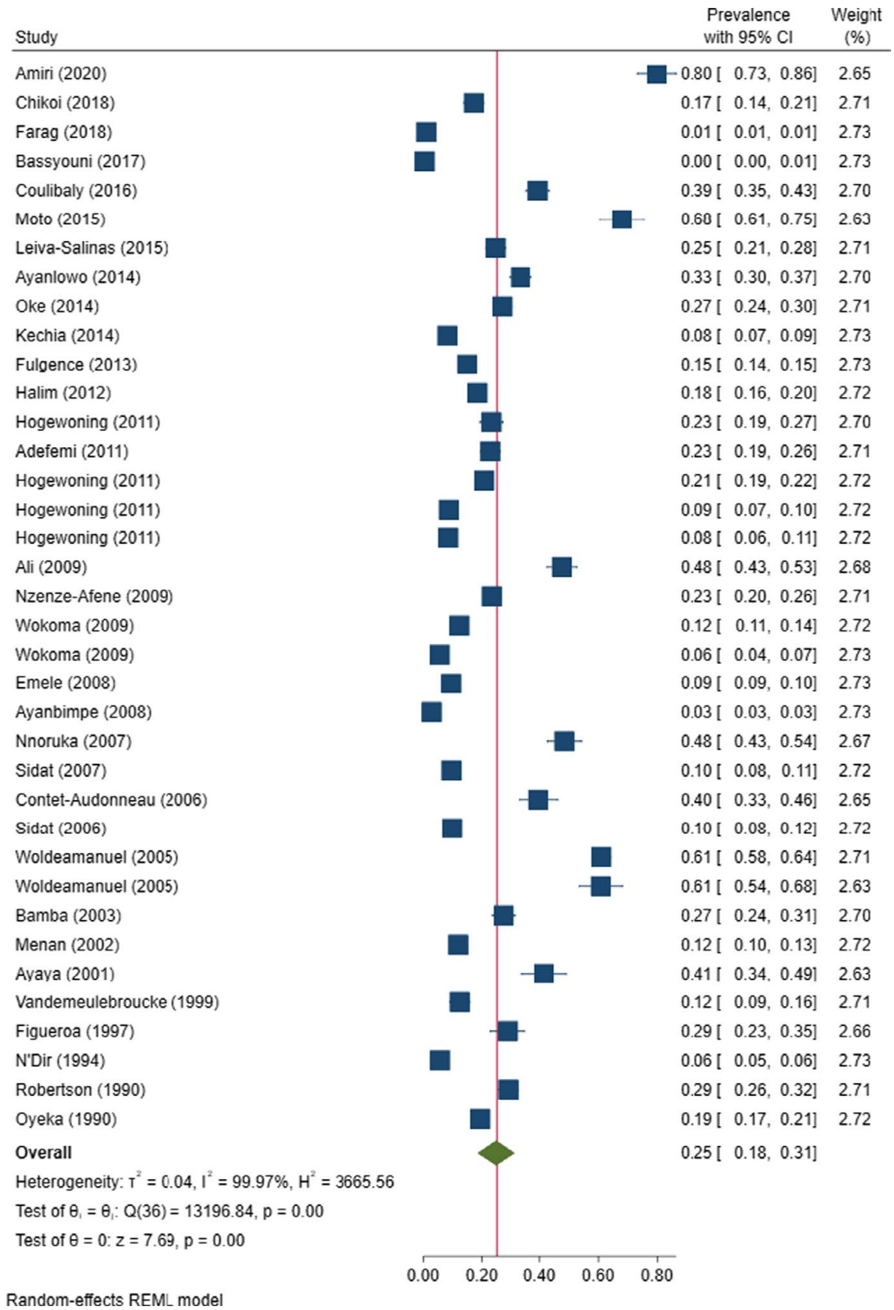

FIGURE 3 Meta-analyses of the prevalence of tinea capitis among children in Africa diagnosed clinically

Thirty-seven studies were cross-sectional (n = 138,337), two were retrospective (n = 73,004), and 1 was prospective (n = 17,745) in design (Table 1). More than one-third (15/40, 37.5%) of the studies were conducted either in Nigeria (n = 9, 22.5%) or in Ethiopia (n = 6, 15%; Table 1).

3.2 | Prevalence of tinea capitis among children in Africa

The prevalence estimates reported by the individual studies ranged from 0.003% to 79.9% for those diagnosed clinically (n = 141,835) and 0.21% to 81.3% for those diagnosed mycologically (n = 172,521; Table 1).

Meta-analytic pooling of the prevalence estimates of tinea capitis reported by 40 studies yielded an overall pooled prevalence of 23% (14,424/229,086 individuals; 95% CI, 17%–29%), with significant evidence of between-study heterogeneity (I^2 = 99.99%, $p < .001$; Figure 2). For those diagnosed clinically, the pooled prevalence was 25% (13,695/141,835 individuals; 95% CI, 18%–31%; I^2 = 99.99%, $p < .001$; Figure 3) and the pooled prevalence was 18% (6728/172,521 individuals; 95% CI, 11%–25%; I^2 = 100%, $p < .001$) children diagnosed mycologically (Figure 4). Due to the extreme heterogeneity of the included studies, sensitivity

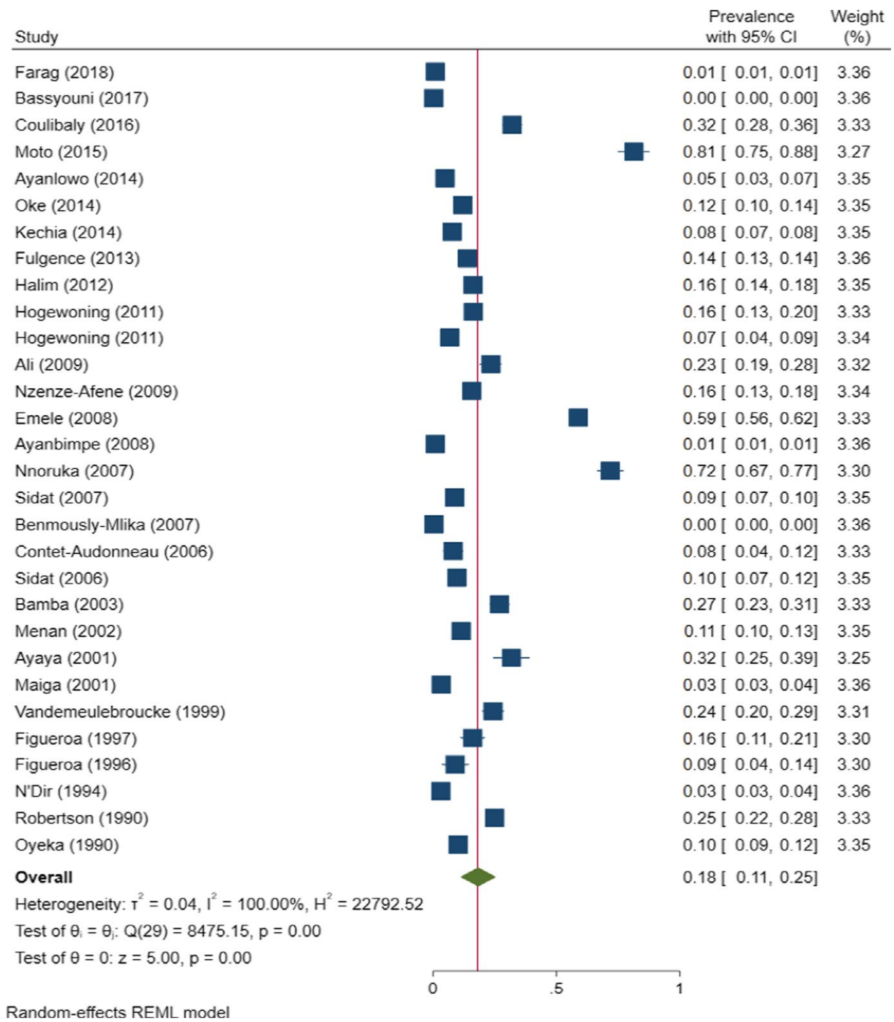

FIGURE 4 Meta-analyses of the prevalence of tinea capitis among children in Africa diagnosed mycologically

analyses were not possible as less than three studies were within the funnel plot.

3.3 | Estimation of the burden of tinea capitis in Africa

At the end of 2019, the total population of Africa was 1.3 billion with children constituting 0.6 billion (46%). Using the pooled prevalence of tinea capitis of 23%, the total burden of tinea capitis among children in Africa was calculated at 138.1 million cases. Sensitivity analyses were performed at the upper and lower limits of the 95% CI of the overall pooled prevalence (Table 2). Nigeria and Ethiopia with the highest population of children contributed 16.4% (98.7 million cases) and 8.5% (52.2 million cases), respectively. Meanwhile, Seychelles & Sao Tome and Principe with the smallest population of children contributed <0.01% (26,756 cases) and 0.02% (104,347 cases), respectively (Table 2). Regionally, 35.3% (48,747,985, 95% CI: 36,031,120–61,464,851) were from the Western African countries and 31.3% (43,148,514, 95% CI: 31,892,380–54,404,648) of the cases were from Eastern African Countries (Table 2). On further sub-analysis, the pooled prevalence of tinea capitis in sub-Saharan Africa was 25% (95% CI: 19–32) which translates to 132,588,160 cases.

3.4 | Aetiology of tinea capitis in Africa

Majority of the studies showed a predominance of dermatophyte species from the genera *Trichophyton* as the commonest causative micro-organisms of tinea capitis among children in Africa, accounting for more than two-thirds (68.9%), followed by *Microsporum* (30.9%; Table 3). Table 4 summarises the mycological aetiology of tinea capitis reported in the studies included. *Trichophyton soudanense* and *Microsporum audouinii* were significantly prevalent in studies in Western Africa, whereas *Trichophyton violaceum* and *Trichophyton tonsurans* isolates were commonly reported in children from East African countries (Table 4). *Epidermophyton* species were very rare with a few isolates reported in Kenya[18,41] and Nigeria.[28,29] In Northern Africa, *Microsporum canis*, *T violaceum* and *M audouinii* were the most common causative species.

TABLE 2 Estimated the burden of tinea capitis in Africa by region

Country	Total population	Population at risk (Age <18 years)	Burden of tinea capitis (95% confidence interval)	Proportional prevalence (%)
Central Africa				
Central African Republic	4,666,368	2,417,912	556,120 (411,045–701,194)	0.40
Congo	5,244,359	2,521,862	580,028 (428,717–731,340)	0.42
Democratic Republic of the Congo	84,068,091	44,281,520	10,184,750 (7,527,858–12,841,641)	7.38
Equatorial Guinea	1,308,975	556,105	127,904 (94,538–161,270)	0.09
Gabon	2,119,275	897,999	206,540 (152,660–260,420)	0.15
Sao Tome and Principe	211,028	104,347	24,000 (17,739–30,261)	0.02
Sub-total	97,618,096	50,779,745	11,679,341 (8,632,557–14,726,126)	8.46
Eastern Africa				
Burundi	11,175,374	5,788,501	1,331,355 (984,045–1,678,665)	0.96
Comoros	900,000	360,000	82,800 (61,200–104,400)	0.06
Djibouti	958,923	338,369	77,825 (57,523–98,127)	0.06
Eritrea	3,452,786	1,659,493	381,683 (282,114–481,253)	0.28
Ethiopia	109,224,414	52,244,045	12,016,130 (8,881,488–15,150,773)	8.70
Kenya	51,392,570	23,964,945	5,511,937 (4,074,041–6,949,834)	3.99
Madagascar	26,262,313	12,455,359	2,864,733 (2,117,411–3,612,054)	2.07
Mauritius	1,267,185	283,186	65,133 (48,142–82,124)	0.05
Rwanda	12,301,970	5,709,680	1,313,226 (970,646–1,655,807)	0.95
Seychelles	97,094	26,756	6154 (4549–7759)	0.00
Somalia	15,008,226	8,055,687	1,852,808 (1,369,467–2,336,149)	1.34
South Sudan	10,975,927	5,315,685	1,222,608 (903,666–1,541,549)	0.89
Sudan	41,801,533	19,757,691	4,544,269 (3,358,807–5,729,730)	3.29
Uganda	42,729,036	23,085,118	5,309,577 (3,924,470–6,694,684)	3.85
United Republic of Tanzania	56,313,438	28,557,721	6,568,276 (4,854,813–8,281,739)	4.76
Sub-total	383,860,789	187,602,236	43,148,514 (31,892,380–54,404,648)	31.25
Northern Africa				
Algeria	42,228,408	14,416,333	3,315,757 (2,450,777–4,180,737)	2.40
Egypt	98,423,598	38,430,438	8,839,001 (6,533,174–11,144,827)	6.40
Libya	6,678,559	2,222,512	511,178 (377,827–644,528)	0.37
Morocco	36,029,093	11,580,683	2,663,557 (1,968,716–3,358,398)	1.93
Tunisia	11,565,201	3,266,099	751,203 (555,237–947,169)	0.54
Sub-total	194,924,859	69,916,065	16,080,695 (11,885,731–20,275,659)	11.65
Southern Africa				
Angola	30,809,787	16,456,988	3,785,107 (2,797,688–4,772,527)	2.74
Botswana	2,254,068	901,084	207,249 (153,184–261,314)	0.15
Eswatini	1,136,281	510,439	117,401 (86,775–148,027)	0.09
Lesotho	2,108,328	821,519	188,949 (139,658–238,241)	0.14
Malawi	18,143,217	9,228,353	2,122,521 (1,568,820–2,676,222)	1.54
Mozambique	29,496,004	15,237,810	3,504,696 (2,590,428–4,418,965)	2.54
Namibia	2,448,301	1,048,889	241,244 (178,311–304,178)	0.17
South Africa	57,792,518	19,702,213	4,531,509 (3,349,376–5,713,642)	3.28
Zambia	17,351,708	9,033,420	2,077,687 (1,535,681–2,619,692)	1.50
Zimbabwe	14,438,802	7,082,180	1,628,901 (1,203,971–2,053,832)	1.18
Sub-total	175,979,014	80,022,895	18,405,266 (13,603,892–23,206,640)	13.33

(Continues)

TABLE 2 (Continued)

Country	Total population	Population at risk (Age <18 years)	Burden of tinea capitis (95% confidence interval)	Proportional prevalence (%)
Western Africa				
Benin	11,485,044	5,630,558	1,295,028 (957,195–1,632,862)	0.94
Burkina Faso	19,751,466	10,219,772	2,350,548 (1,737,361–2,963,734)	1.70
Cabo Verde	543,767	186,328	42,855 (31,676–54,035)	0.03
Cameroon	25,216,267	12,415,166	2,855,488 (2,110,578–3,600,398)	2.07
Chad	15,477,729	8,375,170	1,926,289 (1,423,779–2,428,799)	1.40
Côte d'Ivoire	25,069,230	12,228,478	2,812,550 (2,078,841–3,546,259)	2.04
Gambia	2,280,094	1,159,235	266,624 (197,070–336,178)	0.19
Ghana	29,767,102	13,044,637	3,000,267 (2,217,588–3,782,945)	2.17
Guinea	12,414,293	6,331,058	1,456,143 (1,076,280–1,836,007)	1.05
Guinea-Bissau	1,874,303	914,784	210,400 (155,513–265,287)	0.15
Liberia	4,818,973	2,304,900	530,127 (391,833–668,421)	0.38
Mali	19,077,749	10,367,607	2,384,550 (1,762,493–3,006,606)	1.73
Mauritania	4,403,313	2,039,972	469,194 (346,795–591,592)	0.34
Niger	22,442,822	12,732,373	2,928,446 (2,164,503–3,692,388)	2.12
Nigeria	195,874,683	98,709,274	22,703,133 (16,780,577–28,625,689)	16.44
Senegal	15,854,324	7,852,607	1,806,100 (1,334,943–2,277,256)	1.31
Sierra Leone	7,650,149	3,655,259	840,710 (621,394–1,060,025)	0.61
Togo	7,889,093	3,780,585	869,535 (642,699–1,096,370)	0.63
Sub-total	421,890,401	211,947,763	48,747,985 (36,031,120–61,464,851)	35.31
Total	1,274,273,159	600,268,704	138,061,802 (102,045,680–174,077,924)	100.00

TABLE 3 Genus-level aetiology of tinea capitis among children in Africa

Number	Author (reference)	Country	*Microsporum* spp., frequency (%)	*Trichophyton* spp., frequency (%)	*Epidermophyton* spp., frequency (%)
1	Farag[14]	Egypt	31 (100)	0 (0)	0 (0)
2	Bassyouni[15]	Egypt	22 (75.9)	7 (24.1)	0 (0)
3	Coulibaly[16]	Mali	69 (42.9)	92 (57.1)	0 (0)
4	Moto[18]	Kenya	16 (13.3)	75 (61.3)	9 (7.3)
5	Ayanlowo[19]	Nigeria	8 (27.6)	21 (72.4)	0 (0)
6	Kechia[20]	Cameroon	20 (6)	316 (94)	0 (0)
7	Oke[21]	Nigeria	44 (45.8)	52 (54.2)	0 (0)
8	Fulgence[22]	Ivory Coast	440 (21.4)	1613 (78.6)	0 (0)
9	Adefemi[24]	Nigeria	5 (16.7)	25 (83.3)	0 (0)
10	Ali[26]	Ethiopia	0 (0)	87 (100)	0 (0)
11	Ayanbimpe[30]	Nigeria	88 (35.9)	157 (64.1)	0 (0)
12	Emele[31]	Nigeria	302 (64.3)	168 (35.7)	0 (0)
13	Nnoruka[33]	Nigeria	95 (39.4)	146 (60.6)	0 (0)
14	Sidat[34]	Mozambique	60 (51.3)	57 (48.7)	0 (0)
15	Contet-Audonneau[35]	Madagascar	2 (11.1)	16 (88.9)	0 (0)
16	Sidat[36]	Mozambique	58 (72.5)	22 (27.5)	0 (0)
17	Bamba[39]	Ivory Coast	38 (27.1)	102 (72.9)	0 (0)
18	Menan[40]	Ivory Coast	78 (35.1)	144 (64.9)	0 (0)
19	Vandemeulebroucke[43]	Mali	39 (41.5)	55 (58.5)	0 (0)
	Total		1415 (30.9)	3155 (68.9)	9 (0.2)

TABLE 4 Species-level aetiology of tinea capitis among children in Africa

	Study	Country	Most prevalent Isolates (% where available)
Central Africa			
1	Nzenze-Afene[27]	Gabon	*Trichophyton soudanense* (42.6%), *Trichophyton gourvilii* (15.6%), *Trichophyton tonsurans* (4.1%), *Trichophyton violaceum* 2 (1.6%), *Trichophyton rubrum* 1 (0.8%) and *Microsporum langeronii* 25 (20.5%)
Eastern Africa			
1	Moto[49]	Kenya	*Trichophyton* spp. (61.3%), *Microsporum* spp. (13.3%) and *Epidermophyton* spp. (7.3%)
2	Woldeamanuel[50]	Ethiopia	*Trichophyton violaceum* and *Trichophyton verrucosum*
3	Woldeamanuel[38]	Ethiopia	*Trichophyton violaceum*, *Trichophyton verrucosum* and *Trichophyton tonsurans*
4	Ali[26]	Ethiopia	*Trichophyton violaceum* 86.2%, *Trichophyton verrucosum* (13.8%)
5	Ayaya[41]	Kenya	*Trichophyton tonsurans* (77.8%), *Trichophyton rubrum* (4%), *Epidermophyton flocossum*, *Trichophyton scholini*, *Trichophyton verucossum*, *Microsporum gypseum*
6	Contet-Audonneau[35]	Madagascar	*Trichophyton tonsurans* (88.2%) and *Microsporum boullardii* (11.8%)
7	Figueroa[44]	Ethiopia	*Trichophyton violaceum*, *Trichophyton schoenleinii* and *Trichophyton rubrum*
8	Figueroa[44]	Ethiopia	*Trichophyton violaceum* and *Trichophyton schoenleinii*
Northern Africa			
1	Halim[23]	Morocco	*Trichophyton violaceum* (49%) and *Microsporum canis* (36%)
2	Farag[14]	Egypt	*Microsporum canis*
3	Bassyouni[15]	Egypt	*Microsporum canis* (52%) and *Microsporum audouinii* (36%)
4	Benmously-Mlika[32]	Tunisia	*Trichophyton violaceum* and *Microsporum canis*
Southern Africa			
1	Robertson[48]	Zimbabwe	*Trichophyton violaceum* (78%) and *Microsporum audouinii* (9%). Others included *Trichophyton mentagrophytes*, *Trichophyton yaoundei*, *Microsporum gypseum* and *Microsporum canis*
2	Sidat[36]	Mozambique	*Microsporum audouinii* (86.3%) and *Trichophyton mentagrophytes* (30%)
3	Sidat[34]	Mozambique	*Microsporum audouinii* (51.3%), *Trichophyton violaceum* (43.6%), and *Trichophyton mentagrophytes* (5.1%)
Western Africa			
1	Nnoruka[33]	Nigeria	*Microsporum audouinii* (31.1%), *Trichophyton soudanense* (22.6%), *Trichophyton tonsurans* (13.2%), *Trichophyton yaoundei* (5.6%) and *Microsporum canis* (1.9%)
2	Coulibaly[16]	Mali	*Trichophyton soudanense* (36.6%), *Microsporum audouinii* (32.4%), *Trichophyton violaceum* (3.3%) and *Trichophyton mentagrophytes* (1.9%)
3	Ayanlowo[19]	Nigeria	*Trichophyton mentagrophytes* (51.7%) and *Microsporum audouinii* (20.7%)
4	Bamba[39]	Ivory Coast	*Trichophyton soudanense* 50.68%, *Microsporum langeronii* 23.29% and *Trichophyton violaceum* 17.81%. Other species included *Trichophyton rubrum* (2.74%), *Microsporum rivalieri* (2.74%), *Microsporum audouinii* (1.37%), *Microsporum ferrugineum* (0.68%) and *Trichophyton tonsurans* (0.68%)
5	Oke[21]	Nigeria	*Microsporum audouinii*
6	Adefemi[24]	Nigeria	*Trichophyton mentagrophyte* followed by *Microsporum audouinii* and *Trichophyton verucossum*
7	Oyeka[47]	Nigeria	*Microsporum audouinii* 38.0%, *Trichophyton mentagrophytes* (24%), *Trichophyton soudanense* (15%), *Trichophyton tonsurans*, (9%), *Trichophyton Schoenlenii* (9%) and *Microsporum gypseum* (5%)
8	Fulgence[22]	Ivory Coast	*Trichophyton soudanense* (56.7%), *Microsporum langeronii* (21.4%), and *Trichophyton mentagrophytes* (19.7%)
9	Vandemeulebroucke[43]	Mali	*Trichophyton soudanense* (61.1%) and *Microsporum audouinii* (43.3%)
10	Wokoma[28]	Nigeria	*Microsporum canis*, *Microsporum audounii*, *Trichophyton mentagrophytes*, *Trichophyton soudanense*, *Trichophyton tonsurans* and *Trichophyton yaoundei*, *Microsporum gypseum* and *Microsporum audouinii*, and *Trichophyton soudanense* and *Trichophyton yaoundei*

(Continues)

TABLE 4 (Continued)

	Study	Country	Most prevalent Isolates (% where available)
11	Menan[40]	Ivory Coast	*Trichophyton soudanense* (63.59%) *Microsporum langeronii* (31.34%) , *Trichophyton violaceum* (2.30%)
12	Emele[31]	Nigeria	*Microsporum audouinii* (42.2%), *Microsporum ferrugineum* (17.3%) and *Trichophyton mentagrophytes* (15.7%)
15	Kechia[20]	Cameroon	*Trichophyton soudanense* (56.8%) and *Trichophyton rubrum* (29.2%)
16	N'Dir[46]	Senegal	*Trichophyton soudanense* (80.8%), *Microsporum audouinii* (18.4%), and *Trichophyton violaceum* (0.7%)
17	Wokoma[28]	Nigeria	*Trichophyton*, *Microsporum* and *Epidermophyton* were recovered
18	Maiga[42]	Mali	*Trichophyton soudanense* (66.1%), *Microsporum langeronii* (31.6%) and *Trichophyton rubrum* (2.3%)
19	Ayanbimpe[30]	Nigeria	*Trichophyton soudanense* (30.6%), *Microsporum ferrugineum* (7.7%) and *Microsporum audouinii* (7.7%)

4 | DISCUSSION

Skin, nail and hair infections rank highly among the 10 most common disorders in the world,[51] with tinea capitis as the commonest childhood mycosis globally.[52] There has been no previous attempt to estimate the burden of tinea capitis in Africa as a whole. In the present study pooling data from 40 individual studies involving a total of 229,086 children in 17 countries of Africa over a 30-year period, the prevalence of tinea capitis was 23% translating to over 138.1 million cases This study shows that tinea capitis is a largely neglected and yet major public health problem among children in Africa requiring urgent public health interventions. Our findings are consistent with an earlier study published in 1974 which showed that the tinea capitis was widespread in Africa with prevalence ranging between 10% and 30%.[53]

The clinical manifestations of tinea capitis may range from scalp scaling and pruritus to scalp erythema, patches of alopecia, pustules and inflammatory swellings (kerions) as well as tender occipital lymphadenopathy. The large discrepancy observed between the clinical and mycological diagnosis could be due to misdiagnosis often caused by lack of local capacity for mycology leading to low index of clinical suspicion. A recent paper from Uganda showed that 8/9 dermatomycoses were clinically misdiagnosed as prurigo, leprosy, Kaposi's sarcoma or melanoma, but later identified by histology.[54] Cases were surprisingly mid-aged adults with a mean age of 28 years. Yet, tinea capitis has largely been seen as a disease of poverty, mainly occurring in children from economically disadvantaged communities where overcrowding, sharing of fomites and poor hygiene are common.[3,55] High frequency of tinea capitis is observed in children between the age of 6–12 years, with male predominance.[49] A study from Ivory Coast reported that boys were eight times more likely to have tinea capitis than girls.[40] In our study, the mean age was about 10 years. Children of this age tend to exhibit poor hygiene practices and do have less or absent cutaneous saturated fatty acids that provide a natural protective mechanism against dermatophytes.[56] Untreated tinea capitis is associated with social stigmatisation, low quality of life and may result in complications such as scarring alopecia.[57]

Individual country burden of tinea capitis has been published for several countries through the Leading International Fungal Education (LIFE) project.[58] In this project, for example, the estimated burden of tinea capitis in Ethiopia (Eastern Africa), Senegal (Western Africa), Namibia (Southern Africa), Republic of Congo (Central Africa) and Algeria (Northern Africa) compared to the present study was 7,051,700 vs 12,016,000,[59] 1,523,700 vs 1,806,000,[60] 53,000 vs 241,000,[61] 178,000 vs 580,000 [62] and 4,265 vs 3,316,000,[63] respectively. The differences in the estimated burden of tinea capitis in these two forms of studies could be due to the few studies included in the individual country burden and the lack of epidemiological data in most countries in Africa.

Microbiological aetiology also varies between the five regions in Africa. Our study showed that *Trichophyton* spp. are the commonest cause of tinea capitis in Africa. This is in line with a systematic review on the management of tinea capitis that described *T violaceum* as the predominant organism.[64] In Asia and South America, *M canis* are common, whereas *T tonsurans* is prevalent in North America.[64] Our systematic review shows there are regional variations in the mycological aetiology of tinea capitis as previously reported by Coulibaly and colleagues.[7] *Trichophyton soudanense* which is also found in some parts of Asia was also common in Africa, eminently in West African countries and Gabon.[22,27,30,65,66] Cases of *T soudanense* have also been documented in the United States.[65,67] Of concern, *M canis*, a zoophilic dermatophyte which mainly infects cats, infrequently dogs and humans, is prevalent in parts of Northern Africa like Morocco, Egypt and Tunisia.[14,15] In an earlier study by Verhagen (1974),[53] *T violaceum* and *T schoenleinii* were mainly found in the North African region, *T soudanense* and *M audouinii* in West Africa meanwhile *T violaceum* and *Trichophyton ferrugineum* in Central and Eastern Africa.

Our study has several important limitations. Firstly, the data were derived from studies that had different designs, and varying diagnostic approaches over several years. Clinical practices, epidemiology, socio-economic and demographic characteristics have changed significantly over the study period. It is thus not surprising that we observed a substantial heterogeneity among the studies. Secondly, we may have overestimated the prevalence of tinea capitis in many countries, especially those in North Africa where the prevalence of tinea capitis from primary data is significantly lower than our pooled prevalence.[32]

However, we provide an initial estimation of the burden of tinea capitis in Africa. The impact of human immunodeficiency infection on the burden of tinea capitis was not reported in any of the studies and is an important area for future studies. Future studies should look into the morbidities such as scaring, permanent hair loss and kerions, and attributable mortality. In addition, establishing the co-prevalence of tinea capitis and other common dermatoses such as head lice and tinea corporis would be of interest to the research communities.

In conclusion, in the present study, the summary estimate of the prevalence of tinea capitis among school aged children was 23% translating to over 138 million annual cases. Thus in Africa, every 1 in 5 children suffers from tinea capitis. Urgent public health interventions are required to curb the growing burden of this neglected tropical disease.

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CONFLICT OF INTERESTS

None.

AUTHOR CONTRIBUTIONS

FB conceived the study. FB, RO, LN and JBB designed the concept/protocol. LR performed the search. LN, FB and RO reviewed and curated the data.RO performed the meta-analysis. FB, RO, LN, MN, EdS, LR, IIO, RK and JB participated in initial manuscript drafting. FB, RO, LN, MN, EdS, LR, IIO, RK and JB participated in critical revisions for intellectual content.

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