BMC Endocrine Disorders

RESEARCH

Open Access

Hypothyroidism phenotypes, clinical characteristics, and factors associated with nodular thyroid disease in patients with hypothyroidism in Southern Ghana: a 6-year retrospective study

Samuel Ametepe[1], Brian Yaw Entsiey Nyarko[2], Isaac Wormekpor[2], Bright Kantah[2], Michael Appiah[3], Precious Kwablah Kwadzokpui[4], Esther Ngozi Adejumo[5], Christian Obirikorang[6], Abigail Ibrahim[7], Belinda Ampomah Kwarteng[8], Eric NY Nyarko[9], James Osei-Yeboah[10] and Sylvester Yao Lokpo[2*]

Abstract

Background This study aimed to describe the frequency of hypothyroidism phenotypes, clinical characteristics, and factors associated with nodular thyroid among hypothyroid patients at the University of Ghana Hospital in southern Ghana.

Methods This study was a 6-year hospital-based retrospective study that extracted data from 221 patients with hypothyroidism from the archival records of the University of Ghana Hospital using a checklist. These include socio-demography (age, gender, marital status, residential status, educational level), lifestyle variables (anthropometry, smoking status, alcohol intake), and co-morbidities, as well as ultrasound imaging findings of the thyroid. Serum thyroid hormone levels were used to classify hypothyroidism phenotypes. Bivariate and multivariate logistic regression analyses were performed to identify factors associated with nodular thyroid disease.

Result The frequency of primary, subclinical, and secondary hypothyroidism was 81.4%, 16.3%, and 2.3%, respectively. Fatigue [120(54.3%)], heavy menstrual loss [54/160(33.8%)], and cold intolerance [73(33.0%)], were predominant symptoms while 54/57 (94.7%) were overweight/obese, 23/32 (71.9%) had dyslipidaemia whereas 7/34 (20.6%) had hypertension. The odds of developing nodular thyroid disease were 2.11 times higher (95% CI: 1.07–4.17; $p=0.032$) in males than in females.

Conclusion Our results provide insight into the frequency of hypothyroidism phenotypes, clinical characteristics, and factors associated with nodular thyroid, emphasizing male gender as an independent predictor of nodular thyroid disease. Our findings also emphasize the need for lifestyle adjustment as a mitigating strategy in the management

*Correspondence:
Sylvester Yao Lokpo
sylvesteryao34@gmail.com

Full list of author information is available at the end of the article

of hypothyroidism. However, prospective studies are required to confirm the findings or investigate the histological characteristics of thyroid nodules in patients with hypothyroidism.

Keywords Hypothyroidism phenotypes, Clinical characteristics, Nodular thyroid, Hypothyroidism

Introduction

Hypothyroidism (underactive thyroid disease) is a common thyroid disorder in which the thyroid gland fails to produce enough hormones. Hormones released by the thyroid gland are transported through the bloodstream, where they exert their physiological effect in nearly every part of the body. Thyroid hormones control cellular metabolism that produces the body's energy needs and thus affects the heartbeat and the body's temperature [1].

Hypothyroidism affects up to approximately 5% of the general population, with an estimated 5% undiagnosed. In comparison, more than 99% of patients with hypothyroidism present with the primary phenotype [2]. Data derived from the National Health and Nutrition Examination Survey suggest that about one in 300 persons in the United States has hypothyroidism, while autoimmune thyroid disease is the most common etiology of hypothyroidism [3]. A study by Yang et al. [4] also indicates that the prevalence of hypothyroidism increases with age and is higher in females than in males.

In addition, previous studies have shown an association between hypothyroidism and pregnancy. Nicolaou et al. [5] found that hypothyroidism was present in 2.3–3.5% of pregnancies, with overt hypothyroidism accounting for 0.3–0.5% and subclinical hypothyroidism accounting for 2–3% in iodine-sufficient areas. Meanwhile, worldwide, environmental iodine deficiency is the most common cause of thyroid disorders, including hypothyroidism, but in areas of iodine sufficiency, Hashimoto's disease (chronic autoimmune thyroiditis) is the most common cause of thyroid failure [6].

The symptoms of hypothyroidism are non-specific, including mild to moderate weight gain, fatigue, poor concentration, depression, and menstrual irregularities, while the consequences of untreated or under-treated hypothyroidism may lead to cardiovascular disease and increased mortality [2]. Also, untreated hypothyroidism can contribute to dyslipidaemia, infertility, cognitive impairment, and neuromuscular dysfunction [7]. In severe hypothyroidism, various comorbidities, including congestive heart failure, pericarditis, pleural effusion, intestinal obstruction, and pseudo-obstruction, as well as coagulation disorders, have been reported [8], and these could increase the risk of mortality.

In sub-Saharan African countries, including Ghana, very little data on thyroid disease exists in the literature. However, a prevalence of 13.1% thyroid disorders was reported in a five-year retrospective analysis to ascertain the spectrum of endocrine disorders in Central Ghana [9]. A recent work by Aidoo et al. [10], found that primary hypothyroidism (22.3%), euthyroid sick syndrome (6.5%), and subclinical hypothyroidism (4.6%) were among the most frequently reported thyroid disorders. In addition, the frequency of asymptomatic thyroid nodules in a study conducted among six communities in the Assin North District was 11.3% [11] while 7.7% of hospital admissions from a 9-year review study in a leading tertiary hospital were attributed to thyroid disorders [12].

To reduce endemic iodine deficiency and its consequent disorders among Ghanaians, the universal salt iodization program was instituted in 1996 [13]. However, the program was riddled with poor coverage that resulted from a lack of proper monitoring and coordination of activities. To ascertain the program effectiveness, a study that sought to compare the prevalence of thyroid disorders pre- and post-intervention suggested higher rates post-intervention [9] The outcome, therefore, indicates that the quest to achieve elimination of iodine deficiency disorders by the World Health Organization (WHO) on the African continent [14, 15, 16] had suffered a setback.

Moreover, despite the high risk of thyroid disorders, research work focusing on examining the burden of hypothyroidism and its phenotypes, clinical presentations, and factors contributing to the prevalence of thyroid nodular disease remains underexplored in sub-Saharan countries, including Ghana. To bridge this knowledge gap, the current study was designed to describe the frequency of hypothyroidism phenotypes, clinical characteristics, and factors associated with nodular thyroid disease in patients who presented with hypothyroidism in Accra, southern Ghana.

Materials and methods

Study design and study site

The research was a retrospective study spanning a 6-year (2015–2020) review of electronic records of patients diagnosed with hypothyroidism at the University of Ghana Hospital in southern Ghana. The University of Ghana Hospital, also referred to as Legon Hospital, was established and inaugurated in 1957, and the University of Ghana formally owns it. The hospital is located approximately 12.6 km (about 7.83 miles) from the main Accra–Aburi road. The hospital is a quasi-government hospital with a bed capacity of 130, which includes general wards, maternity, casualty and emergency wards, pediatric and dental units, a pharmacy, as well as an operating theatre and laboratory. The hospital was first founded to address the healthcare requirements of the

student body, staff, and their dependents, but its services are now open to the public.

Study population and sampling technique

The study population included conveniently sampled patients who were clinically diagnosed with hypothyroidism.

Inclusion and exclusion criteria

Data on 228 patients with hypothyroidism were initially extracted from the electronic record of the Hospital. Seven out of 228 patients did not meet the definition of hypothyroidism based on the serum thyroid biomarker levels; hence, these were excluded from the study. The resulting 221 patients were finally included in this study.

Sample size determination

Since information on the prevalence of hypothyroidism in Ghana is scanty from existing literature, we could not calculate the sample size for this study hence, the sample size of 221 patients was based on all individuals with hypothyroidism who met the inclusion criteria between 2015 and 2020.

Data collection technique

The checklist was designed to capture socio-demography (age, gender, marital status, area of residence, and educational level) lifestyle variables (anthropometry, smoking status, and alcohol intake), and clinical details (signs and symptoms, and co-morbid conditions such as hypertension, diabetes mellitus, renal failure, sickle cell disease, HIV infection, etc.) as well as ultrasound imaging findings (multi nodules, single nodule, and diffused type) and laboratory findings (including hormonal profiles and lipid profiles) from the hospital's electronic database.

Biochemical investigation

Thyroid function profiles (TSH, FT3, and FT4) available were performed based on the sandwich ELISA (Enzyme-Linked Immunosorbent Assay) method on a microplate reader using reagents from the manufacturers (Human Diagnostics, Germany). Briefly, the sandwich ELISA is an antibody-based technique that quantifies the amount of protein, hormone, or analyte of interest in a sample. Capture and detection antibodies bind to nonoverlapping epitopes on the protein to sandwich the protein, hence the name, Sandwich ELISA. Following the addition of the detection antibody, a chemical substrate is added to produce a colorimetric signal that an ELISA plate reader can read [17]. The following were the reference ranges of each biomarker based on those provided by the reagent manufacturer;

Thyroid-stimulating hormone (TSH) --- 0.3–4.0 mIU/L.

Free triiodothyronine (FT3) ---------- 1.4–4.2 pg/ml.

Free tetraiodothyronine (FT4) ---------- 0.8–2.0 ng/dl.

Definition of hypothyroidism phenotypes, dyslipidaemia and obesity

Subclinical hypothyroidism was defined as low TSH, normal FT4, and FT3 levels. Primary hypothyroidism was defined as elevated TSH, low FT4 and FT3 levels, while secondary hypothyroidism was defined as low TSH, low FT4 and FT3 levels. Dyslipidaemia was defined according to the National Cholesterol Education Program-Adult Treatment Panel (NCEP-ATP) III (TC > 5.17 mmol/l or TG > 1.7 mmol/l or HDL-c < 1.03 mmol/l in men, and HDL-c < 1.29 mmol/l in women or LDL-c > 4.1 mmol/l) [18]. Overweight and obesity were defined as BMI between 25.00 and 29.9 kg/m^2 and ≥ 30.00 kg/m^2 according to the WHO criteria [19].

Data analysis

Data on the hospital's database, which was based on an Excel Spreadsheet, was extracted, cleaned, and exported to the Statistical Package for Social Sciences (SPSS) software version 22 for analysis. Continuous variables were presented as mean and standard deviation, while categorical variables were presented as frequency and their corresponding proportion. Bivariate and multivariate logistic regression analyses were performed to determine the crude and adjusted odds ratios of factors associated with nodular thyroid. The parameters included in the regression models were age, gender, marital status, educational level, residential status, blood pressure levels, body mass index, dyslipidemia, the presence of chronic conditions, smoking, and alcohol intake statuses.

Results

This study included 221 eligible patients with hypothyroidism. The majority were females [160 (72.4%)], 143 (64.7%) married, 86 (38.9%) were within the 31–50 years age category while 183(60.2%) were residents within the Accra Metropolis, and 90 (40.7%) had attained a tertiary level of education at the time of this study. The history of current and past smoking statuses were 16/221 (7.2%) and 8/205 (3.9%), respectively, whereas current and past alcohol consumptions were 455/211 (20.4%) and 14/176 (8.0%), respectively (Table 1).

Clinical presentations at diagnosis among patients with hypothyroidism

Fatigue was the most predominant symptom [120(54.3%)], followed by heavy menstrual period [54/160(33.8%)], cold intolerance (33.0%), weight gain (27.6%), constipation (16.7%), and other less frequent symptoms (below 2%). The most frequently observed

Table 1 General demographic and behavioral characteristics of the study participants

Variables	Frequency	Percent
Total	**221**	**100.0**
Age (years)		
≤ 30	84	38.0
31–50	86	38.9
51–70	40	18.1
> 70	11	5.0
Marital Status		
Single	78	35.3
Married	143	64.7
Gender		
Male	61	27.6
Female	160	72.4
Area of Residence		
Within-Accra Metropolis	133	60.2
Outside-Accra Metropolis	88	39.8
Educational level		
Tertiary	90	40.7
Secondary	57	25.8
Basic	38	17.2
None	36	16.3
Body Mass Index*(Total = 57)		
Normal	3	5.3
Overweight & Obesity	54	94.7
Current Smoking Status		
No	205	92.8
Yes	16	7.2
Past Smoking Status (Total = 205)		
No	197	96.1
Yes	8	3.9
Current Alcohol Intake		
No	176	79.6
Yes	45	20.4
Past Alcohol Intake (Total = 176)		
No	162	92.0
Yes	14	8.0

Data presented as frequency and the corresponding proportion

signs were slow pulse rate (28.1%), heavy hair loss (10.0%), miscarriages 15/160 (9.4%), and tremor (5.9%) (Table 2).

Prevalence of comorbid conditions among patients with hypothyroidism

Thirty-four (34) out of 221 patients reported with chronic conditions. Of these, 7(20.6%) had hypertension, 5 had sickle cell disease (14.7%), and 11.8% each had diabetes mellitus and hepatitis B virus (HBV) infection. Also, 54/57 (94.7%) were overweight/obese, whereas 23/32 (71.9%) had dyslipidaemia (Table 3).

Table 2 Clinical presentation at diagnosis among patients with hypothyroidism

Variables	Frequency	Percent
Total	**221**	**100.0**
Symptoms		
Fatigue	120	54.3
Heavy Menstrual Period (Total = 160)	54	33.8
Cold Intolerance	73	33.0
Weight Gain	61	27.6
Constipation	37	16.7
Irregular Menstrual period (Total = 160)	3	1.9
Anxiety	4	1.8
Palpitation	3	1.4
Heat Intolerance	1	0.5
Signs		
Slow Pulse Rate	62	28.1
Heavy Hair Loss	22	10.0
Miscarriages (Total = 160)	15	9.4
Tremor	13	5.9
Rapid Pulse Rate	6	2.7
Eyes and Face Swelling	4	1.8
Excessive Sweating	2	0.9

Data presented as frequency and the corresponding proportion

Table 3 Prevalence of comorbid conditions among patients with hypothyroidism

Comorbidities	Frequency	Percentage
Total	**34**	**15.4**
Hypertension	7	20.6
Sickle Cell Disease	5	14.7
Diabetes mellitus	4	11.8
HBV infection	4	11.8
Renal failure	4	11.8
Alzheimer's disease	1	2.9
Arthritis	1	2.9
Asthma	1	2.9
Cancer	1	2.9
Cervical neoplasm	1	2.9
HCV infection	1	2.9
Hypotension	1	2.9
Liver failure	1	2.9
Prostate cancer	1	2.9
Tuberculosis	1	2.9
Overweight & Obesity (Total = 57)	54	94.7
Dyslipidaemia (Total = 32)	23	71.9

Data presented as frequency and the corresponding proportion

Prevalence of hypothyroidism phenotypes and ultrasound imaging characteristics of the thyroid among patients with hypothyroidism

The most frequent hypothyroidism phenotype was primary hypothyroidism [180 (81.4%)], followed by subclinical hypothyroidism (16.3%). Concerning ultrasound imaging characteristics of the thyroid, 49(22.2%) had multinodules, 30(13.6%) and 28 (12.7%0) had diffuse type

and single-nodule, respectively. However, the majority [114(51.6%)] of hypothyroid patients presented with normal thyroid (Fig. 1).

Factors associated with abnormal thyroid based on ultrasound imaging among study participants

The univariate analysis did not reveal any statistically significant association between abnormal thyroid and sociodemographic, lifestyle, and clinical variables of interest. However, upon adjusting for potential confounders in the multivariate analysis, the odds of developing nodular thyroid disease were 2.11 times higher (95% CI: 1.07–4.17; $p = 0.032$) in males than in females (Table 4).

Discussion

In this study, we investigated the frequency of hypothyroidism phenotypes, clinical characteristics, and factors associated with nodular thyroid disease among patients with hypothyroidism based on a retrospective data extracted at a single-center facility in southern Ghana during a 6-year period (2015–2020).

We found that primary hypothyroidism was the most frequently reported phenotype of hypothyroidism, followed by subclinical hypothyroidism and secondary or central hypothyroidism based on biochemical findings. Fatigue, heavy menstrual period, and cold intolerance were predominant symptoms, while overweight/obesity, dyslipidaemia, and hypertension were commonly reported co-morbid conditions. The odds of nodular thyroid based on ultrasound findings were significantly higher in males compared to females.

According to Chiovato et al. [2], over 99% of hypothyroid patients suffer from primary hypothyroidism. Jain et al. [20] also reported that primary hypothyroidism is the most frequent phenotype among Indian patients with hypothyroidism. These findings are consistent with the high frequency of primary hypothyroidism (81.4%), although lower compared to Chiovato et al. [2], which may be attributed to differences in population

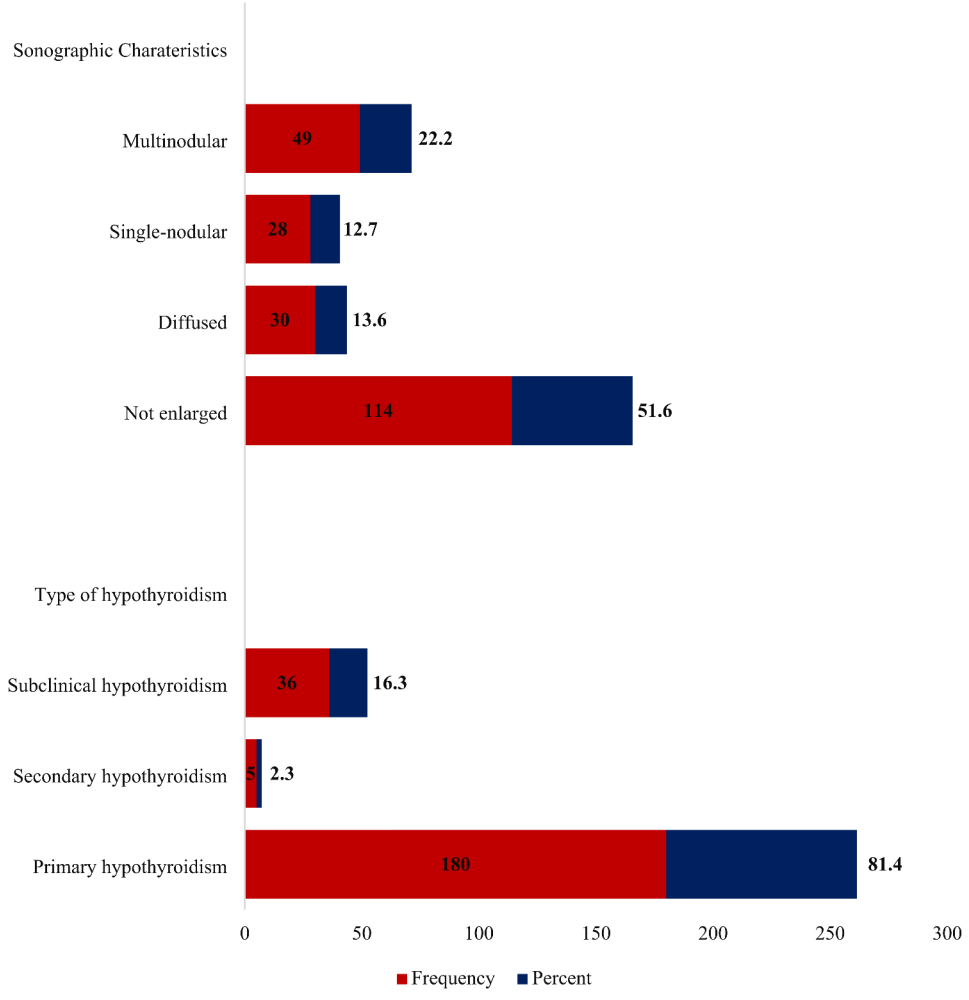

Fig. 1 Hypothyroidism phenotypes and imaging characteristics of the thyroid gland

Table 4 Factors associated with nodular thyroid based on ultrasound imaging findings among patients with hypothyroidism

		Thyroid type					
Variables	**Total n(%)**	**Nodular n(%)[95% CI)**	**Normal n(%)[95% CI)**	**cOR[95% CI]**	**p-value**	**aOR[95% CI]**	**p-value**
Overall	221(100)	107(48.4)[41.8–55]	114(51.6)[45–58.2]				
Age (years)							
≤ 30	84(38.0)	43(51.2)[40.5–61.9]	41(48.8)[38.1–59.5]	1		1	
31–50	86(38.9)	43(50.0)[39.4–60.6]	43(50.0)[39.4–60.6]	0.95[0.52–1.74]	0.877	1.34[0.55–3.27]	0.515
51–70	40(18.1)	19(47.5)[32.0–63.0]	21(52.5)[37.0–68]	0.86[0.41–1.83]	0.701	1.24[0.43–3.59]	0.687
> 70	11(5.0)	2(18.2)[-4.6–41]	9(81.8)[59.0–104.6]	0.21[0.04–1.04]	0.056	0.26[0.04–1.49]	0.130
Gender							
Male	61(27.6)	35(57.4)[45.0–69.8]	26(42.6)[30.2–55.0]	0.49[0.10–1.08]	0.103	2.11[1.07–4.17]	**0.032**
Female	160(72.4)	72(45.0)[37.3–52.7]	88(55.0)[47.3–62.7]	1		1	
Marital Status							
Single	78(35.3)	41(52.6)[41.5–63.6]	37(47.4)[36.4–58.5]	1		1	
Married	143(64.7)	66(46.2)[38–54.3]	77(53.8)[45.7–62.0]	0.77[0.45–1.34]	0.363	0.73[0.31–1.75]	0.484
Educational Level							
Tertiary	90(40.7)	38(42.2)[32.0–52.4]	52(57.8)[47.6–68.0]	1		1	
Secondary	57(25.8)	30(52.6)[39.7–65.6]	27(47.4)[34.4–60.3]	1.52[0.78–2.96]	0.218	1.59[0.79–3.20]	0.195
Basic	38(17.2)	18(47.4)[31.5–63.2]	20(52.6)[36.8–68.5]	1.23[0.57–2.64]	0.592	1.36[0.61–3.04]	0.451
None	36(16.3)	21(58.3)[42.2–74.4]	15(41.7)[25.6–57.8]	1.92[0.88–4.19]	0.104	2.21[0.96–5.08]	0.062
Residential Status							
Within Accra Metro	133(60.2)	60(45.1)[36.7–53.6]	73(54.9)[46.4–63.3]	1		1	
Outside Accra Metro	88(39.8)	47(0.032]	41(46.6)[36.2–57.0]	1.39[0.81–2.39]	0.228	1.52[0.86–2.69]	0.153
Blood Pressure							
Low/Normal	187(84.6)	87(46.5)[39.4–53.7]	100(53.5)[46.3–60.6]	1		1	
High	34(15.4)	20(58.8)[42.3–75.4]	14(41.2)[24.6–57.7]	1.64[0.78–3.44]	0.190	1.84[0.84–4.04]	0.130
Body Mass Index*							
Normal	3(5.3)	2(66.7)[13.3–120.0]	1(33.3)[-20.0–86.7]	1			
Overweight/Obesity	54(94.7)	26(48.1)[34.8–61.5]	28(51.9)[38.5–65.2]	0.46[0.04–5.42]	0.541	-	
Total	57(25.8)	28(49.1)[36.1–62.1]	29(50.9)[37.9–63.9]				
Dyslipidaemia ¥							
No	9(28.1)	7(77.8)[50.6–104.9]	2(22.2)[-4.9–49.4]	1			
Yes	23(71.9)	13(56.5)[36.3–76.8]	10(43.5)[23.2–63.7]	0.37[0.06–2.19]	0.274	-	
Total	32(14.5)	20(62.5)[45.7–79.3]	12(37.5)[20.7–54.3]				
Chronic Condition							
No	187(84.6)	92(49.2)[42.0–56.4]	95(50.8)[43.6–58.0]	1		1	
Yes	34(15.4)	15(44.1)[27.4–60.8]	19(55.9)[39.2–72.6]	0.91[0.41–2.02]	0.822	0.96[0.41–2.29]	0.932
Past/current smoker							
No	197(89.1)	95(48.2)[41.2–55.2]	102(51.8)[44.8–58.8]	1		1	
Yes	24(10.9)	12(50.0)[30.0–70.0]	12(50.0)[30.0–70.0]	1.07[0.46–2.51]	0.869	0.69[0.27–1.78]	0.447
Past/current drinker							
No	162(73.3)	81(50.0)[42.3–57.7]	81(50.0)[42.3–57.7]	1		1	
Yes	59(26.7)	26(44.1)[31.4–56.8]	33(55.9)[43.3–68.6]	0.79[0.43–1.43]	0.435	0.77[0.40–1.47]	0.432

- Observations too small for logistics regression

* Reported for participants whose weight and height measurements were available to calculate BMI

¥ Reported for participants whose lipid profile measurements were available to diagnose dyslipidaemia

characteristics. Conversely, the frequency of subclinical hypothyroidism in our study (16.3%) is moderately higher than the overall prevalence of subclinical hypothyroidism (12.9%) reported in China [21] but approximately four-fold higher than what was reported in Korea (3.1%) [22]. The difference in the results may be due to the difference in the hospital-based study design adopted for our study as opposed to the population-based nationwide study employed in the Asian studies.

It is suggested that iodine deficiency is the most common cause of hypothyroidism globally, underscoring the critical role of iodine in thyroid hormone metabolism, whereas autoimmune thyroiditis (Hashimoto's disease) is the most common cause of primary hypothyroidism

in iodine-replete areas [6]. In Ghana, the 2014 Annual Health Report indicated that iodine deficiency disorders were still high despite the introduction of the mandatory iodization of salt program in 1996 [23]. Sarfo-Kantanka et al. [9], who compared the prevalence of thyroid disorders before and after the introduction of the program, also found a progressive increase in the prevalence of autoimmune thyroid disorders. Thus, the apparent failure of the iodization intervention program reinforces the need to intensify health education programs aimed at promoting regular consumption of iodine-fortified diets. Screening the healthy population regularly to identify antibodies to the thyroid could help initiate early treatment and management to prevent the development of overt hypothyroidism.

Fatigue [120(54.3%)], heavy menstrual loss [54/160(33.8%)], and cold intolerance [73(33.0%)], were predominant in our study participants. The findings in relation to fatigue were corroborated by Ruiz-Pacheco et al. [24], who reported that 63% of patients with primary hypothyroidism presented with asthenia. Kaudha et al. [25] also found that fatigue or exercise intolerance was among the prominent symptoms in hypothyroid children with underlying sickle cell anemia, which is in tandem with our findings. In hypothyroidism, the underactive thyroid slows down the body's metabolism, often leading to many symptoms, including lethargy and fatigue [26]. The frequency of menorrhagia found in this study aligns with a previous study [27], and it is postulated to be due to complex mechanisms that impair hemostasis in the coagulation cascade and neuro-endocrine dysfunction leading to dysfunctional uterine bleeding [28]. Cold intolerance is associated with hypothyroidism due to the hypoactivity of the thyroid hormones, which are responsible for the regulation of body temperature [29]. The presence of metabolic syndrome or its components, namely, hypertension, insulin resistance, abdominal obesity, and dyslipidemia, is a prominent feature of hypothyroidism, which increases the risk of cardiovascular disease [30]. Consistent with this study's findings, 94.7% of the hypothyroid patients were overweight/obese, 71.9% had dyslipidemia, and 20.6% had hypertension.

With regard to nodular thyroid abnormalities, 22.2% had multinodular thyroid glands while 13.6% and 12.7% had diffuse type and single-nodular thyroid gland, respectively, indicating that overall, at least two out of five patients were positive for thyroid gland abnormality upon ultrasound examination. Moreover, the multivariate regression analysis showed that gender is an independent predictor of nodular thyroid. Thus, the odds of developing nodular thyroid disease in males were approximately twice (aOR = 2.11; 95% CI: 1.07–4.17; $p = 0.032$) higher compared to their female counterparts. The reason for the male preponderance to nodular thyroid disease cannot be inferred directly from our study. However, advancing age and iodine deficiency have been shown to be strongly linked to nodular thyroid disease [31] which was not assessed in the current study, hence could not be verified. Our findings also highlight the need for thorough clinical assessment and management of nodular thyroid disease among males with hypothyroidism.

In contrast, Dauksiene et al. [32] found that female gender was an independent risk factor for the presence of both goiter and thyroid nodules in euthyroid subjects. Moreover, our study findings contradict the lack of association found between gender and thyroid volume, or nodularity, among type 2 diabetic patients and non-diabetics [33]. Hence, it could also be speculated that differences in the association between gender and nodular thyroid disease may stem from the differences in the sample characteristics.

Despite the important findings presented in the current study, some limitations are acknowledged. The retrospective study design did not allow for the collection of comprehensive data, including dietary patterns, which are known to be involved in the pathogenesis of thyroid disorders. The cross-sectional design also limits the interpretation of any causality between the study variables and the outcome. Since this is a hospital-based study, the generalization of the findings is also limited. The adoption of a convenient sampling technique could potentially introduce selection bias, while the classification of nodular thyroid disease was based on imaging findings rather than histological findings, which is widely regarded as the gold standard. Moreover, the findings related to obesity and dyslipidaemia should be interpreted within the context that data were available for only 57 and 32 participants, respectively, whereas a larger part of the electronic records reviewed had missing data.

Conclusion

Our results provide insight into the frequency of hypothyroidism phenotypes, clinical characteristics, and factors associated with nodular thyroid disease, emphasizing the male gender as an independent predictor of nodular thyroid disease. Our findings also emphasize the need for adjustment in lifestyle practices as a mitigating strategy for the management of hypothyroidism. However, prospective studies are required to confirm the findings or investigate the histological characteristics of thyroid nodules in patients with hypothyroidism.

Abbreviations

HIV	Human immune deficiency virus
TSH	Thyroid stimulating hormone
FT3	Free triiodothyronine
FT4	Free tetraiodothyronine (FT4)
ELISA	Enzyme-linked immunosorbent assay
WHO	World Health Organization
SPSS	Statistical Package for the Social Sciences

TG	Triglycerides
HDL	High-density lipoprotein cholesterol
NCEP-ATP III	National Cholesterol Education Programme and Adult Treatment Panel III

Acknowledgements
We would like to express our appreciation to the management of the University of Ghana Hospital for permitting us to carry out this investigation.

Author contributions
SA, SYL, CO, BYEN, IW, and, BK: Conceptualised and designed the experiments; Carried out the experiments; Provided reagents, logistics, analysis tools or data; wrote the paper.PKK, ENA, and JOY: Carried out the experiments; Analysed and interpreted the data; wrote the paper.AI, ENYN, BAK, and, MA: Provided reagents, logistics, carried out the experiments, analysis tools, or data; wrote the paper.

Funding
No funding was obtained for this study.

Data availability
The datasets generated and/or analyzed during the current study are available from the corresponding author on request.

Declarations

Ethics approval and consent to participate
Ethical approval was obtained from the Research and Ethical Review Committee of the Department of Medical Laboratory Technology, Accra Technical University, with protocol number ATU/MLT/ET/01200009B/2020–2021. The management of the University of Ghana Hospital also gave permission to carry out this study. However, due to the retrospective study design, obtaining consent to participate in this study was not plausible, hence, this was waived by the committee. This study was carried out according to the Helsinki Declaration.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Clinical Trial Number
Not Applicable.

Author details
[1]Department of Medical Laboratory Science, Faculty of Health and Allied Sciences, Koforidua Technical University, Koforidua, Ghana
[2]Department of Medical Laboratory Sciences, School of Allied Health Sciences, University of Health and Allied Sciences, Ho, Ghana
[3]Department of Medical Laboratory Sciences, Greater Accra Region, Accra Technical University, Accra, Ghana
[4]Labortory Department, Ho Teaching Hospital, Ministry of Health, Ho, Ghana
[5]Department of Medical Laboratory Science, School of Public and Allied Health, Babcock University, Ilishan-Remo, Ogun State, Nigeria
[6]Department of Molecular Medicine, School of Medicine and Dentistry, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
[7]Nursing and Midwifery Training College, Ministry of Health, Odumasi-Krobo, Ghana
[8]Koforidua Technical University Clinic, Koforidua, Ghana
[9]Department of Chemical Pathology, University of Ghana Medical School, Accra, Ghana
[10]School of Public Health, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Received: 24 December 2024 / Accepted: 14 April 2025
Published online: 22 April 2025

References

1. Chawda N, Jain S, Solanki B. Open access A study of cardiovascular manifestations in hypothyroidism A study of cardiovascular manifestations in hypothyroidism. Orig Res Ser Endocrinol. 2022;4(3):68–77.
2. Chiovato L, Magri F, Carlé A. Hypothyroidism in context: where We've been and where we're going. Adv Ther. 2019;36:47–58.
3. Gaitonde DY, Rowley KD, Sweeney LB. Hypothyroidism: an update. Am Fam Physician. 2012;86(3):244–51.
4. Yang M, Cao S. Gender and Age-Specific Differences in the Association of Thyroid Function and Hyperuricemia in Chinese: A Cross-Sectional Study. Int J Endocrinol. 2022;2022.
5. Nicolaou V, Droste C, Huddle KRL, Dickens C, Menezes CN, Shires R. A retrospective analysis of thyroid disease in pregnancy at Chris Hani Baragwanath academic hospital, Soweto, South Africa. S Afr J Obstet Gynaecol. 2017;23(3):85–8.
6. Vanderpump MPJ. The epidemiology of thyroid disease. Br Med Bull. 2011;99(1):39–51.
7. Devaraj TV, Salina S. Prevalence of hypothyroidism in Kannur; a coastal district in Kerala. Thyroid Res Pract. 2021;18(2):55–60.
8. Kostoglou-Athanassiou I, Ntalles K. Hypothyroidism - New aspects of an old disease. Hippokratia. 2010;14(2):82–7.
9. Sarfo-Kantanka O, Kyei I, Sarfo FS, Ansah EO. Thyroid Disorders in Central Ghana: The Influence of 20 Years of Iodization. J Thyroid Res. 2017;2017.
10. Aidoo ED, Ababio GK, Arko-Boham B, Tagoe EA, Aryee NA. Thyroid dysfunction among patients assessed by thyroid function tests at a tertiary care hospital: a retrospective study. Pan Afr Med J. 2024;49.
11. Morna MT, Tuoyire DA, Jimah BB, Eliason S, Appiah AB, Rahman GA. Prevalence and characterization of asymptomatic thyroid nodules in Assin North District, Ghana. PLoS One [Internet]. 2022;17(2 February):1–12. Available from: https://doi.org/10.1371/journal.pone.0263365
12. Sarfo-Kantanka O, Ansah EO, Kyei I, Barnes NA. Causes and predictors of mortality among Ghanaians hospitalised with endocrine disorders. Int Health. 2019;12(2):107–15.
13. Nyumuah RO, Hoang TCC, Amoaful EF, Agble R, Meyer M, Wirth JP, et al. Implementing large-scale food fortification in Ghana: lessons learned. Food Nutr Bull. 2012;33(4 Suppl):293–300.
14. Elizabeth N, Pearce M, Andersson. and MBZ. Global iodine nutrition: where do we stand in 2013? Thyroid Res Pract. 2013;23, N.
15. Ogbera A, Kuku S. Epidemiology of thyroid diseases in Africa. Indian J Endocrinol Metab. 2011;15(6):82.
16. Adesunkanmi ARK, Makinde ON. Goitre prevalence in pregnant women attending antenatal clinic in a teaching hospital. J Obstet Gynaecol (Lahore). 2003;23(2):156–9.
17. Fisher T. Elisa guide thermofisher. Kit Man. 2014;597(815):421–4.
18. Rezaianzadeh A, Namayandeh SM, Sadr SM. National cholesterol education program adult treatment panel III versus international diabetic federation definition of metabolic syndrome, which one is associated with diabetes mellitus and coronary artery disease? Int J Prev Med. 2012;3(8):552–8.
19. Kanazawa M, Yoshiike N, Osaka T, Numba Y, Zimmet P, Inoue S. Criteria and classification of obesity in Japan and Asia-Oceania. World Rev Nutr Diet. 2005;94:1–12.
20. Jain HK, Sharma AK, Mishra A. Study of clinical profile of hypothyroidism in a tertiary care hospital, central India. Int J Health Sci (Qassim). 2022;8(7):2594–601.
21. Song B, Lu C, Teng D, Shan Z, Teng W. Association between different metabolic phenotypes of obesity and thyroid disorders among Chinese adults: a nationwide cross-sectional study. Front Endocrinol (Lausanne). 2023;14(April).
22. Kim D, Kim W, Joo SK, Bae JM, Kim JH, Ahmed A. Subclinical Hypothyroidism and Low-Normal Thyroid Function Are Associated With Nonalcoholic Steatohepatitis and Fibrosis. Clin Gastroenterol Hepatol [Internet]. 2018;16(1):123–131.e1. Available from: https://doi.org/10.1016/j.cgh.2017.08.014
23. Gyamfi D, Wiafe YA, Ofori Awuah E, Adu EA, Boadi EK. Goitre Prevalence and Urinary Iodine Concentration in School-Aged Children in the Ashanti Region of Ghana. Int J Endocrinol. 2020;2020.
24. Ruíz-Pacheco MG, Hernández I, Hernández-Estrella G, Basurto L, Vargas-Ortega G, González-Virla B et al. Severity of fatigue and its relationship with TSH before and after Levothyroxine replacement therapy in patients with primary hypothyroidism. Biomedicines. 2023;11(3).
25. Kaudha G, Piloya T, Musiime V, Kuteesa MG, Namugerwa S, Owomugisha G, et al. Prevalence and factors associated with hypothyroidism in children with sickle cell anemia aged 6 months– 17 years attending the sickle cell

clinic, Mulago hospital, Uganda; a cross-sectional study. BMC Endocr Disord. 2023;23(1):1–9.
26. Stone MB, Wallace RB. Medicare coverage of routine screening for thyroid dysfunction. Medicare coverage of routine screening for thyroid dysfunction; 2003.
27. Güngör Semiz G, Hekimsoy Z. Menstrual Cycle Characteristics in Women With and Without Thyroid Disease. Cureus. 2024;16(December 2013).
28. Ma B-J. Excessive uterine bleeding in a Non-Compliant patient with profound hypothyroidism: A case report and review of the literatures. J Med Cases. 2016;7(6):234–8.
29. Zhang Z, Boelen A, Kalsbeek A, Fliers E. TRH neurons and thyroid hormone coordinate the hypothalamic response to cold. Eur Thyroid J. 2018;7(6):279–88.
30. 1 LYa et al. 1 GP a, 1 ZL c, A LL, A SG, A FL,. Impaired sensitivity to thyroid hormones is associated with different grades of hypertension: A multicenter cross-sectional study. Nutr Metab Cardiovasc Dis. 2024;34:1581–9.
31. Popoveniuc G, Jonklaas J. Thyroid Nodules. Med Clin North Am [Internet]. 2012;96(2):329–49. Available from: https://doi.org/10.1016/j.mcna.2012.02.002
32. Dauksiene D, Petkeviciene J, Klumbiene J, Verkauskiene R, Vainikonyte-Kristapone J, Seibokaite A et al. Factors Associated with the Prevalence of Thyroid Nodules and Goiter in Middle-Aged Euthyroid Subjects. Int J Endocrinol. 2017;2017.
33. Blanc E, Ponce C, Brodschi D, Nepote A, Barreto A, Schnitman M, et al. Association between worse metabolic control and increased thyroid volume and nodular disease in elderly adults with metabolic syndrome. Metab Syndr Relat Disord. 2015;13(5):221–6.

Publisher's note