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9 **Estimation of the Burden of Tinea Capitis Among Children in**
10 **Africa**11 **Authors**

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35

36 **Abstract**

37 **Background:** Tinea capitis is a common and endemic dermatophytosis among school
38 age children in Africa. However, the true burden of the disease is unknown in Africa.

39 **Objective:** We aimed to estimate the burden of tinea capitis among children less than 18
40 years of age in Africa.

41 **Methods:** A systematic review was performed using Embase, Medline and the Cochrane
42 Library of Systematic Reviews to identify articles on tinea capitis among children in Africa
43 published between January 1990 and October 2020. The United Nation's Population data
44 (2019) was used to identify the number of children at risk of tinea capitis in each African
45 country. Using the pooled prevalence, the country-specific and total burden of tinea
46 capitis was calculated.

47 **Results:** Forty studies involving a total of 229,086 children from 17/54 African countries
48 were identified and included in the analysis. The pooled prevalence of tinea capitis was
49 23% (95% CI, 17%-29%) mostly caused by *Trichophyton* species. With a population of
50 600 million (46%) children, the total number of cases of tinea capitis in Africa was
51 estimated at 138.1 (95% CI, 102.0 – 174.1) million cases. Over 96% (132.6 million) cases
52 occur in Sub-Saharan Africa alone. Nigeria and Ethiopia with the highest population of
53 children contributed 16.4% (n=98.7 million) and 8.5% (n=52.2 million) of cases,
54 respectively. Majority of the participants were primary school children with a mean age of
55 10 years. Cases are mostly diagnosed clinically. There was a large discrepancy between
56 the clinical and mycological diagnosis.

57 **Conclusions:** About one in every 5 children in Africa has tinea capitis making it one of
58 the most common childhood conditions in the region. A precise quantification of the
59 burden of this neglected tropical disease is required to inform clinical and public health
60 intervention strategies.

61 **Keywords:** Tinea capitis, children, Africa, dermatomycoses, prevalence, aetiology

62 **PROSPERO Registration Number:** CRD4202018972

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66 **Introduction**

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

71 Majority of the cases reported are of children and the mean age of onset is in patients
72 aged between 3 to 7 years living in Africa or of Sub-Saharan African descent living
73 abroad ^{4,5}. It is highly neglected and under reported in Africa. Determinants of presence
74 of tinea capitis include low socioeconomic status, high population densities, poor health
75 practices ³.

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

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

89 **Material and Methods**

90 ***Study design***

91 This was a systematic review and meta-analysis whose protocol was developed in
92 accordance with recommendations by Meta-analyses Of Observational Studies in

93 Epidemiology (MOOSE) ⁸ and The Preferred Reporting Items for Systematic Review and
94 Meta-Analysis (PRISMA) checklists ⁹. The protocol for this systematic review and meta-
95 analysis was registered by PROSPERO database (CRD42020189727) and published in
96 a peer-reviewed journal ¹⁰.

97 **Search Strategy**

98 The search was conducted by systemically identifying articles published from January
99 1990 to October 2020. We explored databases such Embase, Medline, and the
100 Cochrane Library of systematic review for eligible studies. We restricted the languages to
101 English and French since they are the main national languages in most African countries.
102 Age for children was restricted to zero (0) to 17 years. We identified and refined MeSH
103 (Medical Subject Headlines used for indexing articles in PubMed) search terms such as
104 “tinea capitis,” “dermatophytes,” “dermatophytosis,” “scalp infections,” “scalp ringworms,”
105 “*Trichophyton*,” “*Microsporum*,” “*Epidermophyton*,” “*Nannizzia*,” “*Arthroderma*,” “burden,”
106 “prevalence,” “incidence,” AND “children,” OR “age <18 years” AND “Africa” or each of
107 the individual 54 countries of Africa. The search terms were translated into French and
108 then further refined to facilitate search in other databases.

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

113 **Study Selection and Inclusion Criteria**

114 The research studies were run through Healthcare Databases Advanced Search
115 (National Institute for Health and Care Excellence, UK) program in order to remove
116 duplicate research articles. Initially, two reviewers (F.B, L.R) independently screened the
117 titles and abstracts to rule out articles that were irrelevant to the study purpose.
118 Thereafter, the full texts of potentially eligible papers were retrieved and discussed by the
119 authors. Any disagreements about eligibility of the articles for the study were resolved by
120 consensus-based discussion amongst the authors.

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

- 123 i) Observational studies published in a peer-reviewed journal from January 1990
124 to October 2020 and in the English and French languages.
125 ii) Designed as retrospective, cross-sectional or prospective observational study
126 iii) Among children (<18 years old) in African countries
127 iv) Reporting the prevalence or incidence of tinea capitis

128 The following studies were excluded:

- 129 i) Case reports, case series with subjects less than 10, opinion papers,
130 qualitative research, letters to the editor, comments, conference proceedings,
131 policy papers, reviews and meta-analyses, study protocols without baseline
132 data, and animal studies.
133 ii) Studies reporting other scalp infections.

134 **Data Extraction and Management**

135 Data extraction was done by two independent reviewers and the data was coded. We
136 used a data extraction form prepared using Microsoft Excel 2016 to collect information
137 from all eligible studies such as year of publication, first author's name, country, sample
138 size, population studied, study design, age range, gender distribution, incidence,
139 prevalence, aetiology, clinical versus laboratory diagnosis, and risk factors of tinea
140 capitis. When the required data was not readily available from published articles, we
141 requested raw data from the authors. Data extracted was reviewed by two other
142 independent reviewers (R.O and L.N), and any disagreements were resolved by
143 discussion.

144 **Study Outcomes**

145 *Primary outcome:* Pooled prevalence of tinea capitis among children in Africa.

146 *Secondary outcome:*

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

150 **Quality Assessment**

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

158 **Data Synthesis and Analysis**

159 STATA V.16.0 (StataCorp LLC, College Station, TX, USA) software was used for data
160 analysis. A random-effect model meta-analysis was performed using meta command for
161 in STATA and presented as prevalence, 95% confidence intervals (Cis) and weights. A
162 forest plot was used to present the results of the meta-analysis. Sub-group meta-analysis
163 was also performed to assess the effect of diagnostic modalities on the pooled
164 prevalence. A systematic descriptive synthesis was performed appropriately to complete
165 the meta-analysis. Heterogeneity of studies was assessed using Q statistics; I^2 and p -
166 *value* was used to report heterogeneity between studies. Bias secondary to small study
167 effects was investigated using funnel plots and the Egger test. A $p < 0.05$ was considered
168 statistically significant.

169 **Burden of Tinea Capitis in Africa**

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

176 **Ethics statement**

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

179

180 **Results**

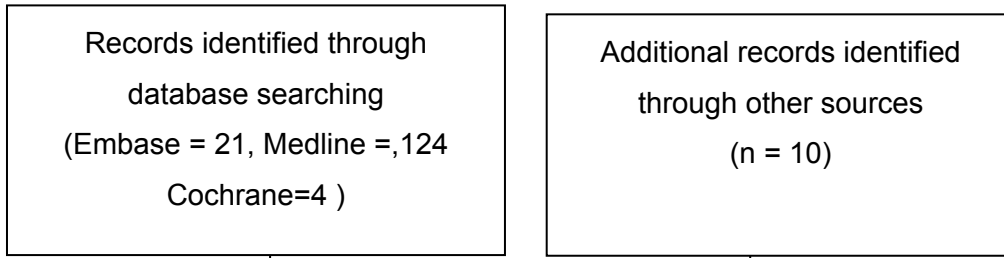
181 **Study Characteristics**

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

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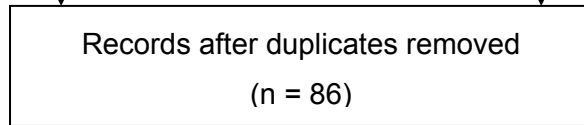
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Identification

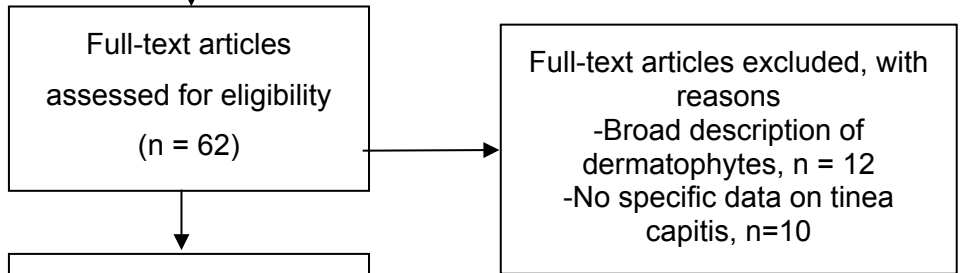


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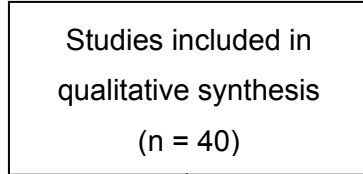
Screening



Eligibility



Included



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206 Figure 1. PRISMA flow diagram

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208 Thirty-seven studies were cross-sectional (n=138,337), 2 were retrospective (n=73,004)
209 and 1 was prospective (n=17,745) in design (**Table 1**). More than one-third (15/40,
210 37.5%) of the studies were conducted either in Nigeria (n=9, 22.5%) or in Ethiopia (n=6,
211 15%) (**Table 1**).

212 **Prevalence of tinea capitis among children in Africa**

213 The prevalence estimates reported by the individual studies ranged from 0.003% to
214 79.9% for those diagnosed clinically (n=141,835) and 0.21% to 81.3% for those
215 diagnosed mycologically (n=172,521) (**Table 1**).

216 Meta-analytic pooling of the prevalence estimates of tinea capitis reported by 40 studies
217 yielded an overall pooled prevalence of 23% (14,424/229,086 individuals; 95% CI, 17%-
218 29%), with significant evidence of between-study heterogeneity ($I^2= 99.99\%$, $p< .001$)
219 (**Figure 2**). For those diagnosed clinically, the pooled prevalence was 25%
220 (13,695/141,835 individuals; 95% CI, 18%-31%; $I^2= 99.99\%$, $p< .001$) (**Figure 3**) and the
221 pooled prevalence was 18% (6,728/172,521 individuals; 95% CI, 11%-25%; $I^2= 100\%$, $p<$
222 $.001$) children diagnosed mycologically (**Figure 4**). Due to the extreme heterogeneity of
223 the included studies, sensitivity analyses were not possible as less than three studies
224 were within the funnel plot.

225 **Estimation of the burden of Tinea capitis in Africa**

226 At the end of 2019, the total population of Africa was 1.3 billion with children constituting
227 0.6 billion (46%). Using the pooled prevalence of tinea capitis of 23%, the total burden of
228 tinea capitis among children in Africa was calculated at 138.1 million cases. Sensitivity
229 analyses were performed at the upper and lower limits of the 95% CI of the overall
230 pooled prevalence (**Table 2**). Nigeria and Ethiopia with the highest population of children
231 contributed 16.4% (98.7 million cases) and 8.5% (52.2 million cases) respectively.
232 Meanwhile, Seychelles & Sao Tome and Principe with the smallest population of children
233 contributed <0.01% (26,756 cases) and 0.02% (104,347 cases), respectively (**Table 2**).
234 Regionally, 35.3% (48,747,985, 95% CI: 36,031,120 – 61,464,851) were from the
235 Western African countries and 31.3% (43,148,514, 95% CI: 31,892,380 – 54,404,648) of
236 the cases were from Eastern African Countries (**Table 2**). On further sub-analysis, the

237 pooled prevalence of tinea capitis in sub-Saharan Africa was 25% (95% CI:19- 32) which
238 translates to 132,588,160 cases.

239 **Etiology of Tinea capitis in Africa**

240 Majority of the studies showed a predominance of dermatophyte species from the genera
241 *Trichophyton* as the commonest causative micro-organisms of tinea capitis among
242 children in Africa, accounting for more than two-thirds (68.9%), followed by *Microsporum*
243 (30.9%) (**Table 3**). **Table 4** summarizes the mycological etiology of tinea capitis reported
244 in the studies included. *T. soudanense* and *M. audouinii* were significantly prevalent in
245 studies in Western Africa whereas *T. violaceum* and *T. tonsurans* isolates were
246 commonly reported in children from East African countries (**Table 4**). *Epidermophyton*
247 species were very rare with a few isolates reported in Kenya ^{13,14} and Nigeria ^{15,16}. In
248 Northern Africa, *M. canis*, *T. violaceum* and *M. audouinii* were the most common
249 causative species.

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 ¹⁷	2018	Tanzania	Cross-sectional	2017	Primary school children	Mean: 9.92 (SD: 1.13)	500	86 (17.2)	-
3	Farag ¹⁸	2018	Egypt	Cross-sectional	2015 to 2016	Primary school children	Mean: 9.88 (SD: 2.37) Range: 6 to 14	3464	35 (1)	31 (0.9)
4	Bassyouni ¹⁹	2017	Egypt	Cross-sectional	2013 to 2014	Primary school children	Mean: 8.4 (SD: 1.8) Range: 5.5 to 12	12128	49 (0.4)	25 (0.2)
5	Coulibaly ²⁰	2016	Mali	Cross-sectional	2010 to 2012	Primary school children	Mean: 9.7 (6 to 15)	590	232 (39.3)	189 (32)
6	Leiva-Salinas ²¹	2015	Ethiopia	Cross-sectional	2012	Primary school children	Mean: 10 (SD:2.4, Range: 4 to 14)	647	159 (24.6)	-
7	Moto ¹³	2015	Kenya	Cross-sectional	2013	Primary school children	Mean: 8.5 (SD: 1.86, Range: 3	150	102 (68)	122 (81.3)

							to 14)			
8	Ayanlowo ²²	2014	Nigeria	Cross-sectional	-	Primary school children	Mean: 8.1 (SD:3.1, Range: 20 to 17)	604	201 (33.3)	29 (4.8)
9	Kechia ²³	2014	Cameroon	Cross-sectional	2011 to 2012	Primary school children	Mean: 10.7 (SD:0.16, 4 to 15)	4601	377 (8.2)	354 (7.7)
10	Oke ²⁴	2014	Nigeria	Cross-sectional	2011	Primary school children	Mean: 9.42 (SD:2.00, 5 to 16)	800	215 (26.9)	96 (12)
11	Fulgence ²⁵	2013	Ivory Coast	Prospective	2008 to 2009	Primary school children	Range 4-16	17,745	2645 (14.9)	2458 (13.9)
12	Halim ²⁶	2012	Morocco	Retrospective	2002 to 2011	Children attended to at a hospital	Mean: 12.7	1418	260 (18.3)	229 (16.1)
13	Adefemi ²⁷	2011	Nigeria	Cross-sectional	2005	Primary school children	5 to 16	602	-	137 (22.8)
14	Hogewoning ²⁸	2011	Gabon	Cross-sectional	2005	Primary school children	4 to 17	454	105 (23.1)	74 (16.3)
15	Hogewoning ²⁸	2011	Ghana	Cross-sectional	2004	Primary school children	4 to 16	463	39 (8.4)	31 (6.7)
16	Hogewoning ²⁸	2011	Ghana	Cross-sectional	2007	Primary school children	4 to 20	1394	121 (8.7)	-

17	Hogewoning ²⁸	2011	Rwanda	Cross-sectional	2007	Primary school children	4 to 20	2528	522 (20.6)	-
18	Ali ²⁹	2009	Ethiopia	Cross-sectional		Primary school children	Median: 10 (5 to 15)	372	-	87 (23.4)
19	Nzenze-Afene ³⁰	2009	Gabon	Cross-sectional	2004	Primary school children	Mean: 10.6 (3 to 17)	794	185 (23.3)	124 (15.6)
20	Wokoma ¹⁵	2009	Nigeria	Cross-sectional	-	Primary school children	5 to 13	1320	73 (5.5)	-
21	Wokoma ¹⁶	2009	Nigeria	Cross-sectional	2007	Primary school children	6 to 10	1441	176 (12.2)	-
22	Ayanbimpe ³¹	2008	Nigeria	Cross-sectional	2004	Primary school children	3 to 16	28505	796 (2.8)	248 (0.9)
23	Emele ³²	2008	Nigeria	Cross-sectional	2002 to 2005	Primary school children	2.5 to 15	47723	4498 (9.4)	502 (58.9)
24	Benmously-Mlika ³³	2007	Tunisia	Retrospective	2000 to 2006	Children attended to at a hospital	<18	71586	-	204 (0.3)
25	Nnoruka ³⁴	2007	Nigeria	Cross-sectional	2005	Primary school children	Mean: 8.4 (SD: 1.3, 4 to 17)	287	139 (48.4)	206 (71.8)
26	Sidat ³⁵	2007	Mozambique	Cross-sectional	2001	Primary school children		1149	110 (9.6)	100 (8.7)
27	Contet-Audonneau ³⁶	2006	Madagascar	Cross-sectional	2002	Primary school children	6 to 14	210	83 (39.5)	17 (8.1)

28	Sidat ³⁷	2006	Mozambique	Cross-sectional	2001	Primary school children		685	67 (9.8)	66 (9.6)
29	Woldeamanuel ³⁸	2005	Ethiopia	Cross-sectional	2000	Primary school children		948	578 (61)	-
30	Woldeamanuel ³⁹	2005	Ethiopia	Cross-sectional	2001	Children living on an island	4 to 15	171	104 (60.8)	-
31	Bamba ⁴⁰	2003	Ivory Coast	Cross-sectional	2001	Primary school children	5 to 15	535	146 (27.3)	144 (26.9)
32	Menan ⁴¹	2002	Ivory Coast	Cross-sectional	1998 to 1999	Primary school children	Mean: 9.8 (SD: 3.8, 4 to 15)	1913	227 (11.9)	217 (11.3)
33	Ayaya ¹⁴	2001	Kenya	Cross-sectional	-	Primary school children	Mean: 9.6 (6 to 14)	164	68 (41.5)	52 (31.7)
34	Maiga ⁴²	2001	Mali	Cross-sectional	-	Primary school children	Mean: 10 (SD: 2.3, 5 to 20)	15,553	-	515 (3.3)
35	Vandemeulebroucke ⁴³	1999	Mali	Cross-sectional	1998	Primary school children	5 to 16	371	46 (12.4)	90 (24.3)
36	Figueroa ⁴⁴	1997	Ethiopia	Cross-sectional	1995	Primary school children	Median: 10 (5 to 15)	219	63 (28.8)	35 (16)
37	Figueroa ⁴⁵	1996	Ethiopia	Cross-sectional	1992	Primary school children	Mean: 8.9 (5 to 16)	112	-	10 (8.9)
38	N'Dir ⁴⁶	1994	Senegal	Cross-sectional	-	Children in the community		4,537	255 (5.6)	140 (3.1)
39	Oyeka ⁴⁷	1990	Nigeria	Cross-	1984	Primary school	4 to 18	1,555	300 (19.3)	158 (10.2)

				sectional		children				
40	Robertson ⁴⁸	1990	Zimbabwe	Cross-sectional	-	Primary school children		704	204 (29)	175 (24.9)

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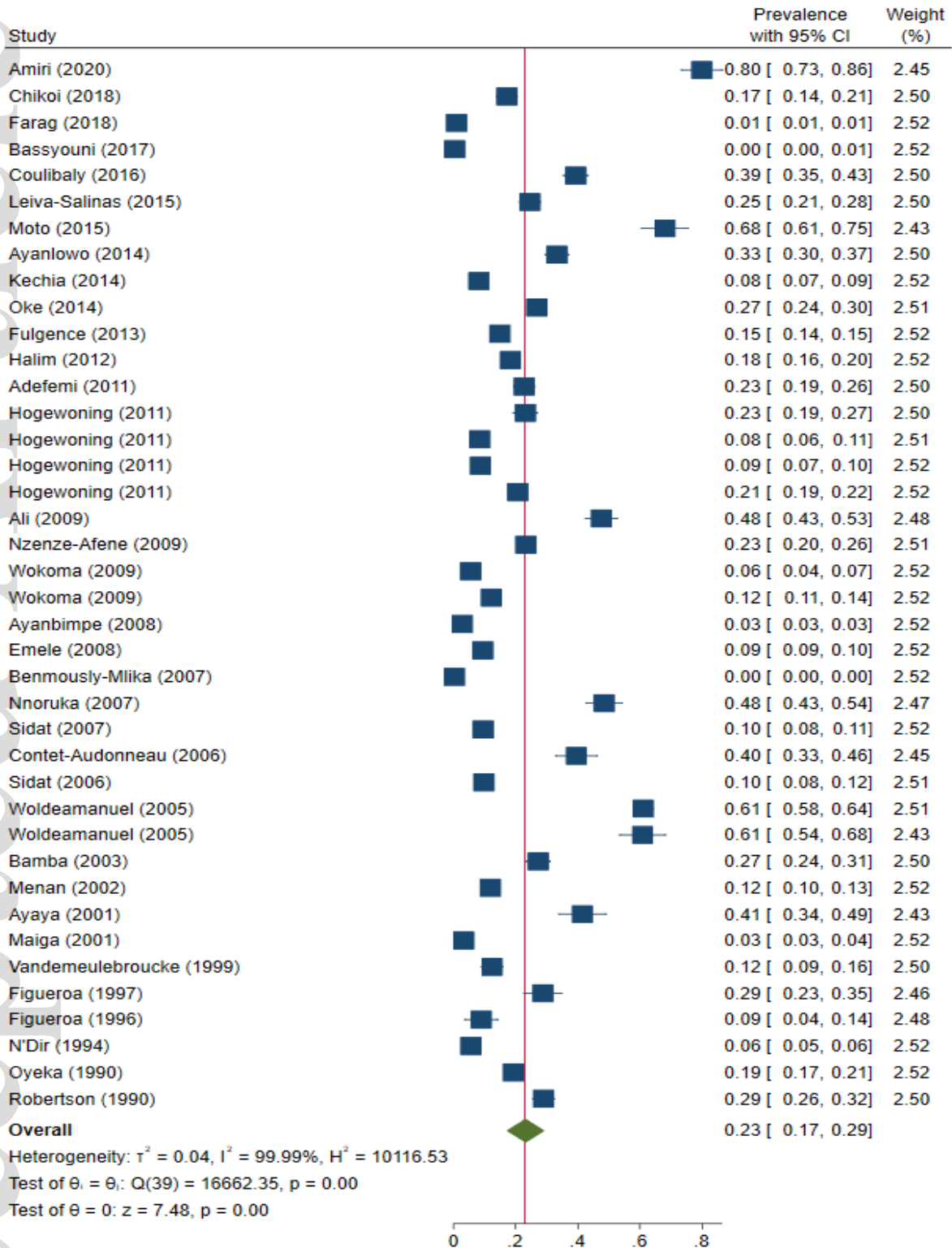
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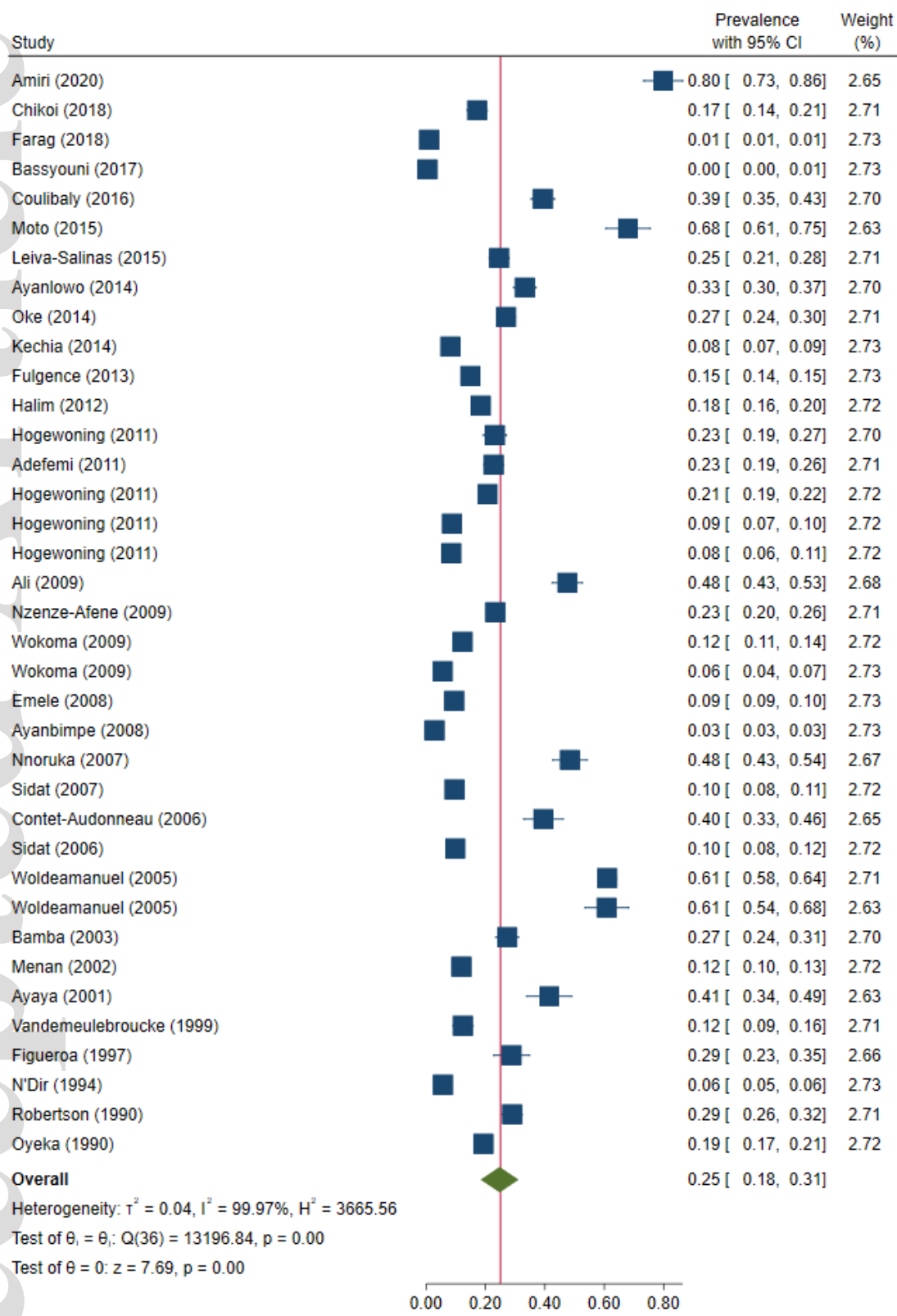
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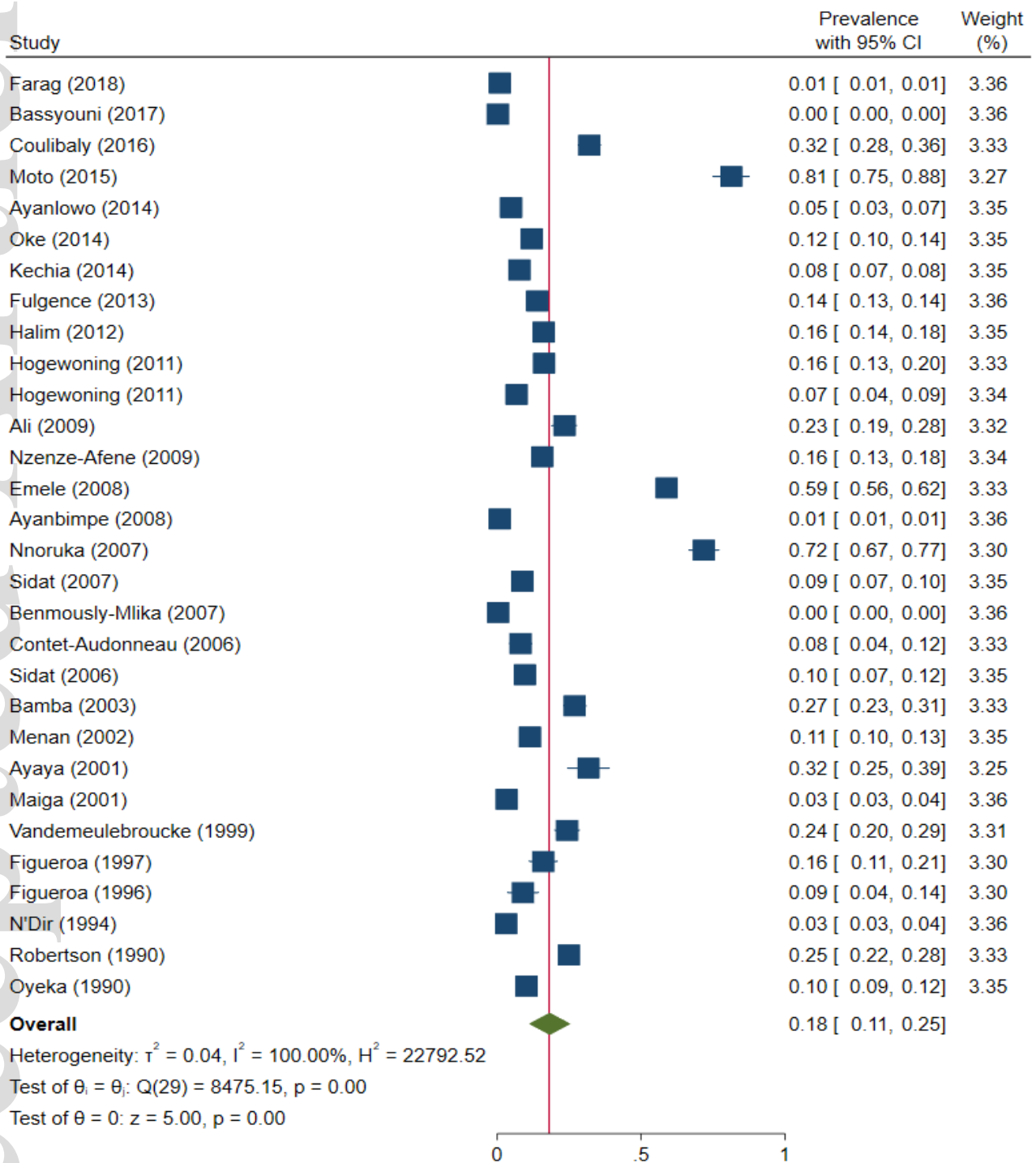


256 Random-effects REML model

257 **Figure 2: Meta-analyses of the Pooled Prevalence of Tinea capitis among children**
 258 **in Africa**



260 **Figure 3: Meta-analyses of the Prevalence of Tinea capitis among children in Africa**
 261 **diagnosed clinically**



262 Random-effects REML model

263 **Figure 4: Meta-analyses of the Prevalence of Tinea capitis among children in Africa**
264 **diagnosed mycologically.**

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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%
<i>Sub-total</i>	<i>97,618,096</i>	<i>50,779,745</i>	<i>11,679,341 (8,632,557 – 14,726,126)</i>	<i>8.46%</i>
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	6,154 (4,549 – 7,759)	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%
<i>Sub-total</i>	<i>383,860,789</i>	<i>187,602,236</i>	<i>43,148,514 (31,892,380 – 54,404,648)</i>	<i>31.25%</i>
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%
<i>Sub-total</i>	<i>194,924,859</i>	<i>69,916,065</i>	<i>16,080,695 (11,885,731 - 20275659)</i>	<i>11.65%</i>
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%
<i>Sub-total</i>	<i>175,979,014</i>	<i>80,022,895</i>	<i>18,405,266 (13,603,892 – 23,206,640)</i>	<i>13.33%</i>
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%
<i>Sub-total</i>	<i>421,890,401</i>	<i>211,947,763</i>	<i>48,747,985 (36,031,120 – 61,464,851)</i>	<i>35.31%</i>
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	<i>Microsporum spp;</i>	<i>Trichophyton spp;</i>	<i>Epidermophyton</i>
			Frequency (%)	Frequency (%)	<i>spp;</i> Frequency (%)
1	Farag ¹⁸	Egypt	31 (100)	0 (0)	0 (0)
2	Bassyouni ¹⁹	Egypt	22 (75.9)	7 (24.1)	0 (0)
3	Coulibaly ²⁰	Mali	69 (42.9)	92 (57.1)	0 (0)
4	Moto ¹³	Kenya	16 (13.3)	75 (61.3)	9 (7.3)
5	Ayanlowo ⁴⁹	Nigeria	8 (27.6)	21 (72.4)	0 (0)
6	Kechia ²³	Cameroon	20 (6)	316 (94)	0 (0)
7	Oke ²⁴	Nigeria	44 (45.8)	52 (54.2)	0 (0)
8	Fulgence ²⁵	Ivory Coast	440 (21.4)	1613 (78.6)	0 (0)
9	Adefemi ²⁷	Nigeria	5 (16.7)	25 (83.3)	0 (0)
10	Ali ²⁹	Ethiopia	0 (0)	87 (100)	0 (0)

11	Ayanbimpe ³¹	Nigeria	88 (35.9)	157 (64.1)	0 (0)
12	Emele ³²	Nigeria	302 (64.3)	168 (35.7)	0 (0)
13	Nnoruka ³⁴	Nigeria	95 (39.4)	146 (60.6)	0 (0)
14	Sidat ³⁵	Mozambique	60 (51.3)	57 (48.7)	0 (0)
15	Contet-Audonneau ³⁶	Madagascar	2 (11.1)	16 (88.9)	0 (0)
16	Sidat ³⁷	Mozambique	58 (72.5)	22 (27.5)	0 (0)
17	Bamba ⁴⁰	Ivory Coast	38 (27.1)	102 (72.9)	0 (0)
18	Menan ⁴¹	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 ³⁰	Gabon	<i>T. soudanense</i> (42.6%), <i>T. gourvilii</i> (15.6%), <i>T. tonsurans</i> (4.1%), <i>T. violaceum</i> 2 (1.6%), <i>T. rubrum</i> 1 (0.8%) and <i>M. langeronii</i> 25 (20.5%).
Eastern Africa		
1 Moto ⁵⁰	Kenya	<i>Trichophyton</i> spp. (61.3%), <i>Microsporum</i> spp. (13.3%) and <i>Epidermophyton</i> spp. (7.3%)
2 Woldeamanuel ⁵¹	Ethiopia	<i>T. violaceum</i> and <i>T. verrucosum</i>
3 Woldeamanuel ³⁹	Ethiopia	<i>T. violaceum</i> , <i>T. verrucosum</i> and <i>T. tonsurans</i>
4 Ali ²⁹	Ethiopia	<i>T. violaceum</i> 86.2%, <i>T. verrucosum</i> (13.8%)
5 Ayaya ¹⁴	Kenya	<i>T. tonsurans</i> (77.8%), <i>T. rubrum</i> (4%), <i>E. floccosum</i> , <i>T. scholini</i> , <i>T. verucossum</i> , <i>M. gypseum</i>
6 Contet-Audonneau ³⁶	Madagascar	<i>T. tonsurans</i> (88.2%) and <i>M. boullardii</i> (11.8%)
7 Figueroa ⁴⁴	Ethiopia	<i>T. violaceum</i> , <i>T. schoenleinii</i> and <i>T. rubrum</i>
8 Figueroa ⁴⁴	Ethiopia	<i>T. violaceum</i> and <i>T. schoenleinii</i>
Northern Africa		
1 Halim ²⁶	Morocco	<i>T. violaceum</i> (49%) and <i>M. canis</i> (36%)
2 Farag ¹⁸	Egypt	<i>M. canis</i>
3 Bassyouni ¹⁹	Egypt	<i>M. canis</i> (52%) and <i>M. audouinii</i> (36%)
4 Benmously-Mlika ³³	Tunisia	<i>T. violaceum</i> and <i>M. canis</i>
Southern Africa		
1 Robertson ⁴⁸	Zimbabwe	<i>T. violaceum</i> (78%) and <i>M. audouinii</i> (9%). Others included <i>T. mentagrophytes</i> , <i>T. yaoundei</i> , <i>M.</i>

			<i>gypseum</i> and <i>M. canis</i> .
2	Sidat ³⁷	Mozambique	<i>M. audouinii</i> (86.3%) and <i>T. mentagrophytes</i> (30%)
3	Sidat ³⁵	Mozambique	<i>M. audouinii</i> (51.3%), <i>T. violaceum</i> (43.6%), and <i>T. mentagrophytes</i> (5.1%)
Western Africa			
1	Nnoruka ³⁴	Nigeria	<i>M. audouinii</i> (31.1%), <i>T. soudanense</i> (22.6%), <i>T. tonsurans</i> (13.2%), <i>T. yaoundei</i> (5.6%) and <i>M. canis</i> (1.9%)
2	Coulibaly ²⁰	Mali	<i>T. soudanense</i> (36.6%), <i>M. audouinii</i> (32.4%), <i>T. violaceum</i> (3.3%) and <i>T. mentagrophytes</i> (1.9%)
3	Ayanlowo ²²	Nigeria	<i>T. mentagrophyte</i> (51.7%) and <i>M. audouinii</i> (20.7%)
4	Bamba ⁴⁰	Ivory Coast	<i>T. soudanense</i> 50.68%, <i>M. langeronii</i> 23.29% and <i>T. violaceum</i> 17.81%. Other species included <i>T. rubrum</i> (2.74%), <i>M. rivalieri</i> (2.74%), <i>M. audouinii</i> (1.37%), <i>M. ferrugineum</i> (0.68%) and <i>T. tonsurans</i> (0.68%).
5	Oke ²⁴	Nigeria	<i>M. audouinii</i>
6	Adefemi ²⁷	Nigeria	<i>T. mentagrophyte</i> followed by <i>M. audouinii</i> and <i>T. verucossum</i>
7	Oyeka ⁴⁷	Nigeria	<i>M. audouinii</i> 38.0%, <i>T. mentagrophytes</i> (24%), <i>T. soudanense</i> (15%), <i>T. tonsurans</i> , (9%), <i>T. Schoenlenii</i> (9%) and <i>M. gypseum</i> (5%)
8	Fulgence ²⁵	Ivory Coast	<i>T. soudanense</i> (56.7%), <i>M. langeronii</i> (21.4%), and <i>T. mentagrophytes</i> (19.7%).
9	Vandemeulebroucke ⁴³	Mali	<i>T. soudanense</i> (61.1 %) and <i>M. audouinii</i> (43.3 %).
10	Wokoma ¹⁵	Nigeria	<i>M. canis</i> , <i>M. audouinii</i> , <i>T. mentagrophytes</i> , <i>T. soudanense</i> , <i>T. tonsurans</i> and <i>T. yaoundei</i> , <i>M. gypseum</i>

11	Menan ⁴¹	Ivory Coast	<i>T. soudanense</i> (63.59%) <i>M. langeronii</i> (31.34%) , <i>T. violaceum</i> (2.30%) and <i>M. audouinii</i> , and <i>T. soudanense</i> and <i>T. yaoundei</i> .
12	Emele ³²	Nigeria	<i>M. audouinii</i> (42.2%), <i>M. ferrugineum</i> (17.3%) and <i>T. mentagrophytes</i> (15.7%)
15	Kechia ²³	Cameroon	<i>T.soudanense</i> (56.8%) and <i>T. rubrum</i> (29.2%).
16	N'Dir ⁴⁶	Senegal	<i>T. soudanense</i> (80.8%), <i>M. audouinii</i> (18.4%), and <i>T. violaceum</i> (0.7%).
17	Wokoma ¹⁵	Nigeria	<i>Trichophyton</i> , <i>Microsporium</i> and <i>Epidermophyton</i> were recovered
18	Maiga ⁴²	Mali	<i>T. soudanense</i> (66.1%), <i>M. langeronii</i> (31.6%) and <i>T. rubrum</i> (2.3%).
19	Ayanbimpe ³¹	Nigeria	<i>T. soudanense</i> (30.6%), <i>M. ferrugineum</i> (7.7%) and <i>M. audouinii</i> (7.7%).

266 Discussion

267 Skin, nail and hair infections rank highly among the ten most common disorders in the
268 world ⁵², with tinea capitis as the commonest childhood mycosis globally ⁵³. There has
269 been no previous attempt to estimate the burden of tinea capitis in Africa as a whole. In
270 the present study pooling data from 40 individual studies involving a total of 229, 086
271 children in 17 countries of Africa over a 30-year period, the prevalence of tinea capitis
272 was 23% translating to over 138.1 million cases This study shows that tinea capitis is a
273 largely neglected and yet major public health problem among children in Africa requiring
274 urgent public health interventions. Our findings are consistent with an earlier study
275 published in 1974 which showed that the tinea capitis was widespread in Africa with
276 prevalence ranging between 10 and 30% ⁵⁴.

277 The clinical manifestations of tinea capitis may range from scalp scaling and pruritus to
278 scalp erythema, patches of alopecia, pustules and inflammatory swellings (kerions) as
279 well as tender occipital lymphadenopathy. The large discrepancy observed between the
280 clinical and mycological diagnosis could be due to misdiagnosis often caused by lack of
281 local capacity for mycology leading to low index of clinical suspicion. A recent paper from
282 Uganda showed that 8/9 dermatomycoses were clinically misdiagnosed as prurigo,
283 leprosy, Kaposi's sarcoma or melanoma, but later identified by histology ⁵⁵. Cases were
284 surprisingly mid-aged adults with a mean age of 28 years. Yet, tinea capitis has largely
285 been seen as a disease of poverty, mainly occurring in children from economically
286 disadvantaged communities where overcrowding, sharing of fomites and poor hygiene
287 are common ^{3,56}. High frequency of tinea capitis is observed in children between the age
288 of 6-12 years, with male predominance ⁵⁰. A study from Ivory Coast reported that boys
289 were 8 times more likely to have tinea capitis than girls ⁴¹. In our study, the mean age
290 was about 10 years. Children of this age tend to exhibit poor hygiene practices and do
291 have less or absent cutaneous saturated fatty acids that provide a natural protective
292 mechanism against dermatophytes ⁵⁷. Untreated tinea capitis is associated with social
293 stigmatisation, low quality of life and may result in complications such as scarring
294 alopecia ⁵⁸.

295 Individual country burden of tinea capitis has been published for several countries
296 through the Leading International Fungal Education (LIFE) project ⁵⁹. In this project, for
297 example, the estimated burden of tinea capitis in Ethiopia (Eastern Africa), Senegal
298 (Western Africa), Namibia (Southern Africa), Republic of Congo (Central Africa), and
299 Algeria (Northern Africa) compared to present study were 7,051,700 vs. 12,016,000 ⁶⁰,
300 1,523,700 vs. 1,806,000 ⁶¹, 53,000 vs. 241,000 ⁶², 178,000 vs. 580,000 ⁶³, and 4,265 vs.
301 3,316,000 ⁶⁴ , respectively. The differences in the estimated burden of tinea capitis in
302 these two forms of studies could be due to the few studies included in the individual
303 country burden and the lack of epidemiological data in most countries in Africa.

304 Microbiological aetiology also varies between the five regions in Africa. Our study showed
305 that *Trichophyton spp.* are the commonest cause of tinea capitis in Africa. This is in line
306 with a systematic review on the management of tinea capitis that described *T. violaceum*
307 as the predominant organism ⁶⁵. In Asia and South America, *M. canis* are common
308 whereas *T. tonsurans* is prevalent in North America ⁶⁵. Our systematic review shows
309 there are regional variations in the mycological aetiology of tinea capitis as previously
310 reported by Coulibaly and colleagues ⁷. *T. soudanense* which is also found in some parts
311 of Asia was also common in Africa, eminently in West African countries and Gabon
312 ^{25,30,31,66,67}. Cases of *T. soudanense* have also been documented in the USA ^{66,68}. Of
313 concern, *M. canis*, a zoophilic dermatophyte which mainly infects cats, infrequently dogs
314 and humans is prevalent in parts of Northern Africa like Morocco, Egypt and Tunisia ^{18,19}.
315 In an earlier study by Verhagen (1974) ⁵⁴, *T. violaceum* and *T. schoenleinii* were mainly
316 found in the North African region, *T. soudanense* and *M. audouinii* in West Africa
317 meanwhile *T. violaceum* and *T. ferrugineum* in Central and Eastern Africa.

318 Our study has several important limitations. Firstly, the data were derived from studies
319 that had different designs, and varying diagnostic approaches over several years. Clinical
320 practices, epidemiology, socioeconomic and demographic characteristics have changed
321 significantly over the study period. It is thus not surprising that we observed a substantial
322 heterogeneity among the studies. Secondly, we may have overestimated the prevalence
323 of tinea capitis in many countries , especially those in North Africa where the prevalence
324 of tinea capitis from primary data is significantly lower than our pooled prevalence ³³.

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

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

336 **Author Contributions**

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

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344 **Conflict of interests**

345 None

346 **Patient consent:**

347 Not applicable

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