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Thyrotoxicosis in Africa: a systematic review and meta-analysis of the clinical presentation

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Abstract

Background: Thyrotoxicosis is a common endocrine disorder. The clinical presentation is variable, and it is often misdiagnosed or diagnosed late in Africa. This study was aimed at collating and analyzing the clinical characteristics of the disease across the continent so as to enhance correct and timely diagnosis.

Methods: The study is a systematic review with a meta-analysis. Studies, done in Africa, which documented the clinical features of thyrotoxicosis were selected. African Journal Online (AJOL), PubMed, SCOPUS and Google Scholar, Research Square, SciELO, and medRxiv were systematically searched using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The study quality was assessed using the Newcastle-Ottawa scale. Heterogeneity was determined using I^2 statistic and Cochran's Q test. LFK index and the symmetry of the Doi plot were used to assess publication bias.

Results: The eligible studies were 59 and the total sample size was 9592. The most common symptoms of thyrotoxicosis on the continent included palpitations (69%), weight loss (65%), heat intolerance (64%), tiredness (49%), increased appetite (49%), hyperhidrosis (48%), and insomnia (47%). The most common signs were thyromegaly (88%), tachycardia (67%), sweaty palms (54%), hand tremor (49%), and exophthalmos (49%). Atrial fibrillation, heart failure, and thyrotoxic heart disease were found in 9, 12, and 22% respectively. Other findings were hypertension (25%) and diabetes (9%).

Conclusion: Clinical presentation of thyrotoxicosis varies, and understanding these peculiarities would mitigate misdiagnosis and delayed diagnosis in Africa.

Keywords: Thyrotoxicosis, Clinical presentation, Africa, Meta-analysis, Signs and symptoms, Systematic review

Introduction

The thyroid gland is a bilobed endocrine gland located in the anterior neck. It produces levothyroxine (T4) and liothyronine (T3) which have myriads of cellular effects across the various organ systems [1]. Thyroid hormones are essential for optimal metabolism in human cells [2]. The effects of thyroid hormones on various organ systems are depicted in Table 1**.** Understanding the physiological effects of thyroid hormones helps to rationalize the possible signs and symptoms of thyroid dysfunction. Excessive or insufficient circulatory levels of thyroid hormones are associated with a variety of symptoms and signs [3]. These signs and symptoms help to identify specific thyroid disorders [4]. Thyroid disorders are the second most common category of diseases seen by Endocrinologists [5, 6]. Thyrotoxicosis is one of the most common thyroid disorders encountered in clinical practice [7].

Thyrotoxicosis is a clinical syndrome characterized by a hypermetabolic state as a result of excess levels of thyroid hormones in the circulation [8, 9]. Based on the statistics from different countries around the globe, as shown in Table 2, the global prevalence of thyrotoxicosis is 0.1–3.4% [10–25, 28, 29]. Common causes of thyrotoxicosis

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Table 1 Physiological effects of thyroid hormones

Organ system	Effects of thyroid hormones
Cardiovascular	Inotropic Chronotropic Increase cardiac output Increase blood pressure
Respiratory	Stimulate respiratory drive Increase minute ventilation Enhances hypoxic and hypercapnic drive of respiration Increase tissue oxygenation
Gastrointestinal	Enhances peristalsis Promote glucose absorption
Hepatobiliary	Increase hepatic low-density lipoprotein (LDL) receptor expression Increase cholesterol metabolism and biliary excretion Enhance gall bladder contractility Increase the synthesis of liver enzymes
Renal	Needed for kidneys growth and development Increase glomerular filtration rate Promote urine concentration and dilution Affect renal handling of electrolytes
Reproductive	Male: Enhances the development of the testicles Promote spermatogenesis Affect erectile function Affect seminal volume Female: Modulate the development of the ovaries, Fallopian tubes and the uterus Regulate menstrual cycle Promote intrauterine growth of fetuses Modulate fertility
Nervous	Essential for brain development and nerve maturation Important for motor co-ordination Modulate psychoaffective functioning Regulate the autonomic nervous system
Musculoskeletal	Influence bone growth and development Regulate bone strength Affect osteotendinous reflexes Modulate muscular contraction Regulate skeletal muscle energy turnover
Integumentary system	Regulate keratinocytes proliferation Control homeostasis
Immune system	Regulate the cellular immune response Contribute to inflammatory response

Table 2 Prevalence of thyrotoxicosis

Country	Prevalence (%)
Australia [10]	**0.3**
Brazil [11]	**0.7**
Cameroon [12]	**0.5**
China [13]	**0.78**
Croatia [14]	**0.1**
Guinea [15]	**3**
India [5]	**1.3**
Iran [16]	**0.69**
Italy [17]	**0.76**
Libya [18]	**0.84**
New Zealand [19]	**0.2**
Nigeria [20]	**1.4**
Paraguay [21]	**2**
Saudi Arabia [22]	**1.2**
South Korea [23]	**2**
Sudan [24]	**3.4**
Republic of Benin [25]	**0.87**
United Kingdom [26]	**1.1**
USA [27]	**0.5**

include Graves' disease, toxic multinodular goiter and toxic adenoma [28]. Other uncommon causes include thyroiditis, thyroid cancer, thyrotropinoma, medications (like Amiodarone) and struma ovarii [29].

In a bid to make a diagnosis of thyrotoxicosis, there is a need to identify the clinical characteristics of the patients. In Africa, it is still believed that autoimmune diseases, generally, are not as common as what is seen in the western world and the hygiene hypothesis has been postulated as a possible explanation [30]. Graves' disease, an autoimmune disorder and the most common cause of thyrotoxicosis, is said to be less common in the developing world and this is partly due to the hygiene hypothesis [31]. There is also a strong possibility of underdiagnosis, misdiagnosis and cultural beliefs leading to apparently low incidence among Africans.

Interestingly, as a result of low iodine intake, the proportion of toxic multinodular goiter and toxic adenoma as a cause of thyrotoxicosis is relatively higher in developing nations when compared to the developed world [32]. Similarly, it has been reported that the clinical presentation as well as cardiovascular prognosis of toxic multinodular goiter is different from that of Graves' disease [33]. Since the proportion of toxic multinodular goiter is higher among African patients with thyrotoxicosis and patients with toxic multinodular goiter present differently, it would be of scientific interest to analyze how Africans with thyrotoxicosis present clinically. This would enhance the accuracy of diagnosis and prognosis in such

patients. To the best of the authors' knowledge, there has been no multinational study or systematic review to critically examine how the generality of thyrotoxic individuals present clinically in Africa, hence the need for the present study. This study aims to do a systematic review and meta-analysis of the clinical features of patients with thyrotoxicosis across the continent of Africa.

Methods

The study is a systematic review with a meta-analysis. Studies that documented the clinical features of thyrotoxicosis up till March 2022 were selected. Other selection criteria stipulated that the studies (or at least the abstract) must have been reported in English language and must have been carried out in an African country.

The sources of the data used include biomedical databases such as African Journal Online (AJOL), PubMed, SCOPUS, and Google Scholar. Other databases such as Research Square, SciELO, and medRxiv were also searched. A concerted effort was also made to search the gray literature. In searching for the relevant articles, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were strictly followed. The search terms used were "each African country", "clinical", "features", "presentation", "signs", "symptoms", and "thyrotoxicosis". Others were "hyperthyroidism", "toxic", "goitre", "Graves' disease", "Basedow's disease", "Plummer's disease", "thyroiditis", "adenoma", and "thyroid". In order to enhance the output of the database search, the Boolean operators "AND," "OR," and "NOT" were utilized.

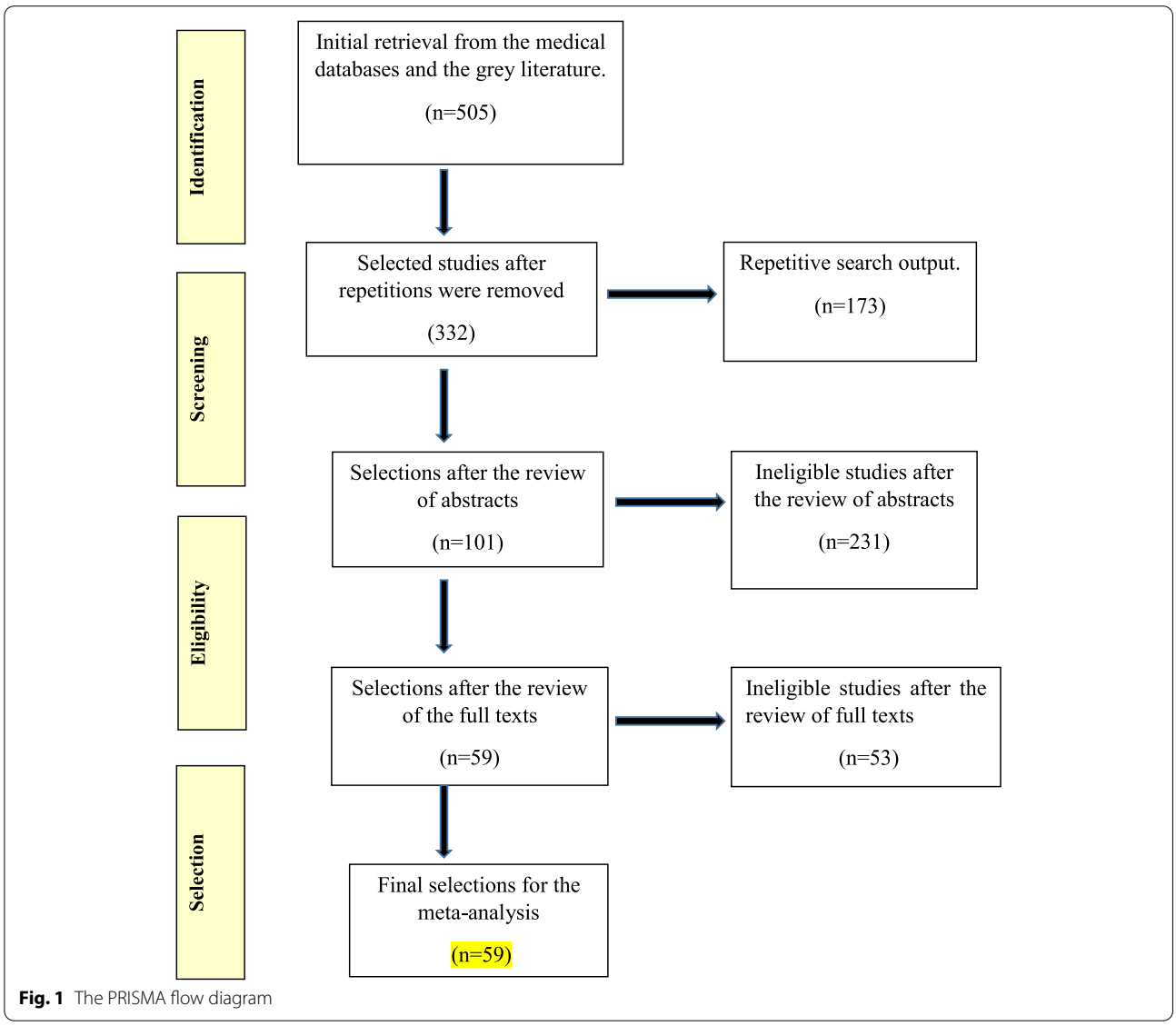

Fig. 1 The PRISMA flow diagram

Table 3 Characteristics of the selected studies

	Study	Sample size	Country	Year	Study type
1	Olurin [36]	46	Nigeria	1972	Retrospective
2	Abdulkadir et al [37]	46	Ethiopia	1982	Prospective
3	Mengistu [38]	163	Ethiopia	1993	Prospective
4	Niakara et al [39]	32	Burkina Faso	2000	Retrospective
5	Akossou et al [40]	82	Togo	2001	Retrospective
6	Sigilai [41]	162	Kenya	2003	Retrospective
7	Mohammed [42]	49	Sudan	2004	Prospective
8	Osime & Okobia [43]	50	Nigeria	2004	Retrospective
9	Chuhwak & Obekpa [44]	103	Nigeria	2006	Retrospective
10	Ogbera et al [45]	103	Nigeria	2007	Prospective
11	Ogbera et al [46]	78	Nigeria	2007	Retrospective
12	Okosieme et al [47]	69	Nigeria	2007	Prospective
13	Sidibe et al [48]	38	Mali	2007	Cross-sectional
14	Ali & Naa'aya [49]	174	Nigeria	2009	Retrospective
15	Hattaoui et al [50]	36	Morocco	2009	Prospective
16	Ali et al [51]	53	Nigeria	2012	Prospective
16	Kebede et al [52]	233	Ethiopia	2012	Cross-sectional
17	Onyenekwe [53]	172	Nigeria	2013	Retrospective
18	Jaja & Yarhere [54]	5	Nigeria	2014	Retrospective
19	Ajibare [55]	47	Nigeria	2015	Cross-sectional
20	Dionadji [56]	125	Chad	2015	Retrospective
21	Ekpebegh et al [57]	57	South Africa	2015	Cross-sectional
22	Balde et al [58]	49	Guinea	2016	Retrospective
23	Diagne et al [59]	108	Senegal	2016	Retrospective
24	Edo et al [60]	35	Nigeria	2016	Retrospective
25	Ogun & Adeleye [61]	75	Nigeria	2016	Cross-sectional
26	Sarr et al [62]	878	Senegal	2016	Retrospective
27	Ackuaku-Dogbe et al [63]	116	Ghana	2017	Cross-sectional
28	Boiro et al	239	Senegal	2017	Retrospective
29	Debebe et al [64]	51	Ethiopia	2017	Retrospective
30	Anakwue [65]	50	Nigeria	2018	Prospective
31	Ayandipo [66]	228	Nigeria	2018	Retrospective
32	Azagoh-Kouadio et al [67]	27	Cote d'Ivore	2018	Retrospective
33	Darouassi et al [68]	60	Morocco	2018	Retrospective
34	Diedhiou et al [69]	624	Senegal	2018	Retrospective
35	El-Shareif [70]	145	Libya	2018	Retrospective
36	Sarfo-Kantanka et al [71]	182	Ghana	2018	Cross-sectional
37	Gebreyohannes et al [72]	211	Ethiopia	2019	Retrospective
38	Isah [73]	352	South Africa	2019	Retrospective
39	Mohammed & Hassanein [74]	60	Egypt	2019	Experimental
40	Mulatu [75]	146	Ethiopia	2019	Cross-sectional
41	Ojo et al [76]	38	Nigeria	2019	Cross-sectional
42	Okafor et al [20]	151	Nigeria	2019	Prospective
43	Toyib et al [77]	33	Ethiopia	2019	Cross-sectional
44	Yazidi et al [78]	538	Tunisia	2019	Retrospective
45	Adeleye et al [79]	61	Nigeria	2020	Retrospective
46	Boundia et al [80]	1040	Senegal	2020	Retrospective
47	Demba et al [81]	210	Senegal	2020	Retrospective
48	Ersumo et al [82]	589	Ethiopia	2020	Retrospective

Table 3 (continued)

	Study	Sample size	Country	Year	Study type
49	Mariko et al [83]	70	Mali	2020	Retrospective
50	Mohammed [84]	159	Ethiopia	2020	Cross-sectional
51	Abera et al [85]	89	Ethiopia	2021	Cross-sectional
52	Docrat et al [86]	171	South Africa	2021	Retrospective
53	Kiffle et al [87]	211	Ethiopia	2021	Cross-sectional
54	Maldey et al [88]	336	Ethiopia	2021	Retrospective
55	Mendes [89]	31	South Africa	2021	Retrospective
56	Ruto [90]	124	Kenya	2021	Cross-sectional
57	Sylla et al [91]	26	Senegal	2021	Retrospective
59	Balde et al [92]	156	Guinea	2022	Cross-sectional

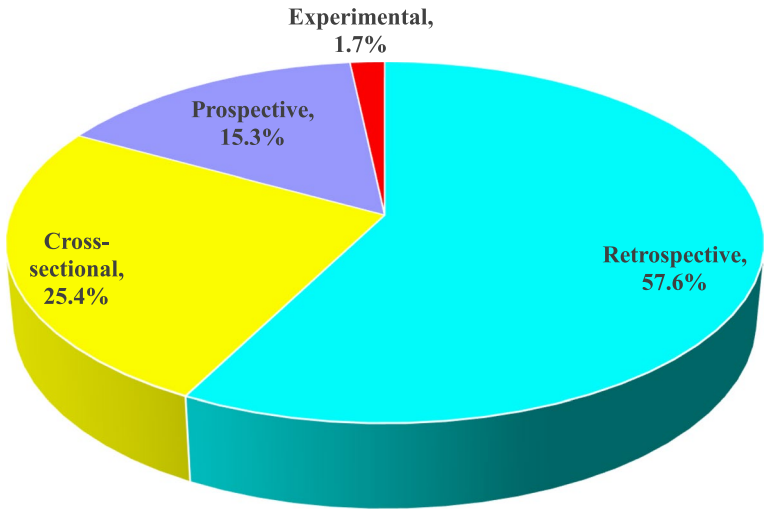

Fig. 2 Types of studies

The authors independently scrutinized the retrieved studies, and those that met the inclusion criteria were added to the systematic review. Data were initially collated using a Microsoft Excel spreadsheet (Redmond, Washington, USA), and the meta-analysis analysis was done using Meta XL version 5.3 (EpiGear International Ltd., Northwestern University, Sunrise Beach, Queensland, Australia.) which is add-in software for Microsoft Excel. The DerSimonian Laird random effect model was used for the meta-analysis.

The quality of the selected studies was assessed using the Newcastle-Ottawa scale. Using the Agency for Healthcare Research and Quality (AHRQ) standards, 76% of the studies were good, 19% were adequate, and 5% were poor. The heterogeneity of the selected studies was determined using I^2 statistic and Cochran's Q test. I^2 values of 25%, 50%, and 75% correspond to small, moderate, and large amounts of heterogeneity respectively [34]. Q statistic value of 75–100 is considered as substantial heterogeneity [35]. LFK index and the symmetry of the Doi plot were used to assess publication bias. Figure 1 shows the PRISMA flow diagram for the systematic review.

Results

Fifty-nine studies met the eligibility criteria and were eventually selected. The characteristics of the studies are shown in Table 3. The studies cut across different regions of Africa. The total sample size was 9592. As shown in Fig. 2, most of the studies were retrospective and cross-sectional in design. The studies were mostly carried out between 1972 and 2022. Table 4 shows the mean age and the female-to-male ratio of the selected studies. The pooled mean age is 37.8 years. The pooled female-to-male ratio among individuals with thyrotoxicosis in Africa is 6.4:1. Table 5i–iii shows the symptoms of thyrotoxicosis among African patients.

Table 4 Mean age and the sex ratio of the selected studies

	Studies	Sample size	Mean age (years)	F:M
1	Olurin [36]	46	NA	3.6:1
2	Abdulkadir et al [37]	46	30.0	4.9:1
3	Mengistu [38]	163	NA	8.1:1
4	Niakara et al [39]	32	42.2	3.4:1
5	Akossou et al [40]	82	NA	NA
6	Sigilai [41]	162	37.0	4.2:1
7	Mohammed [42]	49	NA	5.7:1
8	Osime & Okobia [43]	50	32.0	15.7:1
9	Chuhwak & Obekpa [44]	103	38.6	8:1
10	Ogbera et al [45]	103	40.8	5:1
11	Ogbera et al [46]	78	40.0	5.6:1
12	Okosieme et al [47]	69	37.8	3.9:1
13	Sidibe et al [48]	38	12.5	3:1
14	Ali & Naa'aya [49]	174	33.9	7.8:1
15	Hattaoui et al [50]	36	44.5	NA
16	Ali et al [51]	53	30.8	6.1:1
16	Kebede et al [52]	233	43.1	9:1
17	Onyenekwe [53]	172	40.2	4:1
18	Jaja & Yarhere [54]	5	NA	1.5:1
19	Ajibare [55]	47	46.9	7.3:1
20	Dionadji [56]	125	35.7	5:1
21	Ekpebegh et al [57]	57	39.7	9:1
22	Balde et al [58]	49	42.0	15.3:1
23	Diagne et al [59]	108	34.6	7.3:1
24	Edo et al [60]	35	44.3	10.6:1
25	Ogun & Adeleye [61]	75	42.0	5.3:1
26	Sarr et al [62]	878	34.8	4.2:1
27	Ackuaku-Dogbe et al [63]	116	45.2	4.5:1
28	Boiro et al	239	10.8	2.8:1
29	Debebe et al [64]	51	30.0	NA
30	Anakwue [65]	50	44.0	NA
31	Ayandipo [66]	228	38.0	5.8:1
32	Azagoh-Kouadio et al [67]	27	NA	4.4:1
33	Darouassi et al [68]	60	52.0	NA
34	Diedhiou et al [69]	624	32.1	NA
35	El-Shareif [70]	145	36.8	2.5:1
36	Sarfo-Kantanka et al [71]	182	39.9	5.1:1
37	Gebreyohannes et al [72]	211	47.3	9.4:1
38	Isah [73]	352	NA	7.3:1
39	Mohammed & Hassanein [74]	60	38.2	7.6:1
40	Mulatu [75]	146	47.2	13:1
41	Ojo et al [76]	38	NA	NA
42	Okafor et al [20]	151	49.2	6.5:1
43	Toyib et al [77]	33	41.8	7.9:1
44	Yazidi et al [78]	538	NA	NA
45	Adeleye et al [79]	61	45.0	9:1
46	Boundia et al [80]	1040	31.5	3.3:1
47	Demba et al [81]	210	65.3	5.7:1
48	Ersumo et al [82]	589	40.0	7.9:1
49	Mariko et al [83]	70	13.1	6.25:1
50	Mohammed [84]	159	43.7	6.3:1
51	Abera et al [85]	89	45.0	9:1
52	Docrat et al [86]	171	43.2	5.3:1
53	Kiffle et al [87]	211	NA	13:1
54	Maldey et al [88]	336	46.7	8.8
55	Mendes [89]	31	10.1	5.2:1
56	Ruto [90]	124	40.5	11:1
57	Sylla et al [91]	26	52.8	2.7:1
59	Balde et al [92]	156	39.4	13.3

F:M female-to-male ratio, *NA* not available

The pooled frequencies of the symptoms of thyrotoxicosis among Africans are shown in Table 6. Figures 3, 4, 5, and 6 represent the forest plots of the symptoms while Figs. 7, 8, and 9 represent the corresponding Doi plots. Figure 10 shows the symptoms of thyrotoxicosis among African patients in order of frequency. The commonest symptoms are palpitations, heat intolerance, and weight loss.

Table 7 shows some general signs in Africans with thyrotoxicosis. Table 8 shows the frequencies of some cardiovascular and neurological manifestations of thyrotoxicosis among Africans. Table 9 shows the frequencies of the eye manifestations in thyrotoxicosis. Other eye signs included Joffroy's sign, Goldzieher's sign, and Hertoge's sign. Table 10 shows the cardiometabolic morbidities seen in patients with thyrotoxicosis across Africa. The pooled frequencies of the various signs of thyrotoxicosis are shown in Table 11. Figures 11, 12, 13, 14, and 15 represent the forest plots of the signs while Figs. 16, 17, 18, 19, and 20 represent the corresponding Doi plots. Figure 21 shows the signs of thyrotoxicosis among African patients in order of frequency. Figure 22 shows the pooled frequencies of cardiometabolic morbidities in Africans with thyrotoxicosis.

Discussion

Based on the eligibility criteria, only 59 studies could be analyzed. Interestingly, most of the studies were even in the last two decades. It has been reported that thyrotoxicosis was relatively rare (or underdiagnosed) in Africa which might partly explain this trend in the prevalence of the disease [36]. In addition, Africa is experiencing a transition from iodine deficiency to

Table 5 Clinical features of thyrotoxicosis among African patients

i Study	Weight loss (%)	Heat intolerance (%)	Excessive sweating (%)	Palpitations (%)	Tiredness (%)	Increased appetite (%)
Olurin [36]	74.0	–	70.0	–	41.0	–
Abdulkadir et al [37]	84.6	82.6	82.6	82.6	–	–
Sigilai [41]	60.0	56.0	–	52.0	24.0	31.0
Mohammed [42]	23.0	70.0	–	35.0	10.0	25.0
Osime & Okobia [43]	90.0	84.0	–	86.0	–	100
Chuhwak & Obekpa [44]	50.0	–	–	49.0	–	–
Ogbera et al [46]	63.4	68.0	57.0	58.7	63.4	53.0
Sidibe et al [48]	31.5	–	–	34.4	–	–
Ali & Naa'aya [49]	39.7	28.8	–	35.8	–	14.1
Ali et al [51]	79	78.7	–	94.0	–	78.0
Kebede et al [52]	–	81.9	–	96.0	–	–
Onyenekwe [53]	86.0	82.0	67.4	81.4	54.7	61.2
Jaja & Yarhere [54]	100	–	–	20.0	–	14.1
Ajibare [55]	85.0	85.0	100	95.5	–	–
Dionadji [56]	80.8	–	31.2	–	–	–
Balde et al [58]	73.0	––	–	–	–	–
Diagne et al [59]	39.8	–	–	46.3	–	–
Edo et al [60]	60.0	37.1	–	60.0	–	–
Ogun & Adeleye [61]	63.8	–	52.0	59.4	32.0	35.0
Sarr et al [62]	79.9	53.3	–	83.1	53.6	50.1
Boiro et al	69.8	–	–	–	–	–
Debebe et al [64]	4.0	31.4	9.8	47.1	–	–
Anakwue [65]	48.0	46.0	38.0	60.0	–	32.0
Ayandipo [66]	74.0	84.0	–	–	–	–
Azagoh-Kouadio et al [67]	81.5	30.0	26.0	81.5	–	–
Darouassi et al [68]	39.5	15.1	20.6	–	68.3	–
Diedhiou et al [69]	51.4	–	–	–	–	–
El-Shareif [70]	54.5	35.2	36.6	53.1	18.6	–
Sarfo-Kantanka et al [71]	80.0	76.0	76.0	80.0	80.0	–
Gebreyohannes et al [72]	27.0	70.1	52.2	83.4	37.9	14.7
Ojo et al [76]	100	73.7	100	86.8	–	–
Okafor et al [20]	80.0	86.0	72.0	74.0	80.0	68.0
Toyib et al [77]	100	100	–	100	–	–
Adeleye et al [79]	100	100	–	100	–	–
Demba et al [81]	61.9	–	–	66.7	37.1	–
Ersumo et al [82]	24.8	–	2.0	7.5	36.5	8.0
Mariko et al [83]	87.1	–	–	81.4	–	–
Mohammed [84]	–	25.8	10.7	54.7	–	–
Abera et al [85]	35.0	59.0	44.5	84.5	69.0	33.0
Docrat et al [86]	58.0	92.0	45.0	88.0	80.0	–
Kiffle et al [87]	–	–	–	83.9	–	–
Maldey et al [88]	–	66.3	–	62.7	–	32.4
Mendes [89]	54.5	–	–	18.2	–	–
Ruto [90]	75.8	–	–	75.8	–	–
Sylla et al [91]	68.3	15.1	20.7	–	–	–
Balde et al [92]	89.0	81.0	–	98	–	–

Table 5 (continued)

ii					
Studies	Hyperdefecation (%)	Insomnia (%)	Nervousness (%)	Irritability (%)	Oligomenorrhea (%)
Olurin [36]	47.0	19.0	63.0	63.0	7.0
Abdulkadir et al [37]	–	69.9	73.9	–	25.0
Sigilai [41]	22.0	–	–	30.0	–
Mohammed [42]	13.0	–	–	35.0	15.0
Osime & Okobia [43]	24.0	97.4	–	–	–
Chuhwak & Obekpa [44]	–	–	44.0	–	–
Ogbera et al [46]	–	–	41.0	–	22.0
Ali & Naa'aya [49]	–	14.1	–	–	–
Ali et al [51]	–	–	–	–	41.0
Onyenekwe [53]	74.4	47.7	51.7	–	24
Jaja & Yarhere [54]	60.0	60.0	–	–	–
Ajibare [55]	61.7	–	–	–	–
Balde et al [58]	32.7	46.9	57.1	42.9	–
Ogun & Adeleye [61]	16.0	20.0	18.0	–	6.0
Sarr et al [62]	23.8	56.7	4.4	4.4	–
Debebe et al [64]	–	15.7	–	27.4	–
Ayandipo [66]	–	54.0		–	41.0
Azagoh-Kouadio et al [67]	26.0	44.0	44.0	–	52.0
Darouassi et al [68]	–	–	–	38.9	–
El-Shareif [70]	9.7	–	21.4		
Sarfo-Kantanka et al [71]	40.0	70.0	62.0	–	38.0
Gebreyohannes et al [72]	0.95	–	0.95	13.7	3.5
Ojo et al [76]	78.9	–	–	–	–
Okafor et al [20]	–	–	52.0	–	25.0
Toyib et al [77]	45.0	75.8	–	–	–
Adeleye et al [79]	100.0	–	–	–	–
Demba et al [81]	–	47.6	–	–	–
Ersumo et al [82]	–	–	–	7.1	–
Mohammed [84]	2.5	3.1	–	11.3	–
Abera et al [85]	–	–	55.0	–	–
Maldey et al [88]	–	61.0	27.0	–	–
Mendes [89]	–	–	–	25.5	–
Sylla et al [91]	–	–	–	38.9	–
Balde et al [92]	58.0	68.0	91.0	–	–

iii						
Study	Dyspnea	Psychotic symptoms	Skin darkening	Weight gain	Infertility	Hair loss
Olurin [36]	19.0	–	–	–	–	–
Sigilai [41]	25.0	18.0	–	–	–	–
Mohammed [42]	–	–	–	–	10.0	–
Ogbera et al [45]	–	1.9	–	–	–	–
Ogbera et al [46]	–	–	41.0	–	–	31.0
Onyenekwe [53]	–	1.2	11.6	1.2	5.8	10.5
Ogun & Adeleye [61]	–	–	–	5.0	–	–
Sarr et al [62]	–	–	9.1	–	–	7.5
Boiro et al	–	22.1	–	–	–	–
Azagoh-Kouadio et al [67]	63.0	–	–	–	–	–
Diedhiou et al [69]	–	–	–	3.5	–	–
El-Shareif [70]	–	–	2.1	2.1	–	1.4
Sarfo-Kantanka et al [71]	78.0	–	8.0	–	–	–

Table 5 (continued)

Gebreyohannes et al [72]	10.4	–	–	–	–	–
Okafor et al [20]	–	–	35.0	–	74.0	27.0
Ersumo et al [82]	1.0	3.7	–	–	–	–
Abera et al [85]	5.0	–	–	–	–	–
Kiffle et al [87]	86.3	–	–	–	–	–
Balde et al [92]	98	–	–	–	–	–

–, not available

Table 6 Pooled frequency of the symptoms

Symptoms	Frequency (%)	95% CI	*p*	I^2 (%)	*Q* statistic	LFK index
Weight loss	65	60–70	<0.0001	99	6097	−8.29
Heat intolerance	64	58–70	<0.0001	99	3250	−8.90
Palpitations	69	62–77	<0.0001	100	8536	−5.75
Excessive sweating	48	29–67	<0.0001	100	26,649	−5.3
Tiredness	49	38–60	<0.0001	98	648	1.12
Increased appetite	49	38—60	<0.0001	97	678	1.12
Hyperdefecation	37	23–51	<0.0001	98	856	1.93
Insomnia	47	36–59	<0.0001	97	595	−0.8
Nervousness	41	32–49	<0.0001	99	2919	8.86
Irritability	25	16–36	<0.0001	96	268	5.65
Oligomenorrhea	23	13–34	<0.0001	94	181	0.15
Dyspnea	40	7–78	<0.0001	99	1582	2.58
Psychotic symptoms	3	0–7	<0.0001	92	35	2.64
Skin darkening	15	6–26	<0.0001	96	117	2.22
Weight gain	3	1–5	<0.0001	45	3.62	0.08
Infertility	26	0–86	<0.0001	99	212	1.115
Hair loss	13	5–24	<0.0001	95	82	2.92
Pruritus	9	6–13	<0.0001	1	0.3	–
Persistent headache	5	2–8	<0.0001	30	1.43	–
Menorrhagia	5	3–8	<0.0001	0	0.34	1.22

iodine sufficiency through the universal iodine fortification campaign and this has been associated with increased incidence of autoimmune thyroid disorders [93]. Also, delayed presentation, misdiagnosis, and paucity of experts could translate to falsely low prevalence and lack of interest in studying the disease [94]. Nonetheless, language disparity (as studies selected must have at least the abstract in English to meet the selection criteria) could have also contributed to the relatively limited number of eligible studies.

The study cuts across Africa and a little less than 10,000 people were involved. Considering that autoimmune thyroid disorders, which account for the commonest cause of thyrotoxicosis, are less common among Africans when compared with Caucasians, it can be deduced that the sample size is representative enough and the findings can be applied across the continent [95]. It is not surprising that most of the studies (83%) are retrospective and cross-sectional as these are commonly used to document the frequencies of observations such as signs and symptoms [96]. They are also cheaper and require less logistical outlay which make them suitable for low-resource settings such as Africa [96]. However, it is well known that retrospective studies have recall bias and cross-sectional studies may not be fully representative or establish a cause-effect relationship.

The average age of Africans with thyrotoxicosis was 37.8 years. Other authors have documented an averagely young age among cohorts of people with thyrotoxicosis in different countries [97–99]. Graves' disease is the most common cause of thyrotoxicosis and it tends to peak between 20 and 50 years [100]. This may partly account for the average age of patients with thyrotoxicosis seen in this study. This study demonstrated that thyrotoxicosis is

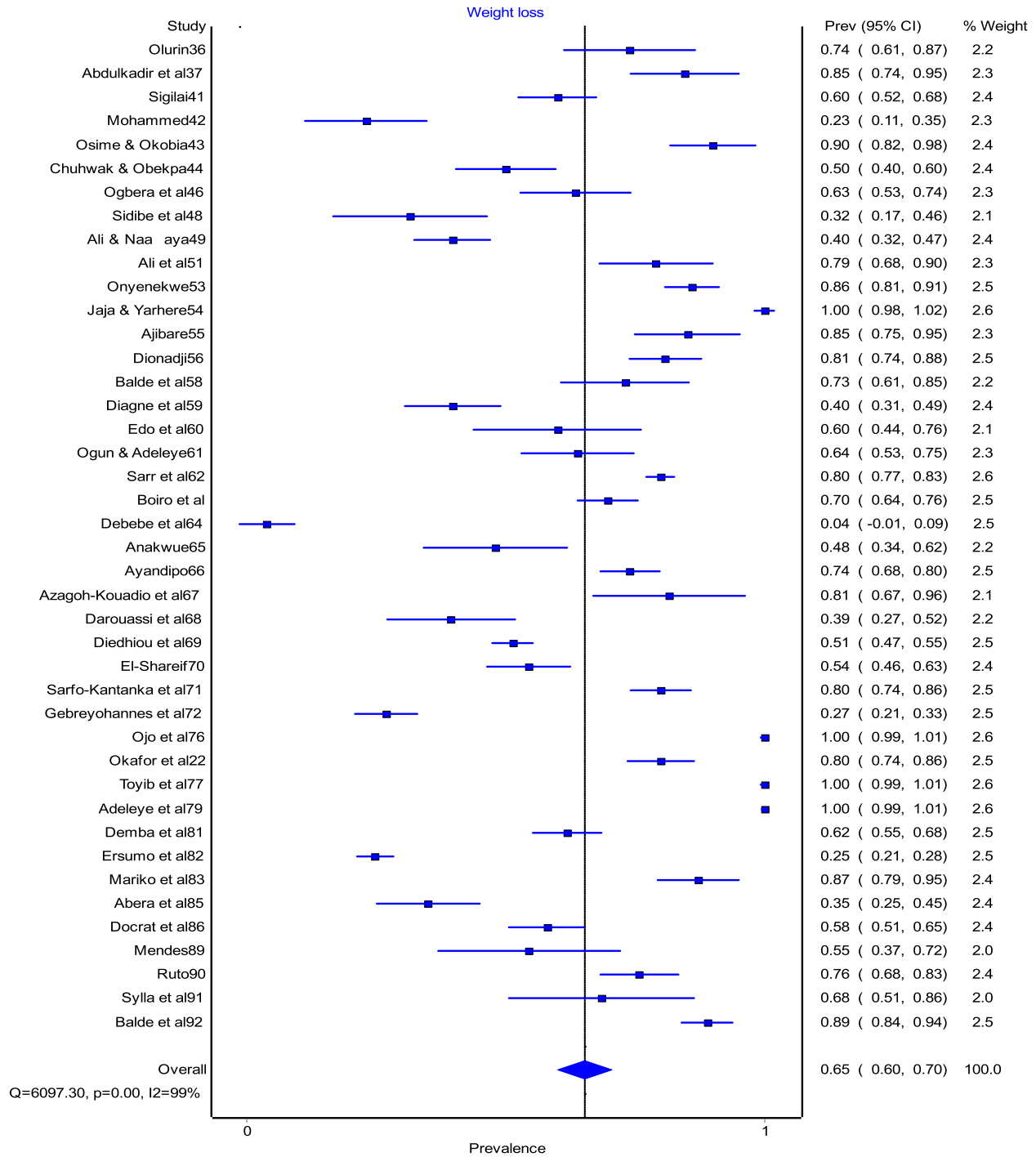

Fig. 3 Forest plots showing the frequencies of weight loss

about 6 times more common among females compared to males. Data from Asia, Europe, Oceania, and America have corroborated this finding of a significant female preponderance of thyrotoxicosis cases [101–103]. Some of the reasons proposed for this female predominance in thyrotoxicosis include the higher prevalence of autoimmune disorders among females, the role of the female sex hormones, and the rebound immune status in postpartum state (as pregnancy is immunosuppressive) [104].

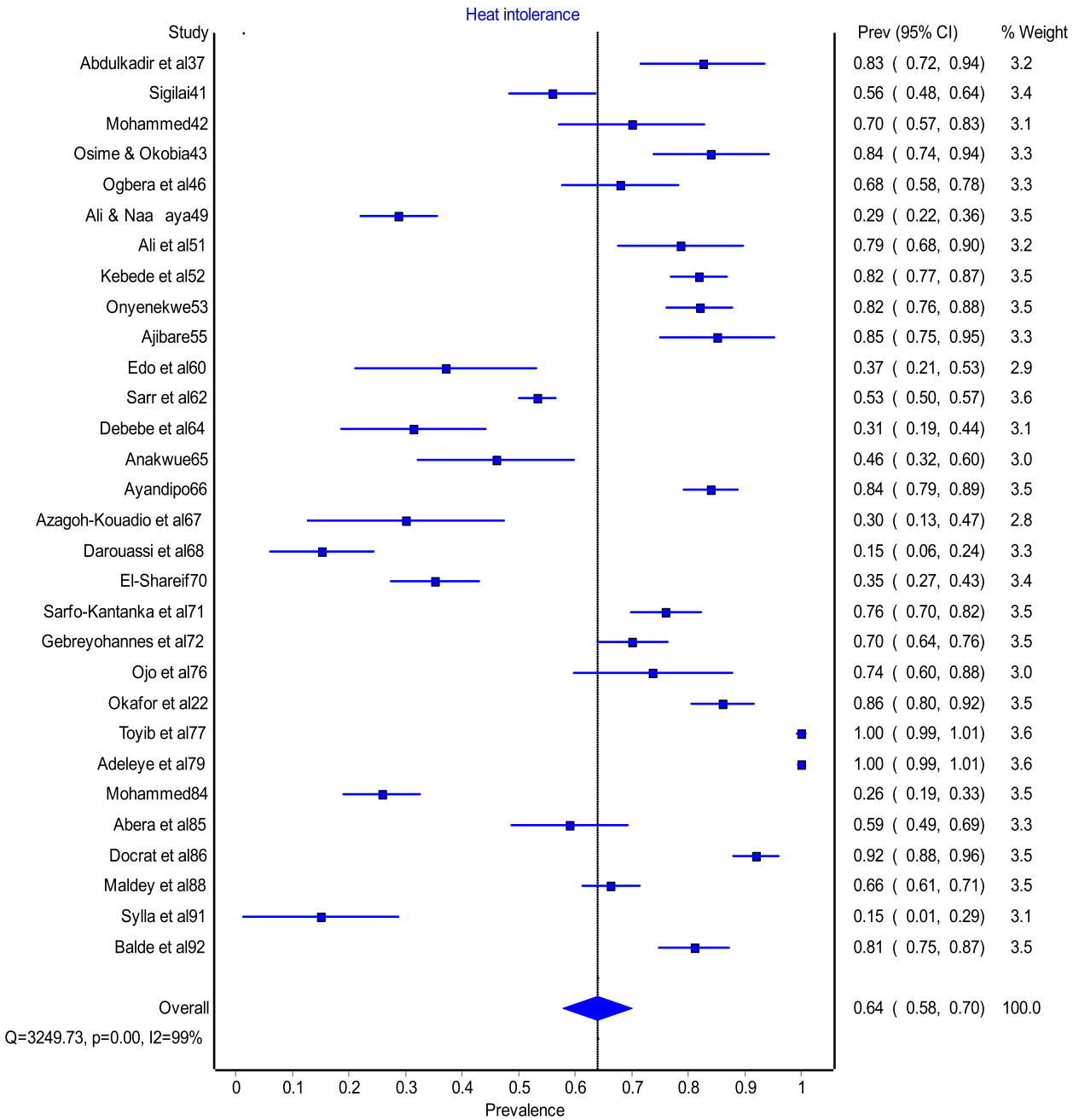

Fig. 4 Forest plots showing the frequencies of heat intolerance

The symptoms of thyrotoxicosis seen in Africa vary in frequencies from what is seen in other parts of the world [105, 106]. These differences in frequencies and patterns of presenting features imply that clinicians practicing in Africa need to understand how patients present here. The most common symptoms of thyrotoxicosis in Africa are palpitations, weight loss, heat intolerance, and tiredness. Similar (but not identical) findings have been reported by non-African authors in various studies conducted outside Africa [107, 108]. Other symptoms, found in this study, were increased appetite, excessive sweating, insomnia, nervousness, and pruritus. Again, these are similar to what is found among thyrotoxicosis patients managed in other continents too [109].

Oligomenorrhea is the most common menstrual abnormality but a minority (3%) also have menorrhagia.

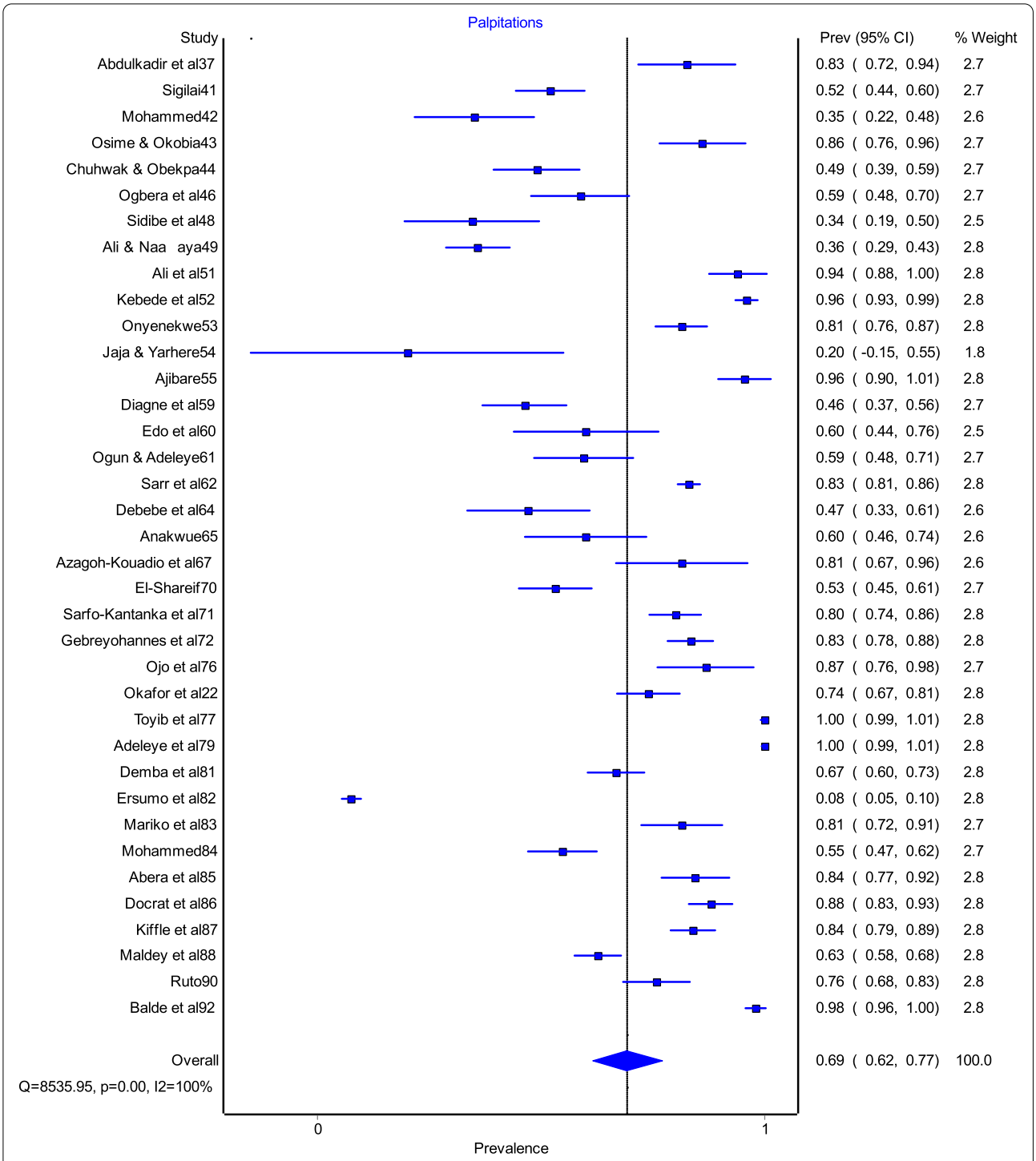

Fig. 5 Forest plots showing the frequencies of heat intolerance

Krassas, in Greece, demonstrated, in his study, that oligomenorrhea is quite common in premenopausal women with thyrotoxicosis while Tara, in Iraq, also reported that menorrhagia can rarely occur in thyrotoxicosis [110, 111]. About 1 out of 4 individuals with thyrotoxicosis in Africa present with infertility. Quintino-Moro did a study in Brazil while Krassas did a similar study in Greece and both found a high prevalence

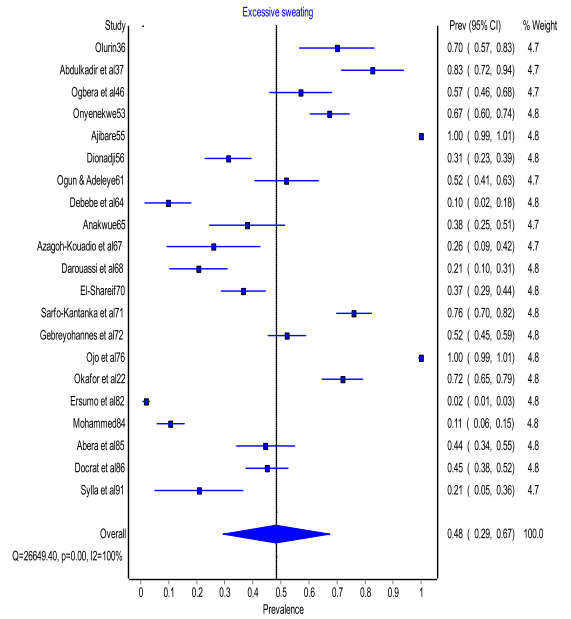

Fig. 6 Forest plots showing the frequencies of excessive sweating

of infertility among female and male hyperthyroid individuals respectively [112, 113].

Again, despite that weight loss is one of the most common symptoms, a minority of thyrotoxicosis patients (3%) present with weight gain. In the thyrotoxic patients experiencing weight gain, it is often due to increased appetite and excess calorie consumption [114]. This usually occurs following the commencement of treatment. The pooled prevalence of psychotic symptoms in the present study is 3%. Some authors, working outside Africa, have also found a similar proportion of thyrotoxic patients presenting with psychotic symptoms [115, 116]. Usually, the psychotic manifestations tend to remit with the treatment of thyrotoxicosis but some may require addition of anti-psychotic drugs.

Based on the findings of this study, enlarged thyroid gland, tachycardia, sweaty palms, and hand tremors are the most common clinical signs seen in a person with thyrotoxicosis in Africa. These manifestations have been documented in other studies and are due to the heightened activities of the sympathoadrenal system in such individuals [117]. In this study, atrial fibrillation was found in 9% of individuals with thyrotoxicosis in Africa. Other studies, outside Africa, have quoted a prevalence rate of 5–15% for atrial fibrillation in thyrotoxicosis and this is similar to the outcome of the present study [118, 119]. Thyrotoxicosis causes a reduction in the repolarization phase of the atria and this predisposes the atrium to fibrillation [120].

Bilateral exophthalmos was found in 49% of Africans with thyrotoxicosis, according to the outcomes of the present study. Retrospective studies done in the UK estimated a proportion of 35–57% of ocular involvement in thyrotoxicosis [121]. Activation of TSH receptors in the ocular tissues by TSH receptor antibodies (TRAb) is

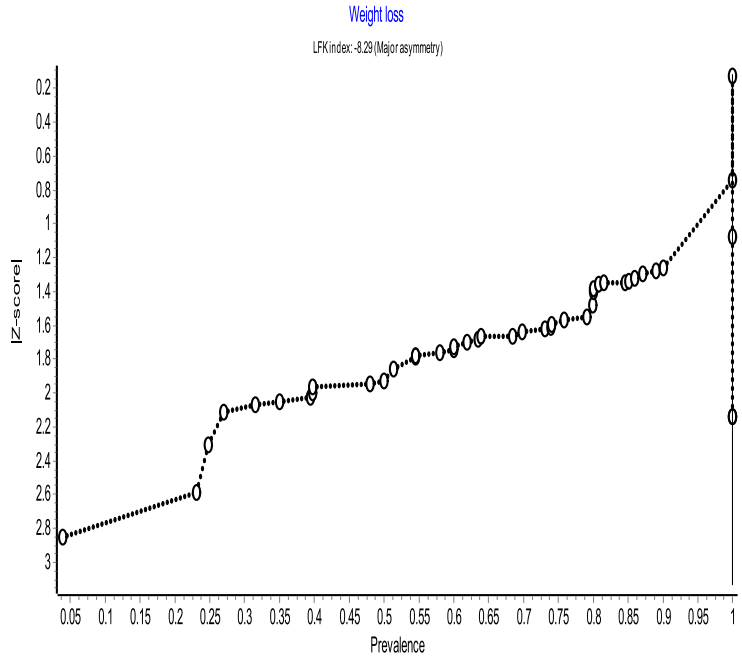

Fig. 7 Doi plot for weight loss

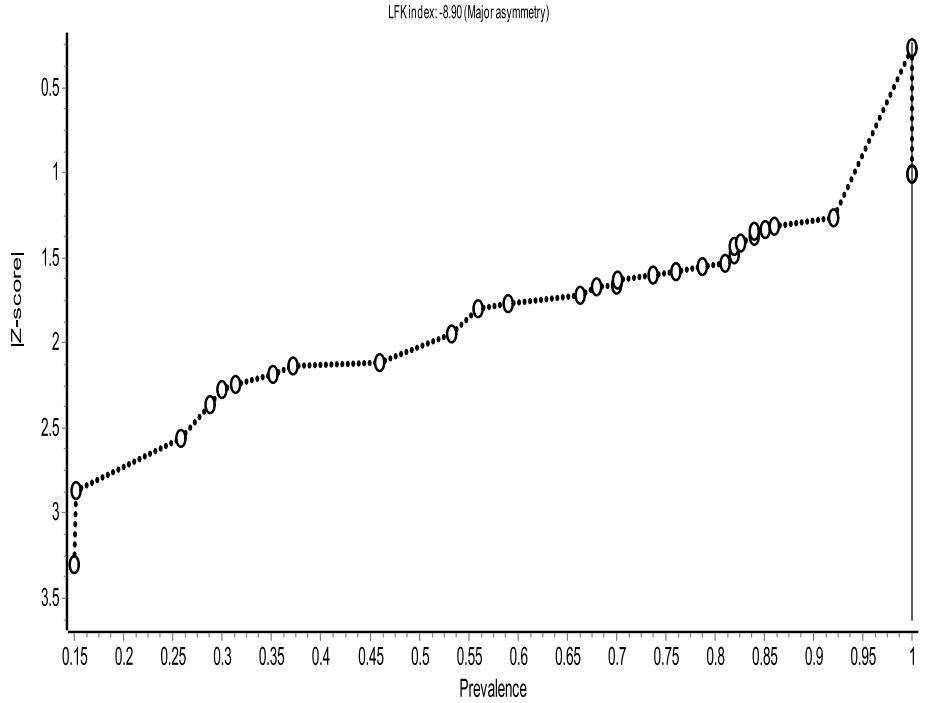

Fig. 8 Doi plot for heat intolerance

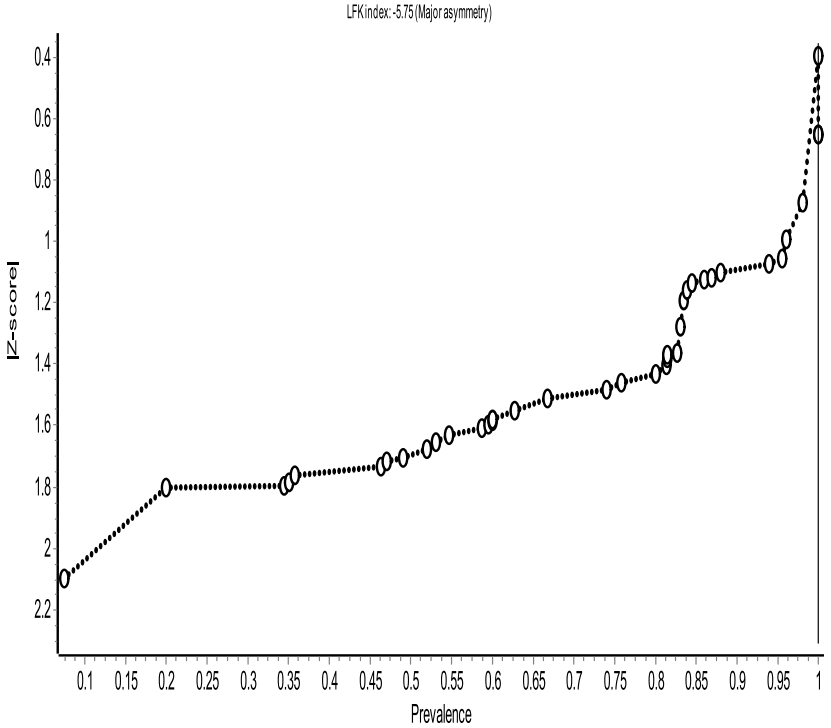

Fig. 9 Doi plot for palpitations

believed to be the underlying link between Graves' disease and thyroid eye changes including exophthalmos [121]. Lid retraction was found in 19% of thyrotoxic Africans. However, in a previous study done in India, a proportion of 28–34% was documented. This may be due to racial differences and the differences in the study protocols [122].

Seven percent of thyrotoxic individuals in this study had pretibial myxedema. It can be found in 5–15% of individuals with Graves' disease, as reported in some non-African studies [123]. It has variable presentation and can occur before, during, and after the clinical presentation of classical thyrotoxicosis signs and symptoms. Hypertension and diabetes mellitus were found in 25% and 9% respectively of Africans with thyrotoxicosis. Prisant et al., in the USA, reported a prevalence of 10–50% for hypertension in hyperthyroid patients [124]. Due to adrenergic hyperactivity in thyrotoxicosis, there is increased cardiac output from enhanced chronotropic and inotropic effects and this ultimately leads to the rise in blood pressure in thyrotoxicosis [125]. Increased metabolic demand and endothelin-1 secretion in thyrotoxicosis are also possible explanations for hypertension in thyrotoxicosis. Proposed mechanisms for a relatively high prevalence of diabetes mellitus in thyrotoxicosis include concurrence of autoimmune disorders (for type 1 diabetes), enhanced degradation of insulin, increased prandial glucose absorption, increased gluconeogenesis, and insulin resistance [126].

In this study, heart failure was documented in 12% of the individuals with thyrotoxicosis. Previous studies outside Africa have quoted a prevalence of 6–19% for heart failure in thyrotoxicosis [127, 128]. Thyrotoxicosis is associated with certain hemodynamic changes such as increased blood volume which increases preload, and hypertension which increases afterload. There is also an increased incidence of tachyarrhythmia. These are some of the possible reasons thyrotoxicosis is associated with more cases of heart failure compared with the general population.

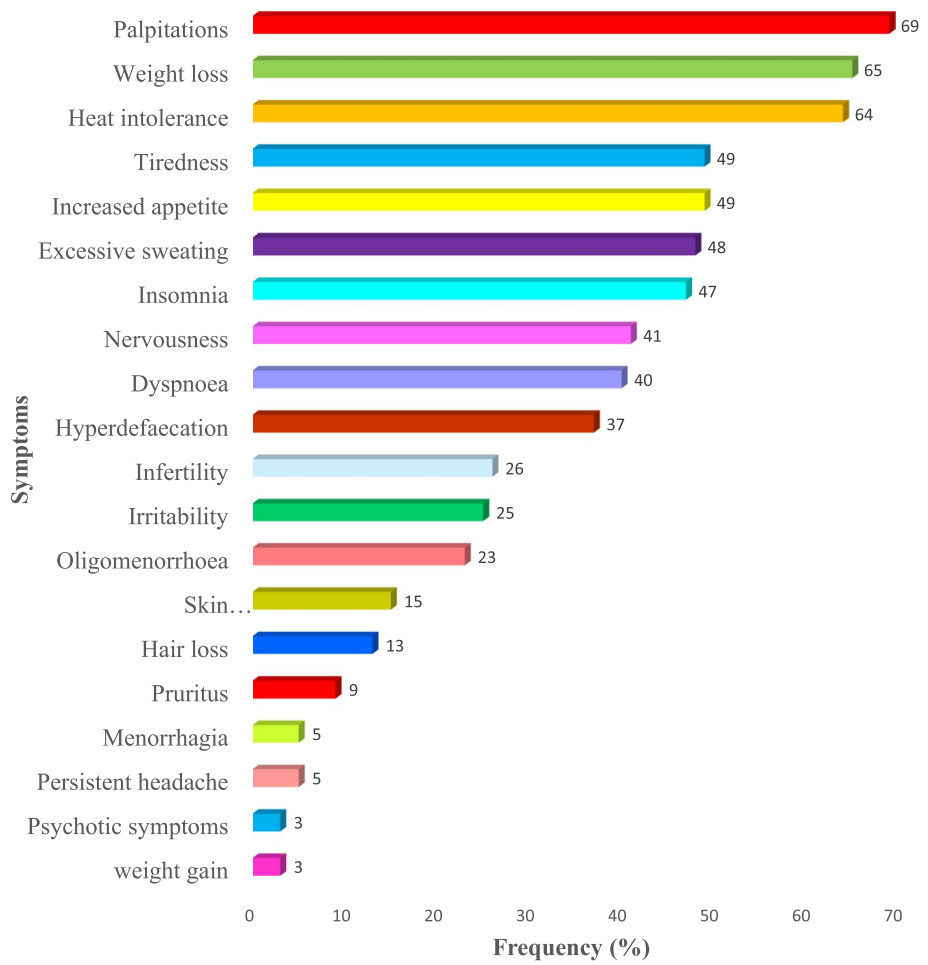

Fig. 10 Frequency of thyrotoxicosis symptoms in Africa

Table 7 General signs of thyrotoxicosis

Study	Goiter (%)	Thyroid bruit (%)	Sweaty palms (%)	Onycholysis (%)	Pretibial myxedema (%)
Olurin [36]	93.0	33.0	78.0	–	–
Abdulkadir et al [37]	97.8	–	–	–	18.2
Sigilai [41]	85.0	–	28.0	–	–
Mohammed [42]	53.4	29.0	–	73.0	–
Osime & Okobia [43]	100	–	–	–	–
Chuhwak & Obekpa [44]	95.0	–	58.0	–	–
Ogbera et al [45]	90.0	–	–	–	–
Ogbera et al [46]	97.0	–	44.0	–	–
Sidibe et al [48]	97.4	–	–	–	–
Ali & Naa'aya [49]	100	–	–	–	–
Kebede et al [52]	99.0	–	–	–	–
Onyenekwe [53]	89.1	–	42.4	7.6	4.1
Jaja & Yarhere [54]	100	–	–	–	–
Ajibare [55]	100	–	–	–	–
Dionadji [56]	97.6	–	–	–	–
Ekpebegh et al [57]	73.8	–	–	–	33
Balde et al [58]	49.0	–	–	–	–
Diagne et al [59]	87.0	–	–	–	–
Edo et al [60]	77.1	–	–	–	8.7
Ogun & Adeleye [61]	68.6	–	–	–	7.0
Sarr et al [62]	97.3	–	–	–	1
Ackuaku-Dogbe et al [63]	67.5	–	–	–	–
Boiro et al	91.1	–	–	–	–
Debebe et al [64]	94.1	–	–	–	–
Anakwue [65]	52.0	–	–	–	–
Azagoh-Kouadio et al [67]	81.5	37.0	–	–	3.7
Darouassi et al [68]	52.0	–	–	–	–
Diedhiou et al [69]	89.9	–	–	–	–
Sarfo-Kantanka et al [71]	82.0	54.0	64.0	–	4.0
Gebreyohannes et al [72]	–	–	37.4	–	–
Okafor et al [20]	81.0	–	54.0	–	–
Toyib et al [77]	100.0	–	–	–	–
Boundia et al [80]	96.1	–	–	–	–
Ersumo et al [82]	82.9	–	–	–	–
Mariko et al [83]	77.1	–	–	–	–
Mohammed [84]	65.4	–	–	–	–
Abera et al [85]	93.0	–	–	–	–
Docrat et al [86]	–	–	–	–	4.0
Kiffle et al [87]	–	–	–	–	0.9
Maldey et al [88]	49.7	–	41.9	–	–
Mendes [89]	96.0	16.0	–	–	–
Ruto [90]	76.6	–	–	–	–
Balde et al [92]	94.0	62.0	91.0	–	28.0

Table 8 Cardiovascular and neurological signs of thyrotoxicosis

Study	Tachycardia (%)	Atrial fibrillation (%)	Hand tremors (%)	Proximal myopathy (%)
Olurin [36]	93.0	–	59.0	–
Abdulkadir et al [37]	100	–	89.1	–
Niakara et al [39]	–	40.0	–	–
Sigilai [41]	55.0	11.0	12.0	–
Mohammed [42]	44.8	1.7	24.0	–
Osime & Okobia [43]	80.0	–	50.0	–
Chuhwak & Obekpa [44]	42.0	–	52.0	–
Ogbera et al [45]	–	6.8	–	–
Ogbera et al [46]	–	14.0	–	–
Okosieme et al [47]	–	2.9	–	–
Sidibe et al [48]	78.9	–	–	–
Ali & Naa'aya [49]	–	–	32.6	–
Hattaoui et al [50]	–	61.1	–	–
Ali et al [51]	–	–	100.0	–
Onyenekwe [53]	–	6.9	62.2	10.9
Ajibare [55]	42.6	10.7	–	–
Dionadji [56]	91.2	–	71.2	64.0
Balde et al [58]	76.0	–	77.0	–
Ogun & Adeleye [61]	–	–	60.9	–
Sarr et al [62]	–	–	69.4	29
Boiro et al	92.4	–	–	–
Debebe et al [64]	49.0	–	–	–
Anakwue [65]	–	–	42.0	–
Azagoh-Kouadio et al [67]	100.0	–	44.0	–
Darouassi et al [68]	78.3	–	21.3	–
Diedhiou et al [69]	50.1	–	–	–
El-Shareif [70]	–	2.8	64.8	–
Sarfo-Kantanka et al [71]	70.0	10.0	–	48.0
Gebreyohannes et al [72]	39.8	–	6.6	–
Isah [73]	40.5	2.3	19.0	–
Mohammed & Hassanein [74]	46.6	–	–	–
Mulatu [75]	–	11.0	–	–
Toyib et al [77]	100	–	100	–
Yazidi et al [78]	–	6.1	–	–
Adeleye et al [79]	–	–	100	–
Demba et al [81]	100	–	38.1	–
Ersumo et al [82]	42.4	–	–	–
Mariko et al [83]	88.6	–	–	–
Mohammed [84]	34.6	–	5.0	–
Abera et al [85]	43.0	–	17.5	–
Docrat et al [86]	–	10.0	–	8.0
Kiffle et al [87]	17.5	–	14.2	–
Maldey et al [88]	–	–	50.2	–
Mendes [89]	27.0	–	33.0	30.0
Sylla et al [91]	78.3	–	21.3	–
Balde et al [92]	92.0	–	83.0	–

Table 9 Ophthalmological manifestations

Study	Exophthalmos (%)	Lid retraction (%)	Lid lag (%)	Other eye signs (%)
Olurin [36]	70.0	51.4	–	–
Abdulkadir et al [37]	59.1	–	–	–
Sigilai [41]	40.0	–	24.0	53.0
Mohammed [42]	64.0	–	13.0	–
Osime & Okobia [43]	–	–	–	24.0
Ogbera et al [45]	22.0	–	–	–
Ogbera et al [46]	–	–	–	38.0
Okosieme et al [47]	–	–	–	55.0
Sidibe et al [48]	81.5	–	–	–
Ali et al [51]	–	–	–	37.2
Onyenekwe [53]	–	–	–	54.7
Jaja & Yarhere [54]	80.0	–	–	–
Dionadji [56]	38.4	–	–	–
Ekpebegh et al [57]	50.0	–	–	–
Balde et al [58]	26.5	–	–	–
Diagne et al [59]	78.7	–	–	–
Edo et al [60]	–	–	–	34.4
Ogun & Adeleye [61]	–	–	–	63.0
Sarr et al [62]	65.9	–	–	–
Ackuaku-Dogbe et al [63]	65.0	–	–	–
Debebe et al [64]	–	5.9	5.9	–
Anakwue [65]	40.0	–	–	–
Ayandipo [66]	–	–	–	74.0
Azagoh-Kouadio et al [67]	85.0	3.7	–	–
Darouassi et al [68]	6.4	–	–	–
Diedhiou et al [69]	72.9	–	–	–
El-Shareif [70]	37.9	–	–	–
Sarfo-Kantanka et al [71]	–	78.0	78.0	76.0
Gebreyohannes et al [72]	1.9	0.47	–	–
Isah [73]	–	–	–	15.6
Okafor et al [20]	–	–	–	75.0
Toyib et al [77]	87.9	–	–	–
Adeleye et al [79]	–	–	–	50.0
Boundia et al [80]	70.7	–	–	–
Demba et al [81]	43.3	–	–	–
Ersumo et al [82]	2.9	–	–	–
Mariko et al [83]	70.0	51.4	–	–
Mohammed [84]	13.8	–	–	–
Abera et al [85]	35.0	0.5	1.0	–
Docrat et al [86]	–	–	–	20.0
Kiffle et al [87]	–	19.0	2.4	–
Mendes [89]	79.0	–	15.8	63.3
Sylla et al [91]	6.8	–	–	–
Balde et al [92]	67.0	–	–	–

Table 10 Associated cardiometabolic morbidities

Study	Hypertension (%)	Thyrotoxic heart disease (%)	Heart failure (%)	Diabetes (%)
Niakara et al [39]	–	–	10.0	–
Akossou et al [40]	–	46.7	–	–
Sigilai [41]	32.0	–	20.0	–
Ogbera et al [45]	14.6	–	11.7	–
Ogbera et al [46]	41.2	–	17.0	–
Okosieme et al [47]	–	–	8.7	–
Hattaoui et al [50]	–	16.6	75	–
Ali et al [51]	–	–	6.4	–
Onyenekwe [53]	–	–	9.7	–
Ajibare [55]	81.5	–	6.4	–
Diagne et al [59]	–	–	11.1	–
Edo et al [60]	–	–	5.7	–
Sarr et al [62]	17.1	–	–	5.1
Debebe et al [64]	9.8	–	–	–
Diedhiou et al [69]	–	–	6.9	–
Isah [73]	30.9	–	–	10.1
Mohammed & Hassanein [74]	43.4	–	–	36.6
Mulatu [75]	48.6	46.6	4.1	8.2
Okafor et al [20]	34.0	–	–	–
Toyib et al [77]	–	–	–	–
Yazidi et al [78]	–	6.5	2.0	–
Demba et al [81]	20.5	9.4	–	4.0
Ersumo et al [82]	10.4	–	–	6.1
Mohammed [84]	1.9	–	–	–
Kiffle et al [87]	2.8	–	–	–
Balde et al [92]	22.0	–	–	8.0

Table 11 The pooled frequencies of the signs of thyrotoxicosis

Signs	Frequency (%)	95% CI	*p*	I^2 (%)	*Q* statistic	LFK index
Goiter	88	87–90	<0.0001	97	1193	−8.31
Thyroid bruit	39	25–54	<0.0001	91	53.2	−3.32
Sweaty palms	54	39–69	<0.0001	98	391	0.93
Onycholysis	40	24–64	<0.0001	99	97	–
Pretibial myxedema	7	4–10	<0.0001	91	106	6.57
Tachycardia	67	62–70	<0.0001	99	4361	−8.7
Atrial fibrillation	9	6–12	<0.0001	88	113	4.38
Hand tremor	49	41–58	<0.0001	100	12,036	−8.88
Proximal myopathy	29	15–46	<0.0001	97	181	0.59
Exophthalmos	49	36–41	<0.0001	99	2085	−1.67
Lid retraction	19	1–48	<0.0001	99	515	0.2
Lid lag	17	0–43	<0.0001	99	407	0.01
Other eye signs	49	35–62	<0.0001	97	454	−0.38

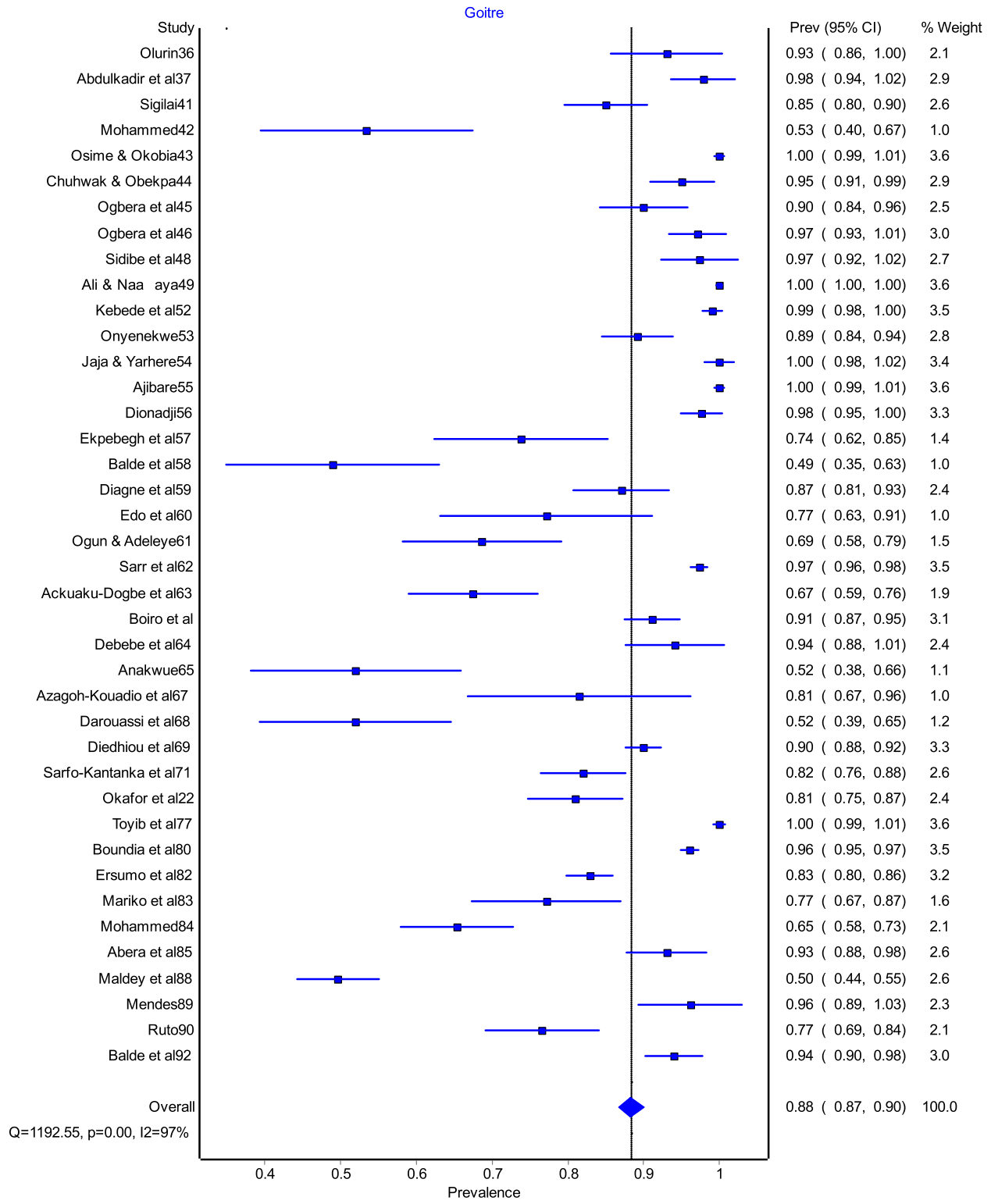

Fig. 11 Forest plots showing the frequencies of goiter

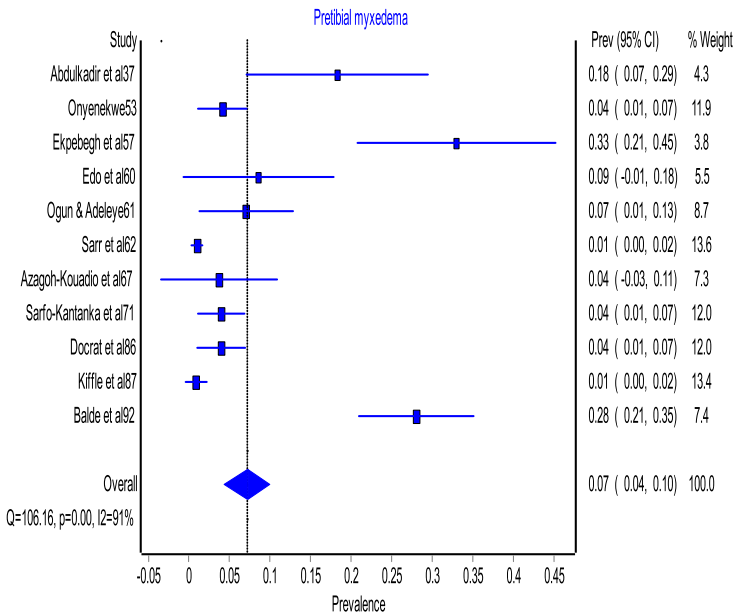

Fig. 12 Forest plots showing the frequencies of pretibial myxedema

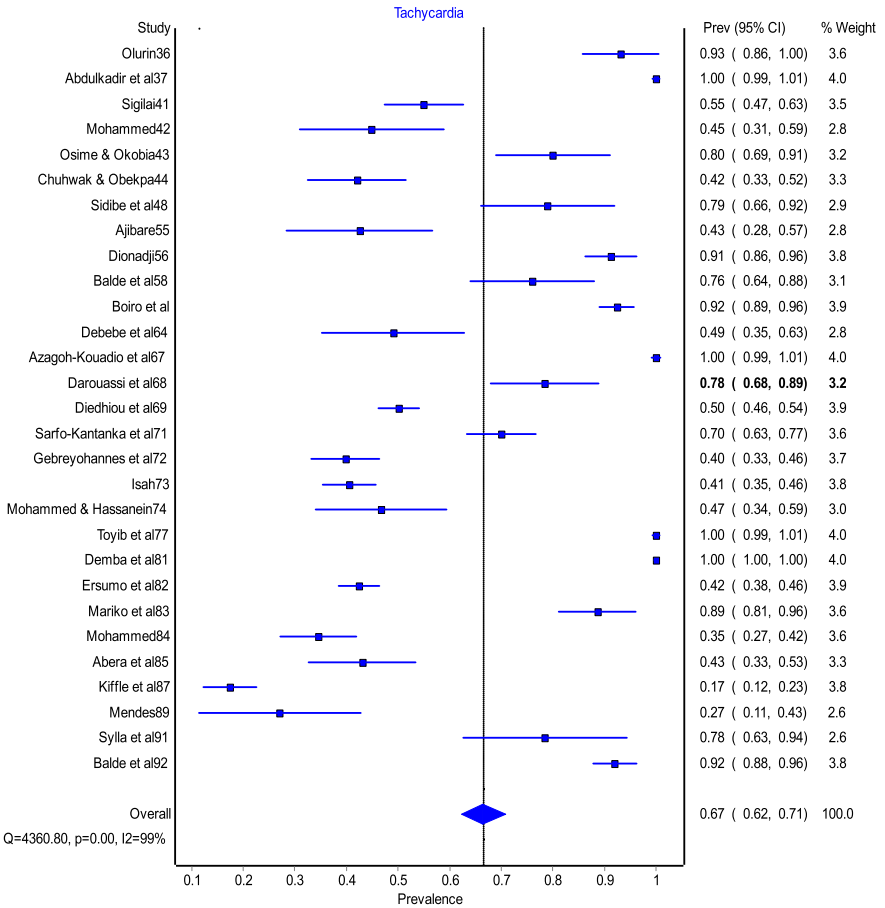

Fig. 13 Forest plots showing the frequencies of tachycardia

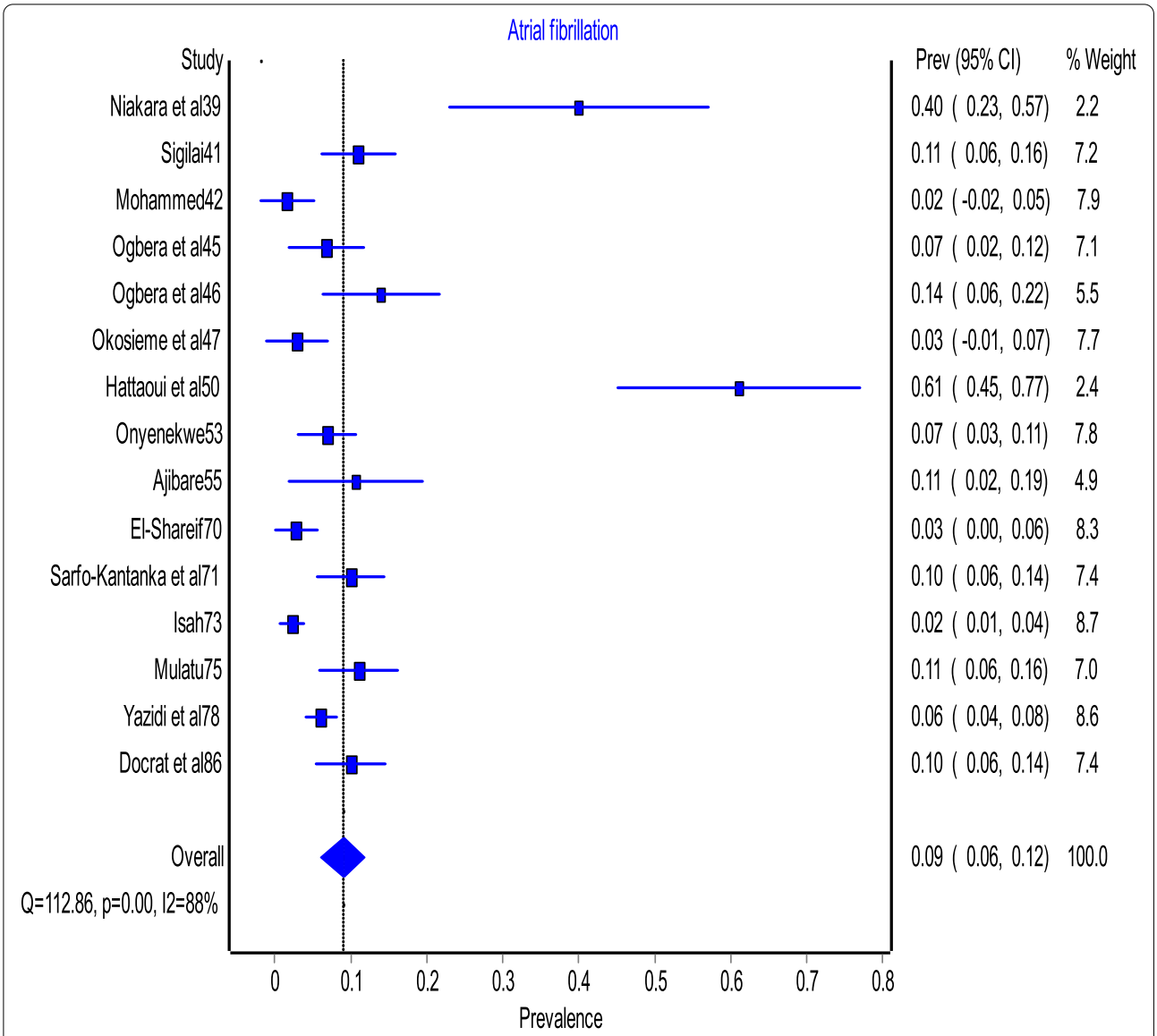

Fig. 14 Forest plots showing the frequencies of atrial fibrillation

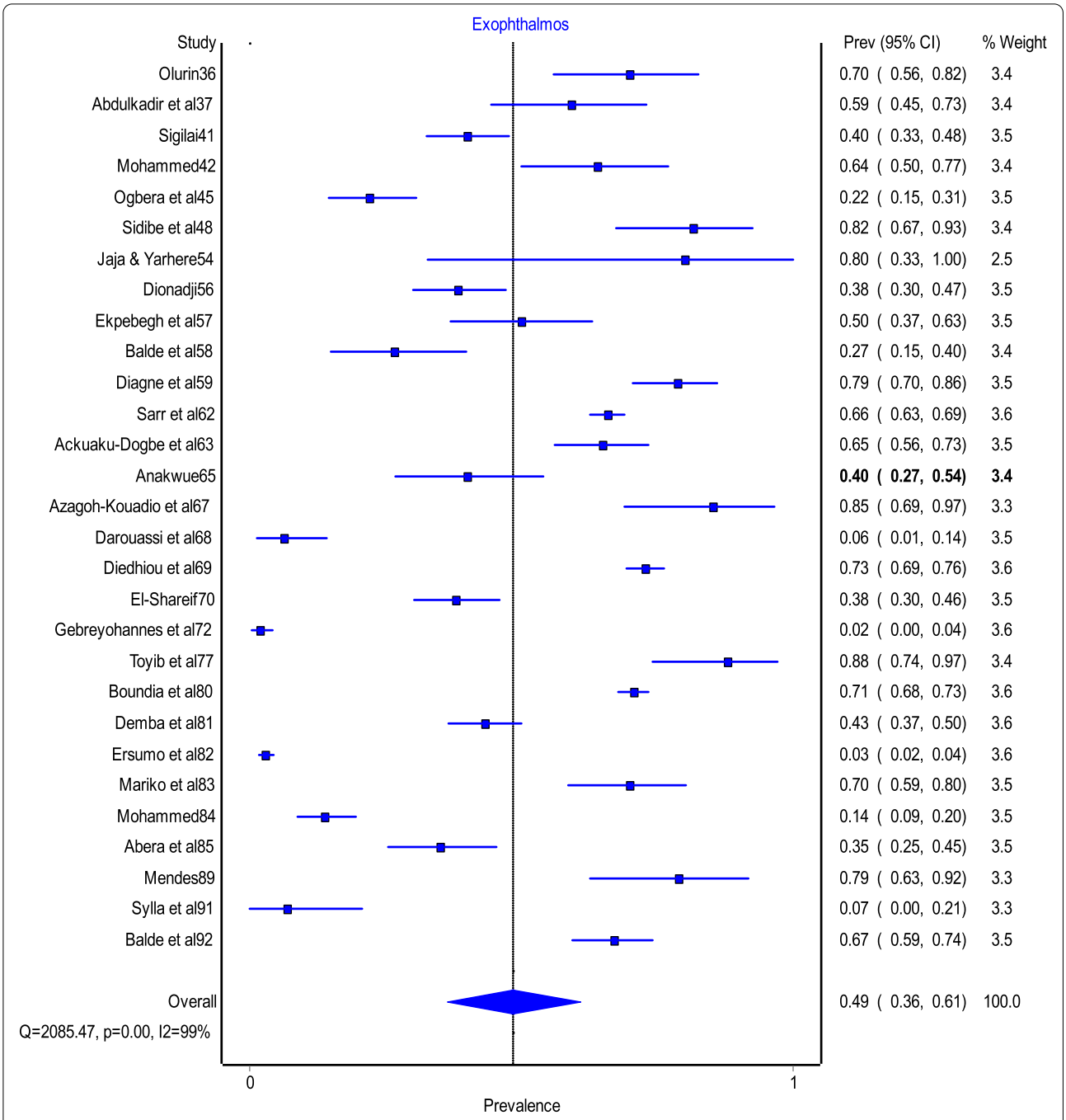

Fig. 15 Forest plots showing the frequencies of exophthalmos

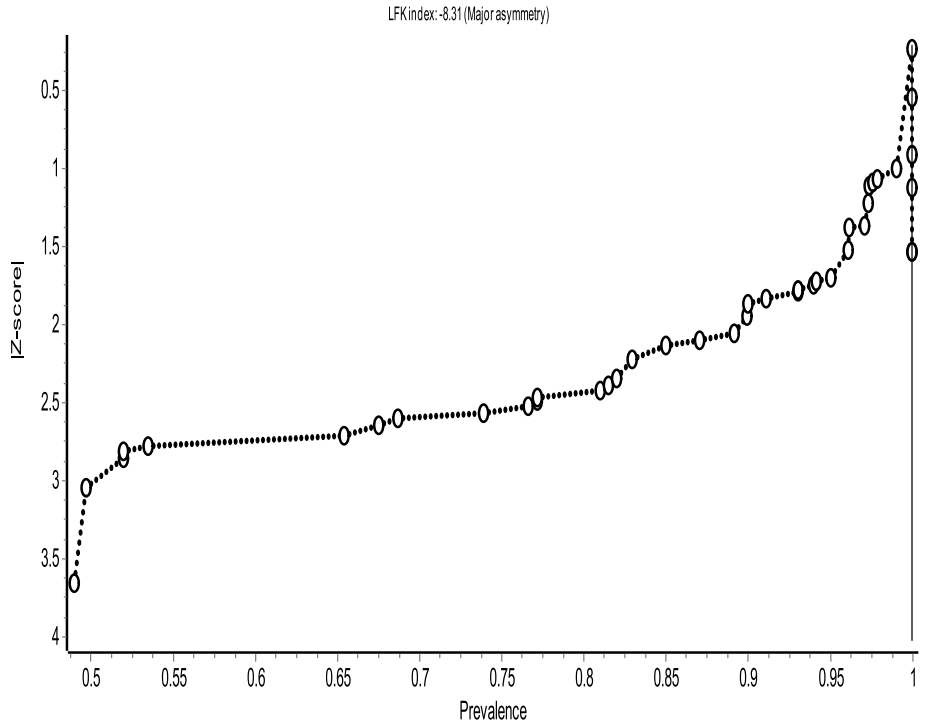

Fig. 16 Doi plot for goiter

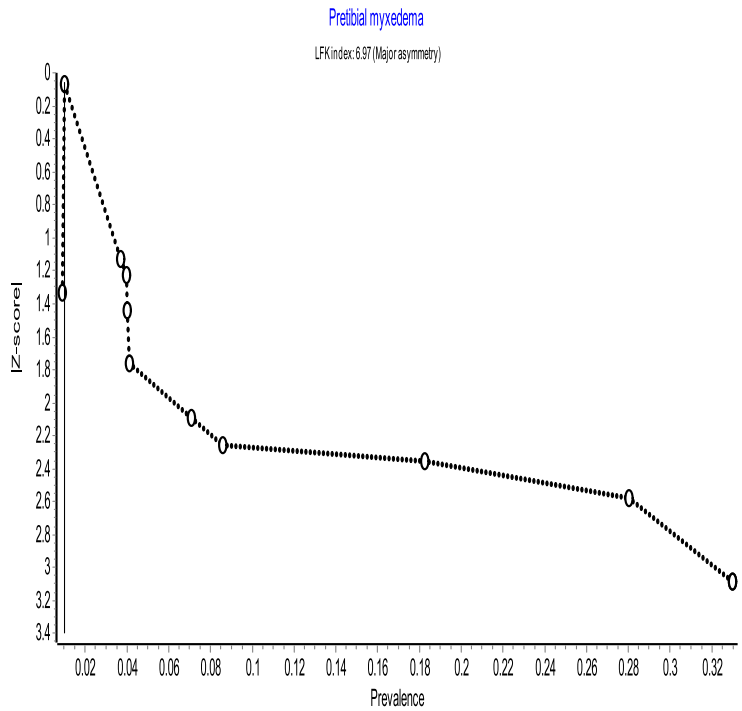

Fig 17 Doi plot for pretibial myxedema

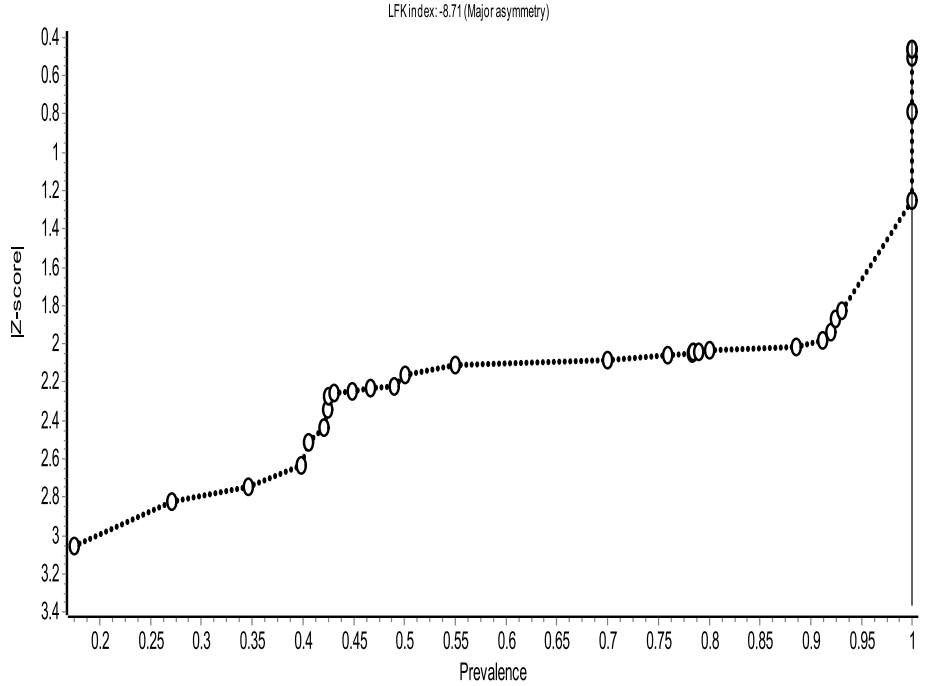

Fig. 18 Doi plot for tachycardia

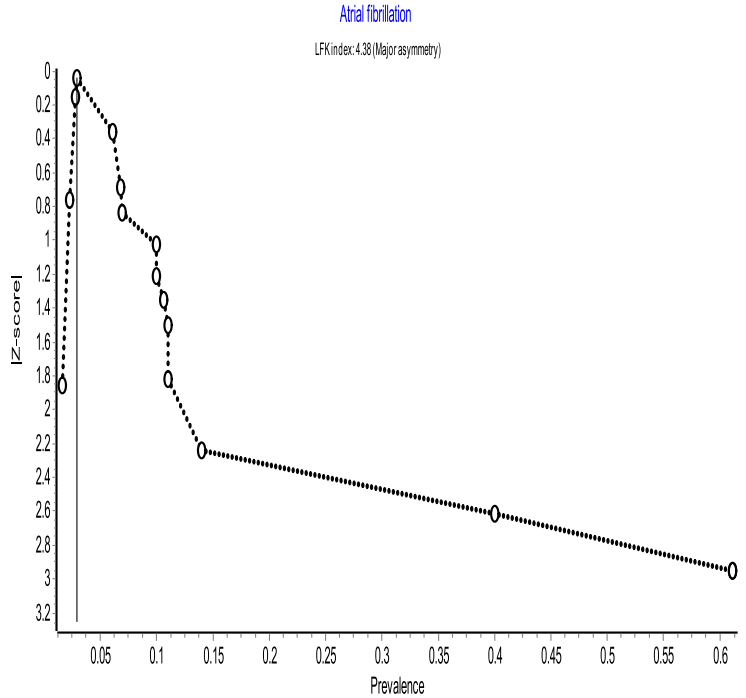

Fig. 19 Doi plot for atrial fibrillation

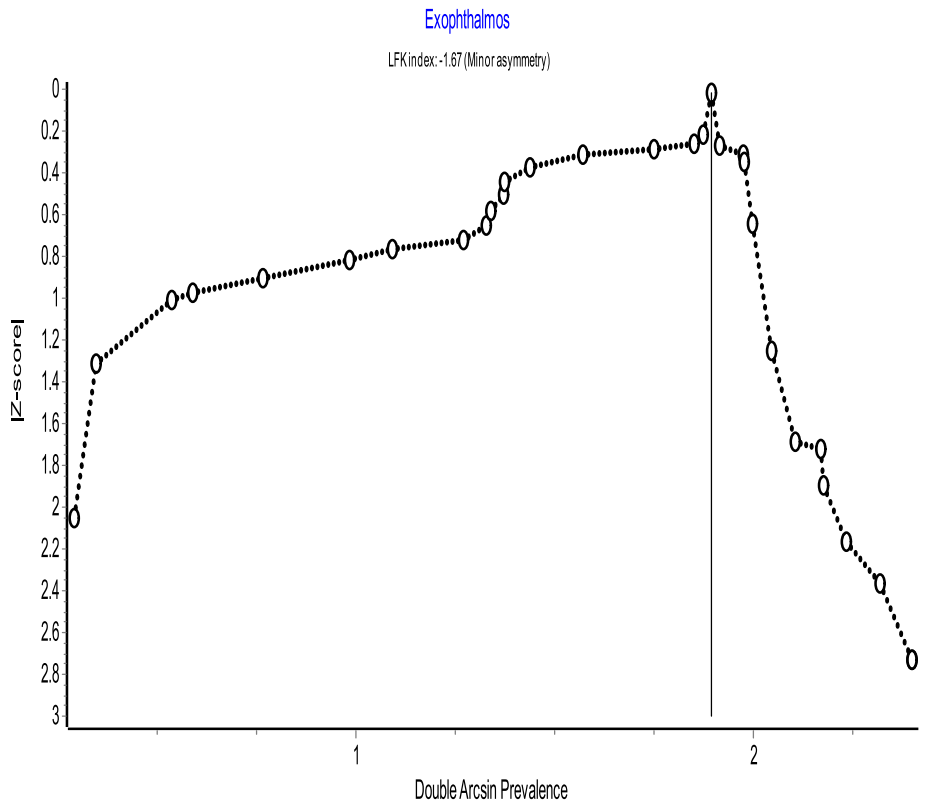

Fig. 20 Doi plot for exophthalmos

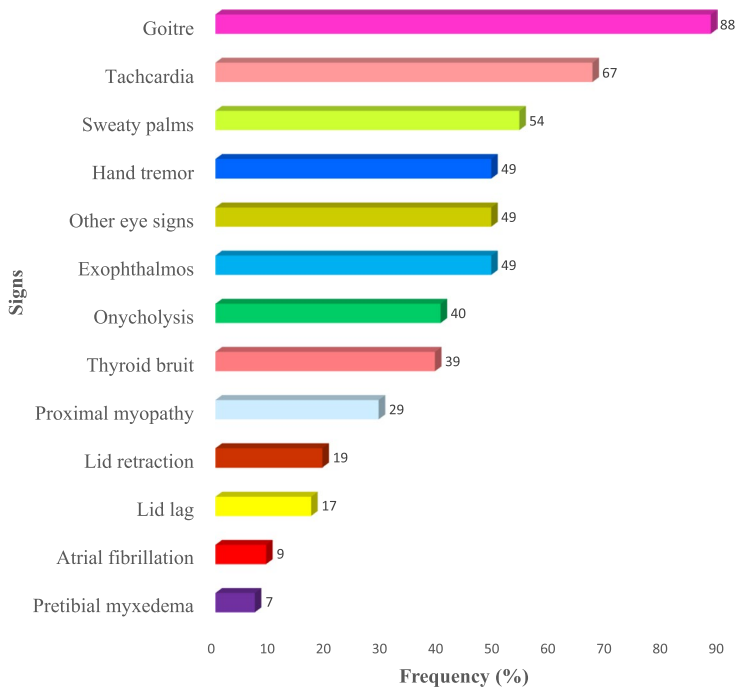

Fig. 21 Signs of thyrotoxicosis among Africans

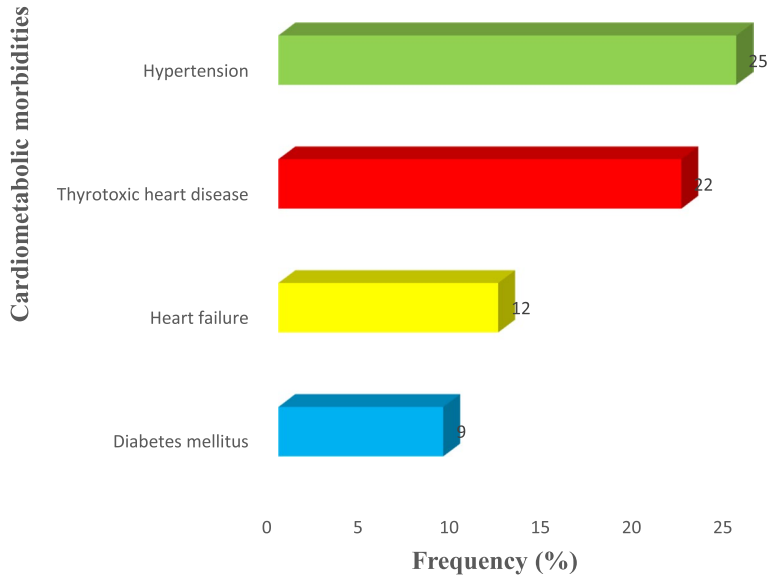

Fig. 22 Pooled frequencies of cardiometabolic morbidities in thyrotoxicosis patients

Strength of the study

The scope of the study is wide and the selected studies cut across all the regions of Africa which make the findings representative enough. Also, this is the first systematic review and meta-analysis, known to the authors, that has discussed the clinical characteristics of thyrotoxicosis in Africa. It is believed that the study will help to reduce delayed diagnosis and misdiagnosis of thyrotoxicosis in Africa.

Limitations

Many African countries are not English-speaking so there is a reasonable possibility that some studies on the subject matter might have been omitted thereby introducing some degree of bias. Some of the selected studies are not detailed enough as far as clinical presentation of thyrotoxicosis is concerned.

Conclusion

Thyrotoxicosis is fairly common in Africa and it has a wide range of clinical manifestations. Physicians in Africa need to pay attention to these clinical features so as to avoid delayed diagnosis or misdiagnosis of the disease.

Authors' contributions
TAA contributed to the conception, data collation, writing and editing of the manuscript. TAA (second author) contributed to the writing and editing of the manuscript. MA contributed to the writing and editing of the manuscript. All author(s) read and approved the final manuscript.

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Declarations

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Consent for publication
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Competing interests
The authors declare that they have no competing interests.

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References

1. Jonklaas J (2022) Optimal thyroid hormone replacement. Endocr Rev 43(2):366–404
2. Maiden MJ, Torpy DJ (2019) Thyroid hormones in critical illness. Crit Care Clin 35(2):375–388
3. Braun D, Schweizer U (2018) Thyroid hormone transport and transporters. Vitam Horm 106:19–44
4. Wouters HJCM, Slagter SN, Kobold ACM, van der Klauw MM, Wolffenbuttel BHR (2020) Epidemiology of thyroid disorders in the lifelines cohort study (the Netherlands). PLoS One 15(11):e0242795

5. Unnikrishnan AG, Menon UV (2011) Thyroid disorders in India: an epidemiological perspective. Indian J Endocrinol Metab 15(Suppl2):S78–S81
6. Ale AO, Odusan O (2019) Spectrum of endocrine disorders as seen in a tertiary health facility in Sagamu, Southwest Nigeria. Niger Med J 60(5):252–256
7. LiVolsi VA, Baloch ZW (2018) The pathology of hyperthyroidism. Front Endocrinol 9 [cited 2022 Mar 28]. Available from: https://www.frontiersin.org/article/10.3389/fendo.2018.00737
8. Cicatiello AG, Di Girolamo D, Dentice M (2018) Metabolic effects of the intracellular regulation of thyroid hormone: old players, new concepts. Front Endocrinol 9 [cited 2022 Mar 28]. Available from: https://www.frontiersin.org/article/10.3389/fendo.2018.00474
9. Idowu AO, Adesegun OA, Osibowale B, Ajiro T, Ezuduemoih D, Osonuga A (2020) A case of thyroxine (T4) toxicosis complicated by thyroid storm with an unusual precipitant. Caspian J Intern Med 11(2):231–234
10. Walsh JP (2016) Managing thyroid disease in general practice. Med J Aust 205(4) [cited 2022 Mar 28]. Available from: https://www.mja.com.au/journal/2016/205/4/managing-thyroid-disease-general-practice?inline=true
11. Bensenor IM (2019) Thyroid disorders in Brazil: the contribution of the Brazilian longitudinal study of adult health (ELSA-Brasil). Braz J Med Biol Res 52 [cited 2022 Mar 28]. Available from: http://www.scielo.br/j/bjmbr/a/5wTNW6r9dsDZPjKrKCkfyTP/?lang=en&format=html
12. Keunmoe P, Halle MP, Nguedia JC, Njounendou AJ, Tengen J, Ngowe M (2020) The spectrum of thyroid function abnormalities and associated biochemical factors in patients with chronic kidney disease in Cameroon. Am J Biomed Sci Res 8(5):387–396
13. Wang C, Li Y, Teng D, Shi X, Ba J, Chen B et al (2021) Hyperthyroidism prevalence in China after universal salt iodization. Front Endocrinol (Lausanne) 12:651534
14. Strikić Đula I, Pleić N, Babić Leko M, Gunjača I, Torlak V, Brdar D et al (2022) Epidemiology of hypothyroidism, hyperthyroidism and positive thyroid antibodies in the Croatian population. Biology. 11(3):394
15. Balde NM, Balde MD, Kake A, Diallo MM, Camara ABD (2007) Hyperthyroidism in Conakry: clinical and therapeutic features. Annales de l'Université Marien NGOUABI 8:23–27
16. Sajjadi-Jazi SM, Sharifi F, Varmaghani M, Meybodi HA, Farzadfar F, Larijani B (2018) Epidemiology of hyperthyroidism in Iran: a systematic review and meta-analysis. J Diabetes Metab Disord 17(2):345–355
17. Caputo M, Pecere A, Sarro A, Mele C, Ucciero A, Pagano L et al (2020) Incidence and prevalence of hyperthyroidism: a population-based study in the Piedmont region, Italy. Endocrine 69(1):107–112
18. Nouh AB, Ehnaf I, Basher M (2008) Prevalence of thyroid dysfunction and its effect on serum lipid profiles in a Murzok, Libya population. Thyroid Sci 3(10):1–6
19. Gibbons V, Conaglen J, Lillis S, Naras V, Lawrenson R (2008) Epidemiology of thyroid disease in Hamilton (New Zealand) general practice. Aus N Z J Public Health 32(5):421–423
20. Okafor EN, Ugonabo MC, Chukwukelu EE, Okonkwo IN, Ezigbo E, Odurukwe O (2019) Prevalence and pattern of thyroid disorders among patients attending University of Nigeria Teaching Hospital, Enugu, southeastern Nigeria. Nigerian Medical Journal 60(2):62
21. Yeza ENG, Mir CN, Ares RM, Pedrozo WR, Bonneau GA (2021) Prevalence of thyroid dysfunction and its relationship with the lipid profile in patients at the Hospital of Encarnación. Revista de Ciencia y Tecnología: RECyT 36(1):70–77
22. Qashqary M, Tobaiqy M, Al-Sutari MM, Mujallad A, Alsheikh I (2020) Prevalence of suspected cases of hyperthyroidism in Jeddah by using Wayne's scoring index. Cureus. 12(11) [cited 2022 Mar 28]. Available from: https://www.cureus.com/articles/41583-prevalence-of-suspected-cases-of-hyperthyroidism-in-jeddah-by-using-waynes-scoring-index
23. Lee JE, Lee DH, Oh TJ, Kim KM, Choi SH, Lim S et al (2018) Clinical feasibility of continuously monitored data for heart rate, physical activity, and sleeping by wearable activity trackers in patients with thyrotoxicosis: protocol for a prospective longitudinal observational study. JMIR Research Protocols 7(2):e8119
24. Saeed AK, Ahmed K, Elmahdi E, Maralyn D, Ali A (2015) The prevalence of thyroid dysfunction among Sudanese pregnant women. SOJGOW. 1(1):1–5
25. Awede B, Hounnou MS, Tshabu-Aguemon C, Adehan G, Djrolo F, Amoussou-Guenou M et al (2018) Thyroid function in pregnant women from a west-African population. Open J Mol Integr Physiol 8(1):1–11
26. Garmendia Madariaga A, Santos Palacios S, Guillén-Grima F, Galofré JC (2014) The incidence and prevalence of thyroid dysfunction in Europe: a meta-analysis. J Clin Endocrinol Metab 99(3):923–931
27. Devereaux D, Tewelde SZ (2014) Hyperthyroidism and thyrotoxicosis. Emerg Med Clin North Am 32(2):277–292
28. Taylor PN, Albrecht D, Scholz A, Gutierrez-Buey G, Lazarus JH, Dayan CM et al (2018) Global epidemiology of hyperthyroidism and hypothyroidism. Nat Rev Endocrinol 14(5):301–316
29. Sharma A, Stan MN (2019) Thyrotoxicosis: diagnosis and management. Mayo Clin Proc 94(6):1048–1064
30. Rook GAW (2012) Hygiene hypothesis and autoimmune diseases. Clinic Rev Allerg Immunol 42(1):5–15
31. Murdaca G, Greco M, Borro M, Gangemi S (2021) Hygiene hypothesis and autoimmune diseases: a narrative review of clinical evidences and mechanisms. Autoimmun Rev 20(7):102845
32. Pooria A, Pourya A, Gheini A (2021) Frequency of pathological types of hyperthyroidism in thyroid scan patients. Curr Med Imaging Rev 17(5):608–612
33. Biondi B, Kahaly GJ (2010) Cardiovascular involvement in patients with different causes of hyperthyroidism. Nat Rev Endocrinol 6(8):431–443
34. Melsen WG, Bootsma MCJ, Rovers MM, Bonten MJM (2014) The effects of clinical and statistical heterogeneity on the predictive values of results from meta-analyses. Clin Microbiol Infect 20(2):123–129
35. Steele J, Plotkin D, Van Every D, Rosa A, Zambrano H, Mendelovits B et al (2021) Slow and steady, or hard and fast? A systematic review and meta-analysis of studies comparing body composition changes between interval training and moderate intensity continuous training. Sports. 9(11):155
36. Olurin EO (1972) Thyrotoxicosis in Nigeria—a study of forty-six patients. Postgrad Med J 48(564):609–615
37. Abdulkadir J, Besrat A, Abraham G, Gebre P (1982) Thyrotoxicosis in Ethiopian patients--a prospective study. Trans R Soc Trop Med Hyg 76(4):500–502
38. Mengistu M (1993) The pattern of thyroid diseases in adult Ethiopians and experience in management. Ethiop Med J 31(1):25–36
39. Niakara A, Nebie LVA, Drabo YJ (2000) La cardiothyréose : étude rétrospective de 32 cas dans les services de cardiologie et de médecine interne à Ouagadougou, Burkina Faso (1993-1998). Bull Soc Pathol Exot 93(1):25–28
40. Akossou SY, Napporn A, Goeh-Akue E, Hillah A, Sokpoh-Diallo K, Soussou B et al (2001) Problems in the management of thyrotoxicosis in black Africa: the Tongolese experience. Ann Endocrinol (Paris) 62(6):516–520
41. Sigilai K (2003) Presentation and surgical management of hyperthyroidism in Kenyatta National Hospital [master of medicine]. University of Nairobi, Kenya, Nairobi
42. Mohammed K (2004) Graves' disease frequency and clinical patterns in Khartoum teaching hospital January - July 2004. University of Khartoum, Sudan, Khartoum
43. Osime U, Okobia MN (2004) Thyrotoxicosis in Benin City: a study of surgical treatment of 50 patients. J Med Biomed Res 3(1) [cited 2022 Apr 1]. Available from: https://www.ajol.info/index.php/jmbr/article/view/10661
44. Chuhwak EK, Obekpa PP (2006) Thyrotoxicosis in Jos, Nigeria: a ten year review. Ann Nigerian Med 2(2):20–24
45. Ogbera AO, Fasanmade O, Isiba A (2007) The scope of cardiac complications of thyrotoxicosis in Lagos, Nigeria. Pak J Med Sci Q 23(5):671–675
46. Ogbera AO, Fasanmade O, Adediran O (2007) Pattern of thyroid disorders in the southwestern region of Nigeria. Ethn Dis 17(2):327–330
47. Okosieme OE, Taylor RC, Ohwovoriole AE, Parkes AB, Lazarus JH (2007) Prevalence of thyroid antibodies in Nigerian patients. QJM: Int J Med 100(2):107–112

48. Sidibé AT, Dembélé M, Diarra AS, Bocoum AI, Mousseni E, Ag Aboubacrine S et al (2007) Hyperthyroïdie chez l'enfant. Expérience d'un service de médecine interne au Mali. Ann Endocrinol 68(2):177–180
49. Ali N, Naa'Ya HU. (2009) Operative management of thyroid disorders in Maiduguri. Niger J Med 18(4):388–392
50. El Hattaoui M, Charei N, Mouniri M, Diouri A (2009) Cardiothyréoses dans la région de Marrakech. À propos de 36 cas. Ann Cardiol Angeiol 58(3):135–138
51. Ali N, Madziga AG, Dogo D, Gali BM, Gadzama AA (2012) Outcome of surgery for toxic goitres in Maiduguri: a single teaching hospital's perspective. Niger J Clin Pract 15(3):280
52. Kebede D, Abay Z, Feleke Y (2012) Pattern, clinical presentations and management of thyroid diseases in national endocrine referral clinics, Tikur Anbessa specialized hospital, Addis Ababa, Ethiopia. Ethiop Med J 50(4):287–295
53. Onyenekwe BM (2019) Thyrotoxicosis, etiology, presentation and management challenges in Nigeria: a review of cases seen over a 5 year period. Eur Sci J ESJ 15(24):144–144
54. Jaja T, Yarhere IE (2014) Clinical characteristics of children and adolescents with thyroid disorders seen at the University of Port Harcourt Teaching Hospital: a five year review. Nigerian J Paediatr 41(4):302–306
55. Ajibare AO. Pattern of arrhythmia and cardiac dysfunction in patients with goiter at obafemi Awolowo University teaching hospitals complex, Ile-Ife, Nigeria. National Postgraduate Medical College of Nigeria; 2015.
56. Dionadji M, Abbas O, Mbero M (2015) Caractéristiques Cliniques et Biologiques de l'Hyperthyroïdie à N'Djamena. Health Sci Dis 16(4) [cited 2022 Apr 1]. Available from: http://www.hsd-fmsb.org/index.php/hsd/article/view/590
57. Ekpebegh C, Longo-Mbenza B, BlancoBlanco E (2015) Autoimmune clinical features and thyroid antibody profiles in black south Africans with toxic graves and primary hypothyroidsim. Int J Endocrinol Metab Disord 1(4):1–5
58. Balde NM, Balde MD, Kake A, Diallo MM, Camara A, Bah D (2016) Hyperthyroidie au cours de la pathologie thyroidienne: frequence, particularities cliniques et therapeutiques a Conakry. Academia
59. Diagne N, Faye A, Ndao AC, Djiba B, Kane BS, Ndongo S et al (2016) Epidemiological, clinical, therapeutic and evolutive aspects of Basedow-graves' disease in the Department of Internal Medicine at CHU Aristide Le Dantec, Dakar (Senegal). Pan Afr Med J 25:6
60. Edo AE, Eregie A, Edo G, Obanor S (2016) Outcomes of medical management of thyrotoxicosis in Benin City, Nigeria. Ann Biomed Sci 15(1):120–124
61. Ogun OA, Adeleye JO (2016) Severe ophthalmological complications of thyroid disease are rare in Ibadan, southwestern Nigeria: results of a pilot study. Ophthalmol Eye Dis 8:OED.S32169
62. Sarr AGR, Diedhiou D, Mbaye MN, Sow D, Diallo I, El Alaoiu S et al (2016) Graves' disease in Senegal: clinical and evolutionary aspects. Open J Intern Med 6(3):77–82
63. Ackuaku-Dogbe EM, Akpalu J, Abaidoo B (2017) Epidemiology and clinical features of thyroid-associated orbitopathy in Accra. Middle East Afr J Ophthalmol 24(4):183–189
64. Debebe K, Genetu G, Feleke Y, Kebede T (2017) Pattern, clinical presentation and pregnancy outcome of thyroid diseases in pregnant women at National Endocrine Referral Clinic of Tikur Anbessa specialized hospital, Addis Ababa, Ethiopia from June 2010 to June 2015. Thyroid Disorder Ther 6(1):209
65. Anakwue R (2018) Thyrotoxicosis associated enhanced systolic function: lessons on possible therapeutic use of thyroid hormone in selected cases of low thyroid hormone levels and poor systolic function. Ann Med Health Sci Res [cited 2022 Apr 1]; Available from: https://www.amhsr.org/abstract/thyrotoxicosis-associated-enhanced-systolic-function-lessons-on-possible-therapeutic-use-of-thyroid-hormone-in-selected%2D%2D4799.html
66. Ayandipo OO, Orunmuyi AT, Akande TO, Ogun OA, Afuwape OO, Afolabi AO et al (2015) Presentation and management outcomes of hyperthyroidism in a sub-Saharan African teaching hospital. Annals Thyroid Res 4(1):130–135
67. Azagoh-Kouadio R, Asse KV, Enoh J, Line G, Couitchere YK et al (2018) International journal of pediatrics and neonatal health hyperthyroidism of the child in Abidjan (Côte d'Ivoire). Retrospective study of 27 cases. Int J Ped Neo Health 2(3):45–49
68. Darouassi Y, Hanine MA, Aljalil A, Ennouali A, Bouaity TMM et al (2018) Surgical management of hyperthyroidism: about 60 cases. Pan African Med J 31:43
69. Diedhiou D, Mane D, Ndour M, Sow D, Diallo A, Boiro D et al (2018) Graves' disease in men's subjects. J Human Endocrinol 3:12
70. El-Shareif H (2018) Clinical profile and long-term remission in patients with graves' disease: the Tripoli medical Centre experience. J Endocrinol Diabetes 6(1):1116
71. Sarfo-Kantanka O, Sarfo FS, Ansah EO, Kyei I (2018) Graves' disease in Central Ghana: clinical characteristics and associated factors. Clin Med Insights Endocr Diab 11:1179551418759076
72. Gebreyohannes EA, Ayele EM, Tesfaye SA, Seid MA (2019) Normalization of thyroid function tests among thyrotoxicosis patients attending a University Hospital in North-West Ethiopia. Thyroid Res 12(1):3
73. Isah AR (2019) Efficacy of single fixed dose of radioiodine (i-131) therapy in patients with hyperthyroidism at groote schuur hospital [MMed]. University of Cape Town, South Africa, Cape Town
74. Mohammed DHA, Hassanein DSM (2019) Effect of shaker exercises on swallowing disturbance among patients with hyperthyroidism at a selected university hospital. Int J Nurs Didactics 9(01):58–69
75. Mulatu HA (2019) Pattern and presentation of thyro-cardiac disease among patients with hyperthyroidism attending a tertiary hospital in Ethiopia: a cross sectional study. Ethiop J Health Sci 29(1):887–894
76. Ojo O, Ikem R, Kolawole B, Ojo O, Ajala M (2019) Prevalence and clinical relevance of thyroid autoantibodies in patients with goitre in Nigeria. J Endocrinol Metab Diabetes S Afr 24(3):92–97
77. Toyib S, Kabeta T, Dendir G, Bariso M, Reta W (2019) Prevalence, clinical presentation and patterns of thyroid disorders among anterior neck mass patients visiting Jimma medical center, Southwest Ethiopia. Biomed J Sci Tech Res 18(2):13431–13435
78. Yazidi M, Chihaoui M, Oueslati H, Chaker F, Rjeb O, Rjaibi S et al (2019) Cardiothyreosis: prevalence and risk factors. Ann Endocrinol 80(4):211–215
79. Adeleye JO, Emuze ME, Azeez TA, Esan A, Balogun WO, Akande TO (2020) Clinical profiles of males with graves' disease: a two year review in a tertiary hospital in Nigeria. Thyroid Disorders Ther 9(2):240
80. Boundia D, Demba D, Djiby S, Assane NM, Mané DI, Limane BA et al (2020) Evolution of Graves's disease: impact of socio-demographic and clinical factors in Senegalese subject. Open J Int Med 10(2):160–170
81. Demba D, Mané DI, Kiné GF, Djiby S, Assane NM, Limane BA et al (2020) Dysthyroidism in elderly subjects. Open J Inter Med 10(2):181–189
82. Ersumo T, Burka M, Tamrat G (2020) Hyperthyroidism in a private medical services center, Addis Ababa: a 5-year experience. Ethiop Med J 58(1):3–11
83. Mariko M, Traore B, Kane B, Bah M, Traore D, Konate M et al (2020) Dysthyroidism in children and adolescents at the Mali hospital. Mali Med 21:7
84. Mohammed A (2020) Pattern, clinical profile and complications related to thyroid disorders among patients attending endocrine clinic of Tikur Anbessa specialized hospital. Addis Ababa University, Ethiopia, Adis Ababa
85. Abera BT, Abera MA, Berhe G, Abreha GF, Gebru HT, Abraha HE et al (2021) Thyrotoxicosis and dilated cardiomyopathy in developing countries. BMC Endocr Disord 21(1):132
86. Docrat F, Mokoena T, Karusseit VOL, Ankrah AO (2021) The adjunctive use of Carbimazole during radioactive iodine treatment reduces the cure rate of graves' disease. SAMJ. S Afr Med J 111(2):176–179
87. Kifle D, Abateneh A, Bekele S, Asaminewu T, Sinaga M (2021) Clinical features and associated risk factors for thyroid eye disease among goiter patients who attended Jimma University medical center surgical referral clinic, Jimma town, Ethiopia. Niger J Ophthalmol 29:45–51
88. Maldey H, Tadesse S, Adugnaw ZA, Haftamu MH, Gufue ZH (2021) Time to euthyroidism and its determinants among - ProQuest. Ther Clin Risk Manag 17:1091–1101
89. Mendes J (2021) A descriptive analysis of children and adolescents with graves' disease attending the paediatric endocrinology services of the red cross war memorial Children's hospital and Groote Schuur hospital over 20 years. [master of philosophy]. University of Cape Town, South Africa, Cape Town

90. Ruto DL (2021) Characterization of thyroid disorders among patients attending surgical clinic at Nakuru level 5 hospital - Nakuru County, Kenya. Moi University, Kenya, Nakuru County
91. Sylla H, Camara SN, Barry MS, Balde H, Diallo B (2021) Surgical hyperthyroidism: epidemiological aspect and management difficulties in the visceral surgery department of the Donka National Hospital. GSC Adv Res Rev 9(2):36–44
92. Baldé NM, Kaké A, Sylla D, Diallo AM, Diallo MM, Diallo MA et al (2022) Graves' disease in 100 cases in Conakry: epidemiological, clinical, therapeutic, and evolutionary aspects. Open J Endocr Metab Dis 12(2):75–81
93. Odeniyi IA, Olopade OB, Fasanmade OA (2018) Thyroid disorders in Africa: where do we stand? Nigerian quarterly. J Hosp Med 28(4) [cited 2022 Apr 8]. Available from: https://www.ajol.info/index.php/nqjhm/article/view/207278
94. Ogbera AO, Kuku SF (2011) Epidemiology of thyroid diseases in Africa. Indian J Endocrinol Metab 15(Suppl2):S82–S88
95. Okosieme OE (2006) Impact of iodination on thyroid pathology in Africa. J R Soc Med 99(8):396–401
96. Mann CJ (2003) Observational research methods. Research design II: cohort, cross sectional, and case-control studies. Emerg Med J 20(1):54–60
97. Kumar AA, Mohan A, Kumar P, Puri P (2017) Scintigraphic profile of thyrotoxicosis patients and correlation with biochemical and sonological findings. J Clin Diagn Res 11(5):OC01–OC03
98. Michelangeli VP, Pawape G, Sinha A, Ongugu K, Linge D, Sengupta SH et al (2000) Clinical features and pathogenesis of thyrotoxicosis in adult Melanesians in Papua New Guinea. Clin Endocrinol 52(3):261–266
99. Baladi IH, Rai AA, Ahmed SM (2018) ECG changes in patients with primary hyperthyroidism. Pan Afr Med J 30(246) [cited 2022 Apr 8]. Available from: https://www.panafrican-med-journal.com/content/article/30/246/full
100. Vos XG, Smit N, Endert E, Brosschot JF, Tijssen JGP, Wiersinga WM (2009) Age and stress as determinants of the severity of hyperthyroidism caused by graves' disease in newly diagnosed patients. Eur J Endocrinol 160(2):193–199
101. Vanderpump MPJ (2011) The epidemiology of thyroid disease. Br Med Bull 99(1):39–51
102. Meng Z, Liu M, Zhang Q, Liu L, Song K, Tan J et al (2015) Gender and age impacts on the association between thyroid function and metabolic syndrome in Chinese. Medicine (Baltimore) 94(50):e2193
103. Tamatea JAU, Reid P, Conaglen JV, Elston MS (2020) Thyrotoxicosis in an indigenous new Zealand population – a prospective observational study. J Endocr Soc 4(3):bvaa002
104. Iddah MA, Macharia BN (2013) Autoimmune thyroid disorders. ISRN. Endocrinology. 2013:e509764
105. Pearce EN (2006) Diagnosis and management of thyrotoxicosis. BMJ. 332(7554):1369–1373
106. Negalur DV (2019) Thyrotoxicosis- review. Medico Res Chron 6(5):259–263
107. Rotman-Pikielny P, Borodin O, Zissin R, Ness-Abramof R, Levy Y (2008) Newly diagnosed thyrotoxicosis in hospitalized patients: clinical characteristics. QJM: Int J Med 101(11):871–874
108. Limpawattana P, Sanwayawisuth K, Mahakkanukrauha A, Wongvivaporn C (2006) Clinical manifestations of primary hyperthyroidism in the elderly patients at the out-patient clinic of Srinagarind hospital. J Med Assoc Thail 89(2):178–181
109. Akbar DH, Mushtaq MM, Al-Sheik AA (2000) Etiology and outcome of thyrotoxicosis at a university hospital. Saudi Med J 21(4):352–354
110. Tara. (2019) Thyroid dysfunction and abnormal uterine bleeding. JGWH. 15(4):1–7
111. Krassas GE (2000) Thyroid disease and female reproduction. Fertil Steril 74(6):1063–1070
112. Krassas GE, Pontikides N, Deligianni V, Miras K (2002) A prospective controlled study of the impact of hyperthyroidism on reproductive function in males. J Clin Endocrinol Metab 87(8):3667–3671
113. Quintino-Moro A, Zantut-Wittmann DE, Tambascia M, Machado H d C, Fernandes A (2014) High prevalence of infertility among women with graves' disease and Hashimoto's thyroiditis. Int J Endocrinol 2014:e982705
114. Kyriacou A, Kyriacou A, Makris KC, Syed AA, Perros P (2019) Weight gain following treatment of hyperthyroidism-a forgotten tale. Clin Obes 9(5):e12328
115. Valdés S, Maldonado-Araque C, Lago-Sampedro A, Lillo JA, Garcia-Fuentes E, Perez-Valero V et al (2017) Population-based national prevalence of thyroid dysfunction in Spain and associated factors: Di@bet.es study. Thyroid. 27(2):156–166
116. Asif H, Nwachukwu I, Khan A, Rodriguez G, Bahtiyar G (2022) Hyperthyroidism presenting with mania and psychosis: a case report. Cureus. 14(2) [cited 2022 Apr 14]. Available from: https://www.cureus.com/articles/86315-hyperthyroidism-presenting-with-mania-and-psychosis-a-case-report
117. De Leo S, Lee SY, Braverman LE (2016) Hyperthyroidism. Lancet 388(10047):906–918
118. Wong CL, Tam HKV, Fok CKV, Lam PKE, Fung LM (2017) Thyrotoxic atrial fibrillation: factors associated with persistence and risk of ischemic stroke. J Thyroid Res 2017:e4259183
119. Lin YS, Tsai HY, Lin CY, Wu VCC, Chen TH, Yang TY et al (2021) Risk of thromboembolism in non-valvular atrial fibrillation with or without clinical hyperthyroidism. Glob Heart 16(1):45
120. Frost L, Vestergaard P, Mosekilde L (2004) Hyperthyroidism and risk of atrial fibrillation or flutter: a population-based study. Arch Intern Med 164(15):1675–1678
121. Bartalena L, Piantanida E, Gallo D, Lai A, Tanda ML (2020) Epidemiology, natural history, risk factors, and prevention of graves' orbitopathy. Front Endocrinol [cited 2022 Apr 14];11. Available from: https://www.frontiersin.org/article/10.3389/fendo.2020.615993
122. Woo KI, Kim YD, Lee SY (2013) Prevalence and risk factors for thyroid eye disease among Korean dysthyroid patients. Korean J Ophthalmol 27(6):397–404
123. Ambachew R, Yosef T, Gebremariam AM, Demere L, Aberra T, Tarekegn G et al (2021) Pretibial myxedema in a euthyroid patient: a case report. Thyroid Res 14(1):4
124. Prisant LM, Gujral JS, Mulloy AL (2006) Hyperthyroidism: a secondary cause of isolated systolic hypertension. J Clin Hypertens (Greenwich) 8(8):596–599
125. Berta E, Lengyel I, Halmi S, Zrínyi M, Erdei A, Harangi M et al (2019) Hypertension in thyroid disorders. Front Endocrinol (Lausanne) 10:482
126. Hage M, Zantout MS, Azar ST (2011) Thyroid disorders and diabetes mellitus. J Thyroid Res 2011:e439463
127. Choudhury RP, MacDermot J (1998) Heart failure in thyrotoxicosis, an approach to management. Br J Clin Pharmacol 46(5):421–424
128. Dahl P, Danzi S, Klein I (2008) Thyrotoxic cardiac disease. Curr Heart Fail Rep 5(3):170–176

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