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Mineral Density and Frequency of Thyroid Malignancy: A Cross-Sectional Analysis

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Abstract: Background: Several trace minerals have been shown to be associated with thyroid cancer. However, there is a paucity of data on the characteristics of thyroid nodules in different mineral rich regions of the Democratic Republic of Congo (DRC). The objective of this study is to establish the spectrum of thyroid nodules in different regions of the most mineral wealthy country in the world. **Method:** We conducted a cross-sectional study, performing descriptive statistics and logistic regression with a p value <0.05 deemed of statistical significance. We enrolled 529 patients diagnosed with thyroid nodules between 2005 and 2019 in two of the richest provinces in minerals (Katanga and South Kivu) and the capital city, Kinshasa. **Results:** The mean age was 44.2±14.6 years with a female predominance, with a female to male ratio of 5.4. 66.5% of patients had a family history of thyroid disease. 74 patients had simple nodules, whereas 455 had multiple nodules. 87.7% of patients with nodules were euthyroid. The nodules mostly presented a solid structure (72.2%), hypoechogenicity (84.5%), a macronodule (59.8%), calcification (14.4%) and lymphadenopathy (15.5%). 22.3% of these nodules had a malignant character. The independent factors associated with this malignancy were age ≥60 years (aOR=2.81), Katanga as province of origin (aOR=8.19), solid echostructure (aOR=7.69), hypoechogenicity (aOR=14.19), macronodule (aOR=9.13), calcification (aOR=2.6) and the presence of adenopathy (aOR=6.94). **Conclusion:** By the way of this first of its kind study, we demonstrated that thyroid nodules were more likely to be malignant if found in patients originating from mineral rich region of Katanga. This high frequency of malignancy in mineral rich regions requires measures aimed at early detection in this population, lower threshold for suspicion of malignancy and adequate training of doctors involved in the management of these patients. This study paves the way for future, more extensive and well-funded studies to better understand the relationship of heavy metals and thyroid cancer incidence in the richest country in heavy metals in the world.

Keywords: thyroid; malignancy; mineral density; kinshasa; Katanga; nodule

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Introduction:

Thyroid nodules are very common and usually come to clinical attention when noted by the patient; during routine physical examination; or when incidentally noted during a radiologic procedure, such as carotid ultrasonography, neck or chest computed tomography (CT), magnetic resonance imaging (MRI), or positron emission tomography (PET) scanning have the same risk of malignancy as palpable nodules of the same size [1–3]. The history and physical examination have a low accuracy for predicting cancer. However, there are several features of the history that suggest an increased likelihood of malignancy, such as a history of rapid growth of a neck mass, childhood head and neck irradiation, total body irradiation for bone marrow transplantation, family history of thyroid cancer, or thyroid cancer syndromes [1–3].

Thyroid nodules are selected for Fine Needle Aspiration (FNA) biopsy based on suspicious ultrasonographic characteristics rather than size alone, as the presence of suspicious ultrasound features is more predictive of malignancy [4,5]. There are several approaches used to categorize thyroid nodules for likelihood of malignancy and to select nodules for biopsy. The American College of Radiology has proposed a system (Thyroid Imaging, Reporting and Data System [TIRADS]) for selecting nodules for FNA [6]. A similar, but not identical system has been proposed in Europe (European Thyroid Imaging, Reporting and Data System [EU-TIRADS]). This latter system has recently been validated in the Congolese population (referefence)and plays a key role in the assessment of thyroid nodules for malignancy; given the fact that FNA is not readily available in the country [7].

The most recent and up to date study on the spectrum of thyroid nodules in the DRC was conducted in a single institution and in a province that is not known to have a soil rich in trace minerals [8]. Several studies around the globe have linked fixed exposure to multiple elements to the development of thyroid cancer [9–11]. However, to the best of our knowledge, there are currently no studies on thyroid nodules in the DRC involving patients of mineral rich provinces. Thus, the need of the current study. The objective of this study is to establish the spectrum of thyroid nodules in the DRC, involving patients of provinces rich in minerals in an attempt to improve the management of thyroid nodules in those populations.

Materials and Methods:

This is a cross-sectional and analytical study of 529 records of patients with thyroid nodules, operated on during the period from 2005 to 2019; having benefited from a thyroid ultrasound and an anatomopathology examination in 35 hospitals in Kinshasa, two in Bukavu and one in Katanga. All available records were reviewed. The sampling was exhaustive.

2.1. Variables of Interest

Using a previously established data sheet, investigators sufficiently trained and aware of the objectives of the study collected the following data: province of residence, age, sex, marital status, clinical parameters (history of thyroid cancer in the family, reasons for consultation, parity , gestation, abortion, duration of the mass, arterial pressure, heart rate, observation of the mass, lymphadenopathy on clinical examination), clinical diagnosis, ultrasound parameters (total volume of the thyroid gland, echostructure, echogenicity, presence of nodule , size, calcification, lymphadenopathy on ultrasound, ultrasound diagnosis) and histopathological diagnosis.

Only files containing all the information on the variables of interest described were retained for the final analyses. The period of analysis was guided by the availability of registers in all the laboratories of the hospitals mentioned above.

2.2. Data Analysis

The statistical analyzes of the data were carried out using Statistical Package for the Social Sciences (SPSS) for Windows version 24 software. The descriptive analyzes carried out are the mean, standard deviation for the quantitative data with Gaussian distribution and the absolute (n) and

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relative (%) frequencies for categorical data. Pearson's Chi-square or Fisher's exact test was performed to compare the proportions (%). The student's t test was performed to compare the means. Logistic regression was used to search for factors associated with cancerous thyroid nodules in univariate and multivariate analysis with OR calculation and their 95% confidence interval to estimate the degree of association. For all the tests used, the value of $p < 0.05$ was considered as the threshold of statistical significance.

The notion of confidentiality was essential for our study, the data was collected anonymously and was used only for the drafting of this work.

Results:

Types of thyroid nodules can be found in Figure 1. A total of 529 nodules were identified in the study population, including 74 (14%) single nodules, 47 (8.9%) binodules and 408 (77.1%) multinodules.

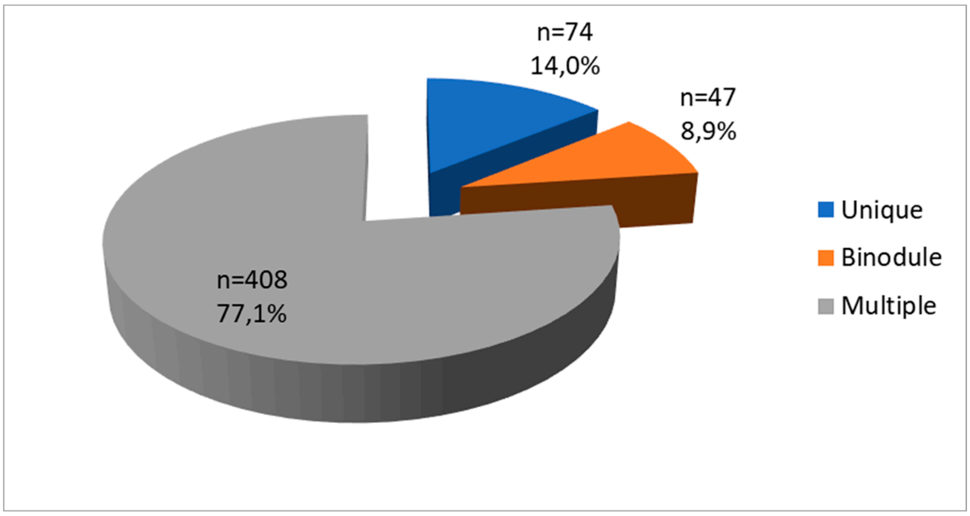

Figure 1. Types de nodules.

The socio-demographic characteristics of nodules are illustrated in Table 1 and show that the mean age of patients was 44.2±14.6 years with a predominance of female sex (84.4%; female to male ratio of 5. 4). Married people were more represented (75.1%) and a large number of samples came from Kinshasa (88.5%). The sociodemographic characteristics of single and multiple nodules were similar (p>0.05).

Table 1. Sociodemographic characteristics according to type of nodules.

Variables	All (n=529)	Single (n=74)	Multiple (n=455)	p
Age	44.2±14,6	45.0±14.9	44.0±14.2	0.206
≤20 years	35(6.6)	8(10.8)	7(5.9)	
21-30 years	54(10.2)	2(2.7)	52(11.4)	
31-40 years	135(25.5)	19(25.7)	116(25.5)	
41-50 years	127(24.0)	19(25.7)	108(23.7)	
51-60 years	96(18.1)	14(18.9)	82(18.0)	

>60 years	82(15.5)	12(16.2)	70(15.4)	
Sex				0.360
Male	82(15.6)	13(17.6)	69(15.3)	
Female	444(84.4)	61(82.4)	383(84.7)	
Marital Status				0.636
Married	373(75.1)	51(77.3)	322(74.7)	
Single	115(23.1)	13(19.7)	102(23.7)	
Divorced/Widowed	9(1.8)	2(3.0)	7(1.6)	
Origin of the sample				0.280
Kinshasa	468(88.5)	64(86.5)	404(88.8)	
Katanga	18(3.4)	1(1.4)	17(3.7)	
Sud Kivu	43(8.1)	9(12.2)	34(7.5)	

Multiparas were more represented, 66.5% of patients had a family history of thyroid pathology, most often first degree (58.2%). On clinical examination, 95.1% of patients had antero-cervical mass, 35.3% were obese, 8.7% had lymphadenopathy and 87.7% had normal thyroid function. No significant difference was found between the single and multiple nodules compared to the clinic. As seen in Table 2.

Table 2. Clinical characteristics.

Variables	**All (n=529)**	**Single (n=74)**	**Multiple (n=455)**	**p**
Parity				0.670
Nulliparous	65(14.6)	10(16.4)	55(14.3)	
Primiparous	40(9.0)	5(8.2)	35(9.1)	
Pauciparous	102(22.9)	17(27.9)	85(22.1)	
Multiparous	239(53.6)	29(47.5)	210(54.5)	
Gravida				0.514
Nulligravid	71(16.0)	11(18.0)	60(15.6)	
Primigravid	40(9.0)	3(4.9)	37(9.6)	
Multigravid	334(75.1)	47(77.0)	287(74.7)	
Abortion	83(18.7)	15(24.6)	68(17.7)	0,135
Family history of thyroid pathology	352(66.5)	51(68.9)	301(66.2))	0,373

First degree	205(58.2)	30(60.0)	175(57.9)	
Second degree	147(41.8)	20(40.0)	127(42.1)	
Anterior-cervical mass	503(95.1)	71(95.9)	391(95.8)	0.099
Overweight	195(36.9)	23(31.1)	172(37.8)	0.163
Obesity	187(35.3)	28(37.8)	159(34.9)	0.360
Clinical LAD	46(8.7)	10(13.5)	36(7.9)	0.091
SBP	135.6±58.6	131.4±13.8	135.8±65.5	0.786
DBP	72.6±8.9	73.9±8.5	72.3±9.2	0.485
BMI	29.8±12.1	29.5±3.1	29.9±13.6	0.959
HR	83.0±11.0	82.0±11.6	83.1±10.6	0.557
Total volume	70.9±31.5	68.5±30.8	70.8±32.2	0.596
Thyroid Fonction				0.631
euthyroid	464(87.7)	63(85.1)	401(88.1)	
Hyperthyroid	50(9.5)	9(12.2)	41(9.0)	
Hypothyroid	15(2.8)	2(2.7)	13(2.9)	

LAD: Lymphadenopathy; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; BMI: Body Mass Index; HR: Heart Rate.

The sonographic characteristics of nodules can be seen in Table 3 showed a predominance of solid echostructure (72.2%), hypoechogenicity (84.5%), a macronodule (59.8%), microcalcification (14.4%) and adenopathy (15 .5%). Anatomopathological analysis of nodules as seen in Table 4, shows that 77.7% of nodules were benign and 22.3% malignant. Colloid goiter was predominant in the benign nodule (73.5%) and papillary carcinoma in the malignant nodule (66.9%); anaplastic carcinoma represented 7.6% of malignant nodules.

Table 3. Sonographic characteristics of nodules.

Variables	All (n=529)	Simple (n=74)	Multiple (n=408)	p
Echostructure				0.837
Solid	382(72.2)	53(71.6)	329(72.3)	
Liquid	12(2.3)	1(1.4)	11(2.4)	
Mixed	135(25.5)	20(27.0)	115(25.3)	
Echogenicity				0.332
Hypoechoic	447(84.5)	59(79.7)	388(85.3)	
Isoechoic	81(15.3)	15(20.3)	66(14.5)	

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Anechoic	1(0.2)	0(0.0)	1(0.2)	
Size				0.360
Macronodule	315(59.8)	50(67.6)	265(58.5)	
Micronodule	82(15.6)	9(12.2)	73(16.1)	
Mixed	130(24.7)	15(20.3)	115(25.4)	
Microcalcification				0.494
No	453(85.6)	64(86.5)	389(85.5)	
Yes	76(14.4)	10(13.5)	66(14.5)	
Adenopathy				0.352
No	447(84.5)	61(82.4)	386(84.8)	
Yes	82(15.5)	13(17.6)	69(15.2)	

Table 4. Characteristics of nodules in pathology.

Variables	Number (n=529)	Percentage
Anapathology		
Benign nodules	441	77.7
Malignant nodules	118	22.3
Benign nodules		
Colloid goiter	302	73.5
Adenomatoid goiter	36	8.8
Follicular adenoma	20	4.9
Macrofollicular adenoma	18	4.4
Follicular cyst	8	1.9
Adenomatoid nodule	5	1.2
Thyroid abscess	3	0.7
Follicular adenoma	3	0.7
Microfollicular adenoma	3	0.7
Reactive LAD	3	0.7
Chronic strumitis	3	0.7
Grave’s disease	2	0.5

Non toxic adenoma	1	0.2
Toxic adenoma	1	0.2
Granulomatous thyroid	1	0.2
Dequervain's subacute thyroiditis	1	0.2
Hashimoto's thyroiditis	1	0.2
Malignant nodules		
Papillary carcinoma	79	66.9
Follicular carcinoma	26	22.0
Anaplastic carcinoma	9	7.6
Lymphoma	3	2.5
Medullary carcinoma	1	0.8

LAD: Lymphadenopathy.

Table 5, which breaks down all the nodules according to their pathology character, indicates that the frequency of malignant nodules was significantly higher in patients aged >60 years (p=0.003); from Katanga (p=0.044), in patients with a family history of thyroid pathology (p=0.002) and in patients with cervical lymphadenopathy (p<0.001). Table 6 indicates that the different ultrasound characteristics of the patients were significantly different between the benign and malignant nodules (p<0.05) except for the number of nodules where the difference was not statistically significant (p=0.284).

Table 5. Sociodemographic and clinical characteristics according to the anatomopathological character.

Variables	**N**	**Benign nodule n(%)**	**Malignant nodule n(%)**	**p**
Age				**0.003**
≤20 years	35	31(87.1)	4(12.9)	
21-60 years	412	333(80.8)	79(19.2)	
>60 years	82	47(57.3)	35(42.7)	
Sex				0.061
Male	82	58(70.7)	24(29.3)	
Female	444	352(79.3)	92(20.7)	
Province of origin of the sample				**0.044**
Kinshasa	468	364(77.8)	104(22.2)	
Katanga	18	10(55.6)	8(44.4)	

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South Kivu	43	37(86.0)	6(14.0)	
Marital status				0.256
Married	373	293(78.6)	80(21.4)	
Single	115	85(73.9)	30(26.1)	
Divorced/widow	9	7(77.8)	2(22.2)	
Parity				0,160
Nulliparous	65	46(70.8)	19(29.2)	
Primiparous	40	32(80.0)	8(20.0)	
Pauciparous	102	87(85.3)	15(14.7)	
Multiparous	239	187(78.2)	52(21.8)	
Gravida				0.311
Nulligravid	71	51(71.8)	20(28.2)	
Primigravid	40	32(80.0)	8(20.0)	
Multigravid	334	268(80.2)	66(19.8)	
FH of thyroid pathology				**0.022**
No	177	147(83.1)	30(16.9)	
Yes	352	264(75.0)	88(25.0)	
BMI				0.505
Normal	25	22(88.0)	3(12.0)	
Overweight	195	150(76.9)	45(23.1)	
Obesity	187	146(78.1)	41(21.9)	
Clinical LAD				**<0.001**
No	100.0	397(82.2)	86(17.8)	
Yes	100.0	14(30.4)	32(69.6)	

FH: Family history; BMI: Body Mass Index; LAD: Lymphadenopathy.

Table 6. Ultrasound characteristics according to the anatomopathological character.

Variables	**N**	**Benign nodule n(%)**	**Malignant nodule n(%)**	**p**
Echostructure				**<0.001**
Solid	382	268(70.2)	114(29.8)	

Liquid	12	12(100.0)	0(0.0)	
Mixed	135	4(97.0)	4(3.0)	
Echogenicity				**<0.001**
Hypoechoic	447	330(73.8)	117(26.2)	
Isoechoic	81	80(98.8)	1(1.2)	
Anechoic	1	1(100.0)	0(0.0)	
Number				0.284
Unique	74	55(74.3)	19(25.7)	
Binodule	47	33(70.2)	14(29.8)	
Multiple	408	323(79.2)	85(20.8)	
Size				**<0.001**
Macronodule	315	211(67.0)	104(33.0)	
Micronodule	82	81(98.8)	1(1.2)	
Mixed	130	119(91.5)	11(8.5)	
Calcification				**<0.001**
No	453	376(83.0)	77(17.0)	
Yes	76	35(46.1)	41(53.9)	
Adenopathy				**<0.001**
No	447	382(85.5)	65(14.5)	
Yes	82	29(35.4)	53(64.6)	

The risk factors associated with nodule malignancy in univariate analysis were age ≥60 years, Katanga as province of origin, family history of thyroid pathology, presence of clinical and ultrasound lymphadenopathy, solid echostructure, hypoechogenicity, macronodule and calcification.

After adjustment in multivariate analysis, age ≥60 years (aOR: 2.81; 95% CI: 1.14-6.94, p=0.025), Katanga as province of origin (aOR: 8.19; 95% CI: 1.14-12.45, p=0.036), presence of ultrasound lymphadenopathy (aOR: 6.94; 95% CI: 2.79-17.25, p<0.001), solid echostructure(aOR: 7.69; 95% CI: 2.40-24.58, p=0.001), hypoechogenicity (aOR: 14.19; 95% CI: 1.60-25.93, p=0.017), macronodule (aOR: 9.13; 95% CI: 4.19-19.89, p<0.001) and calcification (aOR: 2.60; 95% CI: 1.19-5.7, p=0.017) were major factors independently associated with nodule malignancy (Table 7).

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Table 7. Factors associated with risk of malignancy in nodules.

Variables	Univariate analysis		Multivariate analysis	
	p	**OR (CI 95%)**	**p**	**aOR (CI 95%)**
Age				
≤20 years		1		1
21-60 years	0,319	1.52(0,67-3.46)	0.614	1,32(0.26-2.24)
>60 years	**0.003**	2.81(1.37-5.78)	**0.025**	2.81(1.14-6.94)
Province of origin of the sample				
South Kivu		1		1
Kinshasa	0.212	1.76(0.72-4.29)	0,116	2.47(0.80-7.62)
Katanga	**0.014**	4,93(1.39-17.54)	**0.036**	8.19(1.14-12.45)
FH of thyroid pathology				
No		1		1
Yes	**0.022**	1.63(1.03-2.59)	0,105	1.65(0.90-3.34)
Clinical LAD				
No		1		1
Yes	**<0.001**	10.55(5.40-20.62)	0,760	1.20(0.38-3.82)
Echostructure				
Liquid		1		1
Solid	<0.001	15,21(5.50-42.07)	**0.001**	7.69(2.40-24.58)
Echogenicity				
Isoechoic		1		1
Hypoechoic	<0.001	18.72(3.95-28.68)	**0.017**	14.19(1.60-25.93)
Size				
Micronodule		1		1
Macronodule	<0.001	5.33(2.75-10.33)	**<0.001**	9.13(4.19-19.89)
Calcification				
No		1		1
Yes	<0.001	5.72(3.42-9.55)	**0.017**	2.60(1.19-5.70)
Ultrasound LAD				

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No		1		1
Yes	<0.001	10.74(6.36-18.13)	**<0.000**	6.94(2.79-17.25)

FH: Family History; LAD: Lymphadenopathy.

Discussion:

Our nationally representative study revealed that there was a predominance of thyroid nodules among females compared to males. Most patients with a thyroid nodule had a normal thyroid function. Solid structure, hypoechogenicity, micronodule, microcalcification and lymphadenopathy were common ultrasound features among nodules. Advanced age, living in Katanga province, solid echostructure, hypoechogenicity, macronodule, microcalcification and adenopathy were found to be risk factors for malignancy in thyroid nodules.

The clinical importance of the thyroid nodule evaluation is primarily related to the need to exclude thyroid cancer, which is present in 4 to 6.5 percent of thyroid nodules [12]. The female gender and iodine deficiency are two well recognized risk factors for the development of thyroid nodules [8,13]. Our study revealed a female predominance in the occurrence of thyroid nodules which is consistent with findings in the literature. Furthermore, it has been proven in the literature that thyroid nodules are common in the Congolese population, mainly due to the lack of adequate iodine supplement in the typical Congolese meals [8]. The prevalence of cancer is higher in several groups such as children, adults younger than 30, patients with a history of head and neck irradiation, and patients with a family history of thyroid cancer [12,14,15]. Our study revealed a higher frequency of thyroid cancer in patients older than 60 years of age which is similar to the findings of the study done by Kwong et al. [16] but differs from results found in the Sicilian study conducted by Belfiore et al. [15] which found that adults younger than 30 years old were at highest risk of malignant nodules.

Other factors such as exposure to trace minerals and heavy metals have been associated with the development of thyroid cancer [9–11]. A study by Petrosino et al. [17] revealed that all patients with head and neck cancer enlisted for the study had heavy metal and polychlorinated biphenyls (PCB) blood levels at least twice the maximum reference level. The levels of heavy metals in hair were at least double the maximum reference. In contrast, all healthy volunteers enrolled showed no significant levels for either metals or PCBs. A study done at Yale University found that urinary cadmium, antimony and tungsten were significantly associated with increased odds of thyroid dysfunctions, including cancer [18]. A similar study done in south Korea among residents living near national industrial complexes revealed that urinary mercury concentration was positively associated with the risk of thyroid cancer among residents living near national industrial complexes [19]. No such study has been carried out in the DRC. Furthermore, no studies have been done to evaluate the frequency of thyroid cancer in different regions of the country rich in heavy metals. DRC is endowed with exceptional natural resources, including minerals such as cobalt, copper, Coltan, mercury, tantalum, tin, gold, lithium, tungsten, manganese, uranium, and many others [20]. The natural resources are not equally distributed within the country, with some regions containing more natural resources than others.

Katanga province is one of the wealthiest regions in the world in terms of natural resources. It has 34% of the world's cobalt reserves and 10% of the world's copper. It is also rich in zinc, lead, uranium, tin, manganese, chromium, mercury, cadmium, silver, gold, germanium, and coal. A 2009 study in the province found substantial exposure to several metals, especially in children. The urinary Cobalt concentrations found in this population are the highest ever reported for a general population [21]. In 2016, researchers discovered extensive metal contamination in the fish in Katanga's Lake Tshangalele, near mining and other metallurgical operations in Likasi, in species commonly eaten by the local population [22]. However, no studies have been carried out in the country to compare the frequency of malignant thyroid nodules in this region and in regions not rich in mineral resources. Our study found that 44.4 % of nodules in the Katanga region were malignant, whereas only 22.2% were malignant in Kinshasa. This trend shows a possible important role played by heavy metals contamination in the carcinogenesis affecting this population.

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Although ultrasonography yields limited diagnostic information, it provides extremely valuable and pertinent information about the thyroid gland, its diseases, and adjacent structures. This cumulative ultrasonography evidence, in context, can significantly augment diagnosis as well as clinical, surgical, radiation, ablation, and other management [23–25]. Malignant thyroid nodules often have a hypoechoic appearance on ultrasound as evidenced by the studies by Solbiati et al. [26] and Cochand-Priollet et al. [27]. Microcalcifications may be present in both benign and malignant nodules and are therefore only partially predictive of histopathology, however, in a Greek study by Kakkos et al., the prevalence of cancer was significantly higher when there were calcium flecks in a nodule [28]. Our study revealed that hypoechogenicity and microcalcifications were associated with malignancy, findings similar to the current literature. The uniformity of the internal structure of a nodule is not a useful indicator for diagnosis of cancer; cancers may be either entirely solid or contain some component of cystic content. In general, the larger the cystic component, the less likely the nodule is to be malignant [29]. As evidenced in the literature, solid echostructure was associated with malignancy in our study. Large nodule diameter and volume predicts a higher likelihood of thyroid cancer and prognosis [23,30–32]. In a large study, conducted by Angell et al., of over 20,000 thyroid nodules, for every centimeter increase in size of a nodule over 1 cm, there was a 15 to 30 percent escalation in malignancy risk [23].

Thyroid follicular epithelial-derived cancers are divided into three categories which are papillary (85%), follicular (12%) and anaplastic (<3%). Papillary and follicular cancers are considered differentiated cancers. Most anaplastic (undifferentiated) cancers appear to arise from differentiated cancers [33]. Papillary and follicular cancers were the most frequent in our study, and anaplastic cancers were higher in frequency than in the literature (7.6 % VS <3%). One could speculate that given lack of access to healthcare, most of these patients with undifferentiated thyroid cancers had longstanding differentiated carcinomas but failed to seek medical attention as routine visit is not part of the Congolese culture.

This study has several limitations, such as missing data or loss of records inherent to its retrospective design, the multiplicity of types of ultrasound devices and operators and the lack of a validated ultrasound examination protocol for the thyroid gland. Furthermore, there is bias since we only took into consideration the patients who had carried out the anatomopathology while those who had not carried out one, were not included in this study. This may have influenced a high frequency of cancers and certain histological types. Finally, limitations in diagnostic facilities in data reporting in a resource-poor health care facility are also potentially limiting.

Despite these limitations this study has the merit of being the first of its kind addressing a very important subject in a country rich in mineral resources.

In conclusion, by the way of this first of its kind study, we demonstrated that the mineral rich region of Katanga was associated with higher frequency of thyroid malignancy. These findings are especially important in a population that lives below the poverty line. Although routine screening for thyroid cancer in a population at low risk for thyroid cancer is not cost effective, such strategy should be implemented in the national guidelines for management of patients in regions rich in mineral resources; especially since there was a higher frequency of undifferentiated cancers. This study paves the way for larger and well-funded studies to confirm these results and help shape the national guidelines.

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