scientific reports

Check for updates

OPEN

Knowledge, attitudes, and willingness of patients with thyroid diseases toward thyroid thermal ablation techniques

Ying Liu[1,5], Lihong Liu[2,5], Jinling Wang[1,5], Jinke Li[1], Lu Zhou[1], Meng Wang[1], Weiwei Zhao[3], Liang Hao[4], Shurong Wang[1]✉ & Shoujun Yu[4]✉

To investigate the knowledge, attitudes, and willingness (KAW) of patients with thyroid disease regarding thyroid thermal ablation techniques and explore the factors associated with KAW. This cross-sectional survey was conducted at Yantai Hospital of Shandong Wendeng Orthopaedics & Traumatology and Yantai Affiliated Hospital of Binzhou Medical College between October 2022 and March 2023. This study included 632 patients; 66.14% were female. The mean knowledge, attitude, and willingness scores were 6.03 ± 2.42 (possible range: 0–10), 17.52 ± 2.91 (possible range: 5–25), and 33.02 ± 6.34 (possible range: 8–40), indicating poor knowledge, positive attitudes, and proactive willingness. Multivariable analysis showed that ≥ 51 years old, urban areas, consuming alcohol, medical treatment, and surgical treatment were independently associated with adequate knowledge. The knowledge scores, ≥ 51 years old, females, urban areas, medical treatment, and surgical treatment were independently associated with a positive attitude. Only the attitude scores were independently associated with proactive willingness. Patients with thyroid diseases have poor knowledge, positive attitudes, and proactive practice toward thermal ablation. Sustained efforts are required to increase knowledge about thyroid thermal ablation techniques.

Keywords Knowledge, Attitudes, Willingness, Thyroid nodules, Thermal ablation, Cross-sectional study

Abbreviations

KAW	Knowledge, attitudes, and willingness
FNA	Fine needle aspiration
KAP	Knowledge, attitudes, and practice
SD	Standard deviation

The thyroid diseases commonly encountered in clinical practice include thyroid nodules[1,2], hyperthyroidism[3], hypothyroidism[4,5], Hashimoto's thyroiditis[6], and thyroid cancer[7]. The prevalence of hyperthyroidism is 0.75–1.2%[3,8]. Hypothyroidism is observed in 1–2% of the general population, reaching 7% in older adults aged 85–89 years[4]. Hashimoto's thyroiditis is also a common thyroid condition, observed in 2% of the general population[9]. Thyroid cancer is the 11th most common cancer, with an estimated 586,202 new cases in 2020 and 43,646 deaths[10].

Thyroid nodules represent the most common thyroid disease and are detected in about 60% of adults[11]. A thyroid nodule is a discrete lesion in the thyroid gland that is radiologically distinct from surrounding normal thyroid tissue[1,2]. Thyroid nodules are four times more common in female patients than in male patients and occur more frequently with increasing age. Most thyroid nodules are asymptomatic[2,11]. Palpable nodules are often discovered on physical examination, and nonpalpable nodules are frequently detected incidentally on imaging studies performed for unrelated reasons[1,2,12]. Symptomatic patients may report symptoms related to hyperthyroidism or hypothyroidism, compressive symptoms, or cosmetic concerns[1,2,12]. Thyroid nodules may

[1]Department of Ultrasound Intervention, Yantai Hospital of Shandong Wendeng Orthopaedics and Traumatology, Yantai 624000, China. [2]Department of Ultrasound, Yantai Affiliated Hospital of Binzhou Medical University, Yantai 624000, China. [3]Department of Traditional Chinese Medicine, Yantai Affiliated Hospital, Binzhou Medical University, Yantai 624000, China. [4]Hepatobiliary Pancreatic Splenic Surgery, Yantai Affiliated Hospital of Binzhou Medical University, Yantai 624000, China. [5]Ying Liu, Lihong Liu and Jinling Wang have contributed equally to this work. ✉email: 7762808@sina.com; 13573552822@163.com

be caused by both benign (about 90%) and malignant (about 10%) lesions[2]. Risk factors for malignancy include a family history of thyroid cancer and a history of radiation therapy. While thyroid nodules may be associated with thyroid dysfunction or local mass effects, the primary clinical concern is to identify and treat lesions that are malignant or at high risk for malignancy[1,12].

Ultrasound-guided thermal ablation can be used for benign thyroid nodules causing symptoms or cosmetic concerns as a minimally invasive alternative to surgery or radioactive iodine therapy[2,11–13]. The indications for thermal ablation include mixed, predominantly solid and/or growing nodules determined to be benign after two serial fine needle aspiration (FNA) biopsies and an evaluation of serum calcitonin levels and cystic or mostly cystic nodules when refractory to initial treatment with percutaneous ethanol injection[14]. The most commonly used thermal ablation techniques include radiofrequency ablation, laser ablation, and microwave ablation[13,15]. Radiofrequency ablation and laser ablation are each reported to be well-tolerated and result in reduced nodule volume and improved symptoms[13,15]. Chinese experts on thyroid ablation have confirmed that microwave ablation of thyroid microcarcinoma is safe and effective based on postoperative pathology[16]. According to another report in China, compared with RFA and LA, MWA is more suitable for treating greater thyroid nodules, with volume reduction rates ranging from 75 to 90% in follow-up studies up to 12 months[17]. Radiofrequency ablation may be preferred for benign solid nodules, while laser ablation is reported to be more effective for nodules > 30 mL[13]. Serious adverse effects or major complications, such as severe pain or recurrent nerve palsy, are reported to be rare and transient[13,15]. High-intensity focused ultrasound ablation (a needle-free alternative) is a newer procedure with limited evidence for use in the management of thyroid nodules[18,19].

Knowledge, attitudes, and practice (KAP) surveys, including variations like knowledge, attitudes, and willingness (KAW) surveys, aim to identify the factors, gaps, misconceptions, and misunderstandings that represent barriers to the performance of a specific subject in a specific population[20,21]. Previous studies reported variable KAP/KAW regarding thyroid thermal ablation techniques. A study highlighted that the implementation of thyroid thermal ablation techniques was relatively slow in the United States of America[22]. A survey in Europe showed that only a minority of thyroid practitioners use thermal ablation techniques[23]. Thermal ablation for thyroid nodules is not a popular option[24,25]. A study among patients with thyroid nodules reported poor KAW regarding radiofrequency ablation[26]. A study in Canada by Baerlocher et al.[27] showed that none of the patients had ever heard about radiofrequency ablation. The KAP toward radiofrequency has been shown to affect self-management after the procedure[28]. Some patients also undergo microwave ablation to treat thyroid nodules[19], and the present study focused on thermal ablation. Hence, strengthening the KAW toward thermal ablation should help the patients select this effective technique and improve their experience after ablation.

Therefore, this study evaluated the KAW of patients with thyroid diseases regarding thyroid thermal ablation techniques.

Results

Characteristics of the participants

This study collected 656 questionnaires. After excluding those with the same options selected for the whole questionnaire, logical errors, and less than 100 s for answering, 632 questionnaires were included in the analysis. The characteristics of the participants are shown in Table 1. Most participants were 41–50 years of age (31.33%), female (66.14%), living in urban areas (66.14%), with junior college/undergraduate education and above (63.61%), earning 5000–10,000 (51.11%), with long-term stable jobs (56.33%), not drinking (83.70%), not smoking (79.42%), with medical insurance (98.42%), with an illness history < 3 years (38.29%), and with treatments (76.58%). The diseases included hyperthyroidism (23.42%), Hashimoto's thyroiditis (17.25%), thyroid nodules (54.91%), thyroid cancer (15.19%), and others (19.15%).

Knowledge

The mean knowledge score was 6.03 ± 2.42 on a maximum of 10 (60.30%), indicating poor knowledge. Higher knowledge scores were observed in older participants ($P < 0.001$), females ($P < 0.001$), urban residency ($P = 0.001$), middle income ($P = 0.040$), long-term stable job ($P = 0.023$), not drinking ($P = 0.001$), not smoking ($P < 0.001$), with medical insurance ($P < 0.001$), with thyroid cancer ($P < 0.001$), and with a history of thermal ablation ($P < 0.001$) (Table 1). As shown in Supplementary Table S1, the knowledge items with poor knowledge were K3 (55.70%; "Thermal ablation of thyroid nodules is a technique for in situ inactivation of lesions in vivo to achieve local radical cure"), K4 (47.94%; "Thermal ablation techniques include radiofrequency ablation, microwave ablation, and laser ablation"), K6 (9.02%; "The common complications that can be treated with thyroid thermal ablation therapy include bleeding and transient voice changes, but no nerve or parathyroid damage"), K8 (58.23%; "Imaging of the lesion is required before, during and after ablation, where ultrasound imaging is recommended"), K9 (54.91%; "Therapeutic advantages of thermal ablation therapy include minimally invasive, rapid recovery, no impact on thyroid function and no need for lifelong medication"), and K10 (48.89%; "All thyroid diseases can be completely cured by thermal ablation techniques").

Attitudes

The mean attitude score was 17.52 ± 2.91 on a maximum of 25 (70.08%), indicating favorable attitudes. Higher attitude scores were observed with older age ($P < 0.001$), males ($P < 0.001$), living in urban areas ($P < 0.001$), not drinking ($P = 0.001$), not smoking ($P < 0.001$), with medical insurance ($P < 0.001$), with thyroid cancer ($P = 0.001$), and with a history of thermal ablation ($P < 0.001$) (Table 1). Supplementary Table S2 presents the distributions of the attitudes.

Variables	n (%)	Knowledge		Attitude		Willingness	
		Mean ± SD	*P*	Mean ± SD	*P*	Mean ± SD	*P*
Total	632	6.03 ± 2.42		17.52 ± 2.91		33.02 ± 6.34	
Age, years			< 0.001		< 0.001		0.001
< 30	121 (19.15)	5.57 ± 2.25		16.63 ± 2.53		31.74 ± 7.46	
31–40	160 (25.32)	5.73 ± 2.46		17.03 ± 2.93		32.44 ± 6.22	
41–50	198 (31.33)	6.06 ± 2.37		17.63 ± 2.96		33.06 ± 6.18	
≥ 51	153 (24.21)	6.68 ± 2.45		18.61 ± 2.79		34.59 ± 5.39	
Gender			< 0.001		< 0.001		< 0.001
Male	214 (33.86)	5.50 ± 2.38		17.83 ± 2.91		31.75 ± 6.81	
Female	418 (66.14)	6.31 ± 2.40		16.92 ± 2.84		33.67 ± 5.99	
Residence			0.001		< 0.001		< 0.001
Urban	418 (66.14)	6.25 ± 2.48		17.83 ± 2.91		33.65 ± 5.60	
Non-Urban	214 (33.86)	5.60 ± 2.24		16.92 ± 2.84		31.79 ± 7.45	
Education			0.369		0.659		0.212
High school/technical secondary school and below	230 (36.39)	5.92 ± 2.60		17.59 ± 3.00		32.60 ± 6.69	
Junior college/undergraduate and above	402 (63.61)	6.10 ± 2.31		17.49 ± 2.86		33.26 ± 6.13	
Incomes per capita, CNY			0.040		0.227		0.670
< 5000	180 (28.48)	5.84 ± 2.77		17.43 ± 3.12		33.04 ± 6.07	
5000–10,000	323 (51.11)	6.27 ± 2.12		17.70 ± 2.83		33.18 ± 6.09	
> 10,000	129 (20.41)	5.71 ± 2.53		17.20 ± 2.80		32.59 ± 7.30	
Type of work			0.023		0.401		0.082
Long-term stable employed	356 (56.33)	6.22 ± 2.26		17.61 ± 2.84		33.41 ± 5.63	
Non-fixed work (unemployed)	276 (43.67)	5.78 ± 2.59		17.41 ± 3.00		32.52 ± 7.14	
Drinking			0.001		0.001		< 0.001
Yes	103 (16.30)	5.31 ± 2.66		16.69 ± 2.91		31.03 ± 7.11	
No	529 (83.70)	6.17 ± 2.34		17.69 ± 2.89		33.41 ± 6.12	
Smoking			< 0.001		< 0.001		< 0.001
No	521 (79.42)	6.26 ± 2.40		17.80 ± 2.87		33.66 ± 5.82	
Yes	135 (20.58)	5.16 ± 2.28		16.48 ± 2.83		30.62 ± 7.58	
Type of medical insurance (multiple choice)							
Basic medical insurance for urban employees	436 (68.99)	6.32 ± 2.41	< 0.001	17.89 ± 2.93	< 0.001	33.50 ± 5.82	0.005
Basic medical insurance for urban residents	159 (25.16)	5.16 ± 2.03	< 0.001	16.40 ± 2.57	< 0.001	31.07 ± 7.55	< 0.001
New Cooperative Medical Insurance	154 (24.37)	5.34 ± 1.77	< 0.001	16.43 ± 2.46	< 0.001	30.90 ± 7.04	< 0.001
No insurance	10 (1.58)	5.40 ± 3.13	0.405	16.90 ± 2.23	0.495	33.10 ± 6.38	0.968
Type of thyroid diseases (multiple choice)							
Hyperthyroidism	148 (23.42)	5.01 ± 2.59	< 0.001	15.77 ± 1.84	< 0.001	29.30 ± 7.54	< 0.001
Hashimoto's thyroiditis	109 (17.25)	5.99 ± 2.15	0.847	17.09 ± 2.85	0.089	32.92 ± 6.76	0.852
Thyroid nodules	347 (54.91)	6.12 ± 2.34	0.321	17.58 ± 2.81	0.579	32.90 ± 6.32	0.605
Thyroid Cancer	96 (15.19)	6.84 ± 1.84	< 0.001	18.44 ± 3.44	0.001	33.81 ± 6.44	0.184
Other	121 (19.15)	5.91 ± 3.02	0.536	17.63 ± 2.89	< 0.001	34.28 ± 5.08	0.015
Duration of illness, years			0.526		0.722		0.126
< 3	242 (38.29)	5.95 ± 2.55		17.50 ± 2.81		33.62 ± 5.82	
3–5	193 (30.54)	5.97 ± 2.16		17.66 ± 3.00		32.90 ± 6.18	
> 5	197 (31.17)	6.19 ± 2.49		17.43 ± 2.96		32.40 ± 7.04	
Treatment for thyroid diseases			< 0.001		< 0.001		< 0.001
Medical treatment/Drug conservative treatment	95 (15.03)	5.41 ± 1.58		16.51 ± 2.21		31.79 ± 6.13	
Surgical treatment/Surgical excision	71 (11.23)	5.39 ± 1.40		16.51 ± 2.56		31.24 ± 6.62	
Thermal ablation therapy	205 (32.44)	7.15 ± 1.71		18.72 ± 2.88		34.79 ± 5.76	
Radiation therapy	46 (7.28)	4.76 ± 0.95		15.65 ± 2.44		28.11 ± 8.45	
No treatment	148 (23.42)	6.03 ± 3.14		17.76 ± 2.85		33.47 ± 5.32	
Other	67 (10.60)	5.04 ± 3.41		17.15 ± 3.10		33.63 ± 6.11	

Table 1. Characteristics of the participants.

Willingness

The mean willingness score was 33.02 ± 6.34 on a maximum of 40 (82.55%), indicating proactive willingness. Higher willingness scores were observed with older age ($P = 0.001$), males ($P < 0.001$), urban areas ($P < 0.001$), not drinking ($P < 0.001$), not smoking ($P < 0.001$), with medical insurance ($P < 0.001$), with other thyroid lesions ($P = 0.015$), and with a history of thermal ablation ($P < 0.001$). Supplementary Table S3 presents the distributions of the willingness items.

Correlations

Table 2 shows that the knowledge scores were correlated to the attitude (r = 0.401, $P < 0.001$) and willingness (r = 0.326, $P < 0.001$) scores. The attitude scores were correlated to the willingness scores (r = 0.511, $P < 0.001$).

Multivariable analyses

As shown in Table 3, ≥ 51 years old (vs. ≤ 30 years old, OR = 2.19, 95%CI: 1.13–4.23, $P = 0.020$), urban areas (OR = 2.01, 95%CI: 1.28–3.16, $P = 0.003$), consuming alcohol (OR = 0.51, 95%CI: 0.28–0.92, $P = 0.025$), medical treatment (vs. no treatment, OR = 0.17, 95%CI: 0.08–0.34, $P < 0.001$), and surgical treatment (vs. no treatment, OR = 0.14, 95%CI: 0.06–0.32, $P < 0.001$) were independently associated with the adequate knowledge.

As shown in Table 4, the knowledge scores (OR = 1.26, 95%CI: 1.16–1.43, $P < 0.001$), ≥ 51 years old (vs. ≤ 30 years old, OR = 2.30, 95%CI: 1.13–4.70, $P = 0.022$), females (OR = 1.90, 95%CI: 1.10–4.70, $P = 0.021$), urban areas (OR = 1.68, 95%CI: 1.00–2.67, $P = 0.048$), medical treatment (vs. no treatment, OR = 0.25, 95%CI: 0.10–0.58, $P = 0.001$), and surgical treatment (vs. no treatment, OR = 0.33, 95%CI: 0.13–0.83, $P = 0.018$) were independently associated with the positive attitude.

As shown in Table 5, only the attitude scores (OR = 1.50, 95%CI: 1.38–1.64, $P < 0.001$) were independently associated with proactive willingness.

Discussion

The results showed that patients with thyroid diseases from two Chinese hospitals in the Yantai area have poor knowledge, favorable attitudes, and proactive willingness toward thermal ablation. The results could help design education interventions and identify the points worth more discussions during consultations. Specific knowledge gaps could be identified, allowing interventions to be designed to improve the KAW.

Thermal ablation of thyroid nodules has been shown to be effective and safe[2,11–13]. It is a convenient option that can be performed in the outpatient setting at a relatively low cost and without radiation. Although there is a risk of thyroid/parathyroid function damage after thermal ablation, it is not an absolute risk as with radioactive iodine. Still, previous studies reported a low willingness of American and European thyroid physicians to use thermal ablation for the management of thyroid nodules[22,23]. Of course, the availability of specialized equipment could influence surgeons' decisions. In addition, the destruction of the tissues without removing them prevents the possibility of histopathological examinations to determine the exact nature of the nodule. Still, the main indication of thermal ablation is for solid nodules proved benign by two successive FNAs or for cystic nodules refractory to ethanol ablation[14]. Therefore, according to guidelines[14], thermal ablation is used for thyroid nodules with a low risk of malignancy. Still, the accuracy of FNA for thyroid nodules is not 100%[29], but in the absence of signs and symptoms of malignant disease, thermal ablation of thyroid nodules is a reasonable option.

A study in Canada showed that none of the 100 patients scheduled for an interventional radiology procedure had ever heard about radiofrequency ablation[27]. A previous study in Saudi Arabia reported a poor KAW toward radiofrequency ablation of thyroid nodules[26]. In the present study, Chinese patients showed poor knowledge but favorable attitudes and proactive willingness toward thermal ablation.

The present study showed gaps in specific knowledge items. Specifically, specific knowledge items had poor scores, especially knowledge about the biological mechanisms of thermal ablation, the available thermal ablation methods, the necessity of peri-operative lesion imaging, the advantages of thermal ablation, and which thyroid diseases can be managed using thermal ablation. The knowledge of the complications after thermal ablation scored particularly low (9%). Indeed, only 9% of the patients could correctly identify that the statement "the common complications of thyroid thermal ablation therapy include bleeding and transient voice change but no nerve or parathyroid damage" was incorrect since the most important major post-ablation complication is transient or permanent voice changes due to thermal injury to the recurrent laryngeal nerve[30]. Therefore, educational activities or materials should be designed for this specific patient population to provide or rectify knowledge on thyroid ablation procedures. Future studies should also examine the knowledge of healthcare providers since they act as a primary source of healthcare-related information for patients. Nevertheless, the patients had good attitudes and willingness toward thermal ablation procedures for thyroid diseases, indicating a high level of trust in the judgment of their healthcare providers.

In addition, knowledge was independently associated with attitudes, and attitudes were independently associated with willingness. Therefore, improving knowledge should improve the KAW of the patients. Indeed,

	Knowledge	Attitude	Willingness
Knowledge	1		
Attitude	0.401 ($P < 0.001$)	1	
Willingness	0.326 ($P < 0.001$)	0.511 ($P < 0.001$)	1

Table 2. Correlations.

Factors	Univariable logistic regression		Multivariable logistic regression	
	OR (95%CI)	*P*	OR (95%CI)	*P*
Age				
30 years old and below	Ref		Ref	
31–40 years old	1.36 (0.80 2.30)	0.254	1.25 (0.65 2.43)	0.506
41–50 years old	1.89 (1.15 3.10)	0.012	1.22 (0.64 2.30)	0.548
51 years old and above	3.63 (2.16 6.09)	< 0.001	2.19 (1.13 4.23)	0.020
Gender				
Male	Ref		Ref	
Female	2.58 (1.79 3.72)	< 0.001	1.56 (0.97 2.52)	0.068
Place of residence				
Urban	2.18 (1.52 3.11)	< 0.001	2.01 (1.28 3.16)	0.003
Non-Urban	Ref		Ref	
Education				
High school/Technical secondary school and below	Ref			
Junior college/Undergraduate and above	0.95 (0.68 1.32)	0.755		
Monthly household income				
< 5000	Ref			
5000–10,000	0.86 (0.59 1.24)	0.409		
> 10,000	0.65 (0.40 1.04)	0.069		
Type of work				
Long-term stable employed	1.06 (0.76 1.46)	0.743		
Non-fixed work (unemployed)	Ref			
Alcohol consumption				
Yes	0.42 (0.26 0.69)	0.001	0.51 (0.28 0.92)	0.025
No	Ref		Ref	
Smoking				
No	Ref		Ref	
Yes	0.33 (0.21 0.52)	< 0.001	0.55 (0.30 1.00)	0.051
Duration of illness				
< 3 years	Ref			
3–5 years	0.84 (0.57 1.24)	0.376		
> 5 years	1.17 (0.80 1.72)	0.420		
Type of therapy for thyroid diseases				
No treatment currently available	Ref		Ref	
Medical treatment/Drug conservative treatment	0.17 (0.09 0.33)	< 0.001	0.17 (0.08 0.34)	< 0.001
Surgical treatment/Surgical excision	0.13 (0.06 0.28)	< 0.001	0.14 (0.06 0.32)	< 0.001
Thermal ablation therapy	1.38 (0.90 2.12)	0.134	1.53 (0.95 2.48)	0.083
Radiation therapy	0	0.997	0	0.997
Other	0.81 (0.45 1.45)	0.478	1.14 (0.59 2.22)	0.694

Table 3. Multivariable analysis for knowledge.

according to the KAP theory, knowledge is the basis for practice (or willingness), while attitude is the force driving practice (or willingness)[20,21]. Therefore, improving knowledge should improve the KAW of the patients. Salah et al.[31] showed that an education intervention on thyroid thermal ablation reduced the consultations for post-ablation syndrome. In their study, Xu et al.[28] also showed that a KAW intervention improved the patient experience with an ablation procedure. The present study identified younger patients, those with potentially poorer life habits (i.e., drinking), and those who underwent medical or surgical treatment. There is a possibility that the physicians did not consider the option of thermal ablation in some patients and did not discuss the option with the patients. In addition, some included participants had hyperthyroidism and Hashimoto's thyroiditis; such patients are not eligible for thermal ablation, and the option was probably not discussed at all.

This study had limitations. It was performed at only two hospitals in China, limiting the generalizability of the conclusions. The questionnaire was designed by local investigators and might be biased based on local guidelines and practice, also limiting generalizability. No previous data on the KAW of Chinese patients with thyroid diseases toward thermal ablation were available, preventing comparisons. Nevertheless, the present study could serve as a baseline to examine the impact of future education interventions. KAP surveys (and variations) are also subject to the social desirability bias, in which the participants can answer what they should do instead of what they really do[32,33]. Finally, an information bias is possible regarding the attitude and practice

Factors	Univariable logistic regression		Multivariable logistic regression	
	OR (95%CI)	*P*	OR (95%CI)	*P*
Knowledge	1.51 (1.36 1.67)	< 0.001	1.26 (1.16 1.43)	< 0.001
Age				
30 years old and below	Ref		Ref	
31–40 years old	1.72 (0.92 3.20)	0.087	1.66 (0.80 3.43)	0.170
41–50 years old	2.26 (1.25 4.06)	0.007	1.68 (0.83 3.37)	0.146
51 years old and above	3.49 (1.92 6.35)	< 0.001	2.30 (1.13 4.70)	0.022
Gender				
Male	Ref		Ref	
Female	2.41 (1.59 3.66)	< 0.001	1.90 (1.10 4.70)	0.021
Place of residence				
Urban	2.11 (1.41 3.18)	< 0.001	1.64 (1.00 2.67)	0.048
Non-urban	Ref		Ref	
Education				
High school/Technical secondary school and below	Ref			
Junior college/Undergraduate and above	1.13 (0.78 1.64)	0.513		
Monthly household income				
< 5000	Ref			
5000–10,000	1.09 (0.72 1.65)	0.672		
> 10,000	0.93 (0.56 1.57)	0.795		
Type of work				
Long-term stable employed	1.25 (0.88 1.79)	0.218		
Non-fixed work (unemployed)	Ref			
Alcohol consumption				
Yes	0.61 (0.36 1.04)	0.068		
No	Ref			
Smoking				
No	Ref		Ref	
Yes	0.54 (0.33 0.87)	0.012	1.07 (0.56 2.04)	0.835
Duration of illness				
< 3 years	Ref			
3–5 years	1.12 (0.73 1.73)	0.595		
> 5 years	1.15 (0.75 1.76)	0.522		
Type of therapy for thyroid diseases				
No treatment currently available	Ref		Ref	
Medical treatment/Drug conservative treatment	0.19 (0.09 0.43)	< 0.001	0.25 (0.10 0.58)	0.001
Surgical treatment/Surgical excision	0.23 (0.10 0.53)	0.001	0.33 (0.13 0.83)	0.018
Thermal ablation therapy	1.48 (0.95 2.30)	0.085	1.33 (0.79 2.24)	0.275
Radiation therapy	0.20 (0.07 0.59)	0.003	0.40 (0.12 1.31)	0.128
Other	0.71 (0.37 1.36)	0.298	1.17 (0.55 2.49)	0.676

Table 4. Multivariable analysis for attitude.

scores. Indeed, the patients with thyroid diseases were not specially informed about thyroid thermal ablation therapy during the study, but there were no limits based on their background to that information. About 30% of the patients had experience with thermal ablation therapy, and such patients probably already had knowledge about thermal ablation therapy. Many thyroid diseases do not require thermal ablation therapy for treatment, and it is possible that such patients would never seek information about thermal ablation therapy. Hence, it is possible that their first information about ablation therapy came from the questionnaire itself. Nevertheless, they did not know whether the knowledge statements were true or false, and they had to answer to the best of their knowledge. Although the participants knew that some knowledge statements were false (since they were asked to tell whether the statements were true or not), many patients without experience of thermal ablation procedures were exposed for the first time to the knowledge statements, and they could consider many of them to be true while they were not. Hence, they could come to know, falsely, that these procedures were advantageous, minimally invasive, and required limited anesthesia to be performed, with no mention of the rare though most commonly cited risks of surgery (permanent nerve damage and severe hypocalcemia). Hence, positive attitudes and willingness could be expected, as patients might be naturally inclined, based on positive presentation, to see ablation procedures as less harmful and advantageous with respect to surgery. Therefore, there is a risk of

Factors	Univariable logistic regression		Multivariable logistic regression	
	OR (95%CI)	*P*	OR (95%CI)	*P*
Knowledge	1.27 (1.17 1.38)	< 0.001	1.05 (0.95 1.16)	0.367
Attitude	1.53 (1.41 1.65)	< 0.001	1.50 (1.38 1.64)	< 0.001
Age				
30 years old and below	Ref		Ref	
31–40 years old	0.69 (0.40 1.18)	0.177	0.56 (0.29 1.10)	0.094
41–50 years old	1.23 (0.75 2.01)	0.412	0.87 (0.46 1.64)	0.676
51 years old and above	1.77 (1.06 2.94)	0.028	0.85 (0.43 1.67)	0.640
Gender				
Male	Ref		Ref	
Female	2.13 (1.45 3.12)	< 0.001	1.35 (0.82 2.23)	0.240
Place of residence				
Urban	1.06 (0.74 1.51)	0.756		
Non-Urban	Ref			
Education				
High school/Technical secondary school and below	Ref			
Junior college/Undergraduate and above	0.99 (0.70 1.41)	0.969		
Monthly household income				
< 5000	Ref			
5000–10,000	0.99 (0.67 1.47)	0.972		
> 10,000	1.115 (0.71 1.86)	0.579		
Type of work				
Long-term stable employed	0.90 (0.64 1.26)	0.528		
Non-fixed work (unemployed)	Ref			
Alcohol consumption				
Yes	0.47 (0.28 0.79)	0.004	0.58 (0.30 1.13)	0.108
No	Ref		Ref	
Smoking				
No	Ref		Ref	
Yes	0.56 (0.36 0.88)	0.012	1.26 (0.69 2.30)	0.451
Duration of illness				
< 3 years	Ref			
3–5 years	0.89 (0.59 1.33)	0.563		
> 5 years	0.97 (0.65 1.45)	0.882		
Type of therapy for thyroid diseases				
No treatment currently available	Ref		Ref	
Medical treatment/Drug conservative treatment	0.63 (0.34 1.17)	0.143	1.08 (0.53 2.20)	0.842
Surgical treatment/Surgical excision	0.62 (0.31 1.23)	0.171	1.01 (0.45 2.24)	0.985
Thermal ablation therapy	2.14 (1.36 3.35)	0.001	1.56 (0.90 2.69)	0.113
Radiation therapy	0.45 (0.19 1.09)	0.078	0.70 (0.23 2.09)	0.519
Other	1.41 (0.76 2.60)	0.274	1.82 (0.85 3.90)	0.125

Table 5. Multivariable analysis for willingness.

misrepresenting patient's feelings if a potential lack of information about procedure risk is not considered. It will have to be carefully considered and controlled for in future studies.

In conclusion, patients with thyroid diseases in the Yantai area have poor knowledge, favorable attitudes, and proactive willingness toward thermal ablation. Specific gaps in knowledge could be identified. Interventions should be designed to inform the patients of the treatment options for thyroid diseases to improve the KAW of the patients toward thermal ablation. Sustained efforts are required to increase knowledge about thyroid thermal ablation techniques.

Methods

Study design and participants

This cross-sectional survey was conducted at Shandong Wendeng Osteopathic Hospital and Yantai Affiliated Hospital of Binzhou Medical University between October 2022 and March 2023 and included patients with thyroid diseases attending outpatient clinics. The study was approved by the Shandong Wendeng Osteopathic

Hospital Ethics Committees and Yantai Affiliated Hospital of Binzhou Medical University Ethics Committees. Informed consent was obtained from the study subjects.

The inclusion criteria were (1) 18–75 years old, (2) with thyroid disease, including hyperthyroidism, Hashimoto's thyroiditis, thyroid nodules, and thyroid cancer, and (3) voluntarily participated in this study.

Procedures

The questionnaire was designed with reference to the Chinese Expert Consensus on the Thermal Ablation of Benign Thyroid Nodules, Microscopic Carcinoma, and Metastatic Lymph Nodes in the Neck (2018 version)[34]. The first draft was revised by one senior expert. Fifty patients were randomly selected for reliability testing, showing Cronbach's $\alpha = 0.8563$.

The final questionnaire contained four dimensions: demographic characteristics (age, gender, education, place of residence, type of work, monthly household income, alcohol consumption, smoking, type of medical insurance, type of thyroid disease, duration of illness, and type of therapy for thyroid diseases), knowledge dimension, attitude dimension, and willingness dimension. The knowledge dimension consisted of 10 items, with 1 point for a correct answer and 0 points for a wrong or unclear answer, ranging from 0 to 10 points. The attitude dimension consisted of five items using a 5-point Likert scale, with positive attitude questions being forward assigned, from strongly agree to strongly disagree scored 5 points to 1 point, and negative attitude questions (items A2 and A5) being reverse assigned, with scores ranging from 5 to 25 points. The willingness dimension contained eight items, also using a five-point Likert scale, ranging from always (5 points) to never (1 point), with a score range of 8–40 points. Adequate knowledge, positive attitudes, and proactive willingness were defined using a threshold of ≥ 70% for each score[35].

Questionnaire distribution and quality control

The questionnaire was imported into the Sojump online questionnaire platform (https://www.wjx.cn/app/survey.aspx), and a valid link was generated. The questionnaires were distributed to the study participants through a live code scan on WeChat. The questionnaire was set to ensure that only one person could fill in the questionnaire with a given IP address. The uniformly trained research assistants instructed the participants on the requirements and instructions for completing the questionnaire before distribution, and they were available to answer patients' questions. The questionnaires were automatically numbered and anonymous and stated the requirements for completing the questionnaire, the purpose of the information collected, and the confidentiality of the information. Questionnaires with missing items could not be submitted. The questionnaires with the same options selected for the whole questionnaire, logical errors, and less than 100 s for answering were excluded.

Statistical analysis

Stata 17.0 (Stata Corporation, College Station, TX, USA) was used for statistical analysis. Continuous variables were first tested for normality. Continuous data with a normal distribution were expressed as the mean ± standard deviation (SD), and Student's t-test was used to compare the two groups. For continuous variables with three or more groups that conformed to a normal distribution with homogeneous variance, ANOVA was used for comparisons among multiple groups; otherwise, the Kruskal–Wallis analysis of variance was used. Categorical variables are expressed as frequency (percentage). Multivariable regression was used to analyze the association between demographic information and adequate knowledge, positive attitude, and proactive willingness. Variables with $P < 0.05$ in the univariable analyses were included in the multivariable analysis. Two-sided P-values < 0.05 were considered statistically significant.

Availability of data and materials

All data generated or analysed during this study are included in this published article [and its supplementary information files].

Received: 22 March 2024; Accepted: 18 June 2025
Published online: 10 July 2025

References

1. Haugen, B. R. et al. 2015 American Thyroid Association Management guidelines for adult patients with thyroid nodules and differentiated thyroid cancer: The American Thyroid Association guidelines task force on thyroid nodules and differentiated thyroid cancer. *Thyroid* **26**, 1–133 (2016).
2. Durante, C. et al. The diagnosis and management of thyroid nodules: A review. *JAMA* **319**, 914–924 (2018).
3. Ross, D. S. et al. 2016 American Thyroid Association guidelines for diagnosis and management of hyperthyroidism and other causes of thyrotoxicosis. *Thyroid* **26**, 1343–1421 (2016).
4. Taylor, P. N. et al. Global epidemiology of hyperthyroidism and hypothyroidism. *Nat. Rev. Endocrinol.* **14**, 301–316 (2018).
5. Chaker, L., Bianco, A. C., Jonklaas, J. & Peeters, R. P. Hypothyroidism. *Lancet* **390**, 1550–1562 (2017).
6. Caturegli, P., De Remigis, A. & Rose, N. R. Hashimoto thyroiditis: Clinical and diagnostic criteria. *Autoimmun. Rev.* **13**, 391–397 (2014).
7. NCCN Clinical Practice Guidelines in oncology (NCCN Guidelines). Thyroid Carcinoma. Version 1.2023. Fort Washington: National Comprehensive Cancer Network; 2023.
8. Garmendia, M. A., Santos, P. S., Guillen-Grima, F. & Galofre, J. C. The incidence and prevalence of thyroid dysfunction in Europe: A meta-analysis. *J. Clin. Endocrinol. Metab.* **99**, 923–931 (2014).
9. Ahmed, R., Al-Shaikh, S. & Akhtar, M. Hashimoto thyroiditis: A century later. *Adv. Anat. Pathol.* **19**, 181–186 (2012).
10. Sung, H. et al. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. *CA Cancer J. Clin.* **71**, 209–249 (2021).
11. Grani, G., Sponziello, M., Pecce, V., Ramundo, V. & Durante, C. Contemporary thyroid nodule evaluation and management. *J. Clin. Endocrinol. Metab.* **105**, 2869–2883 (2020).

12. Gharib, H. et al. American Association of Clinical Endocrinologists, American College of endocrinology, and associazione medici endocrinologi medical guidelines for clinical practice for the diagnosis and management of thyroid nodules–2016 update. *Endocr. Pract.* **22**, 622–639 (2016).
13. Cho, S. J., Baek, J. H., Chung, S. R., Choi, Y. J. & Lee, J. H. Long-term results of thermal ablation of benign thyroid nodules: A systematic review and meta-analysis. *Endocrinol. Metab. (Seoul).* **35**, 339–350 (2020).
14. Papini, E., Monpeyssen, H., Frasoldati, A. & Hegedus, L. 2020 European Thyroid Association clinical practice guideline for the use of image-guided ablation in benign thyroid nodules. *Eur. Thyroid. J.* **9**, 172–185 (2020).
15. Chen, F., Tian, G., Kong, D., Zhong, L. & Jiang, T. Radiofrequency ablation for treatment of benign thyroid nodules: A PRISMA-compliant systematic review and meta-analysis of outcomes. *Medicine (Baltimore)* **95**, e4659 (2016).
16. Ding, M. et al. Pathology confirmation of the efficacy and safety of microwave ablation in papillary thyroid carcinoma. *Front Endocrinol. (Lausanne).* **13**, 929651 (2022).
17. Liu, L. H. et al. Factors related to the absorption rate of benign thyroid nodules after image-guided microwave ablation: A 3-year follow-up. *Int. J. Hyperthermia.* **39**, 8–14 (2022).
18. Lang, B. H. & Wu, A. L. H. High intensity focused ultrasound (HIFU) ablation of benign thyroid nodules—a systematic review. *J. Ther. Ultrasound.* **5**, 11 (2017).
19. Cui, T., Jin, C., Jiao, D., Teng, D. & Sui, G. Safety and efficacy of microwave ablation for benign thyroid nodules and papillary thyroid microcarcinomas: A systematic review and meta-analysis. *Eur. J. Radiol.* **118**, 58–64 (2019).
20. Andrade, C., Menon, V., Ameen, S. & Kumar, P. S. Designing and conducting knowledge, attitude, and practice surveys in psychiatry: practical guidance. *Indian J. Psychol. Med.* **42**, 478–481 (2020).
21. World Health Organization. Advocacy, communication and social mobilization for TB control: A guide to developing knowledge, attitude and practice surveys. http://whqlibdoc.who.int/publications/2008/9789241596176_eng.pdf. Accessed November 22, 20222008.
22. Kuo, J. H., McManus, C. & Lee, J. A. Analyzing the adoption of radiofrequency ablation of thyroid nodules using the diffusion of innovations theory: Understanding where we are in the United States?. *Ultrasonography.* **41**, 25–33 (2022).
23. Hegedus, L., Frasoldati, A., Negro, R. & Papini, E. European Thyroid Association survey on use of minimally invasive techniques for thyroid nodules. *Eur. Thyroid J.* **9**, 194–204 (2020).
24. Merdad, M. A contemporary look at thyroid nodule management. What every Saudi physician and surgeon should know. *Saudi Med. J.* **41**, 123–127 (2020).
25. Barajas, M. S., Fraga, T. C., Acevedo, M. A. & Cabrera, R. G. Radiofrequency ablation: A review of current knowledge, therapeutic perspectives, complications, and contraindications. *IJBSBE.* **4**, 56–58 (2018).
26. Albaqawi, R., Alreschidi, M., Almuhelb, A., Aladel, F. & Alrashidi, I. Awareness, knowledge and attitudes regarding radiofrequency ablation as treatment option for thyroid nodules in Saudi Arabia. *Med. Sci.* **24**, 2439–2444 (2020).
27. Baerlocher, M. O. et al. Awareness of interventional radiology among patients referred to the interventional radiology department: A survey of patients in a large Canadian community hospital. *J. Vasc. Interv. Radiol.* **18**, 633–637 (2007).
28. Xu, W. et al. Knowledge, attitude, and behavior in patients with atrial fibrillation undergoing radiofrequency catheter ablation. *J. Interv. Card Electrophysiol.* **28**, 199–207 (2010).
29. Lan, L. et al. Comparison of diagnostic accuracy of thyroid cancer with ultrasound-guided fine-needle aspiration and core-needle biopsy: A systematic review and meta-analysis. *Front Endocrinol. (Lausanne).* **11**, 44 (2020).
30. Kim, J. H. et al. 2017 thyroid radiofrequency ablation guideline: Korean society of thyroid radiology. *Korean J. Radiol.* **19**, 632–655 (2018).
31. Salah, M. A., Tawfeek, S. O. & Ahmed, H. O. Radiofrequency ablation therapy: Effect of educational nursing guidelines on knowledge and post ablation syndrome for patients withhepatocellular carcinoma. *Am. J. Sci.* **8**, 719–729 (2012).
32. Bergen, N. & Labonte, R. Everything is perfect, and we have no problems: Detecting and limiting social desirability bias in qualitative research. *Qual. Health Res.* **30**, 783–792 (2020).
33. Latkin, C. A., Edwards, C., Davey-Rothwell, M. A. & Tobin, K. E. The relationship between social desirability bias and self-reports of health, substance use, and social network factors among urban substance users in Baltimore, Maryland. *Addict. Behav.* **73**, 133–136 (2017).
34. Thyroid tumor ablation Technology Expert Group of Chinese Medical Doctor Association, Thyroid Cancer Professional Committee of Chinese Anti-Cancer Association, Ultrasonic Intervention Professional Committee of Interventional Physicians Branch of Chinese Medical Doctor Association. Expert consensus on the treatment of benign thyroid nodule, microcarcinoma and cervical metastatic lymph node by thermal ablation (2018 edition). *Chin J oncol.* **27**, 768–773 (2018).
35. Lee, F. & Suryohusodo, A. A. Knowledge, attitude, and practice assessment toward COVID-19 among communities in East Nusa Tenggara, Indonesia: A cross-sectional study. *Front Public Health.* **10**, 957630 (2022).

Author contributions

Ying Liu, Lihong Liu, Weiwei Zhao and Jinling Wang carried out the studies, participated in collecting data, and drafted the manuscript. Shoujun Yu and Shurong Wang performed the statistical analysis and participated in its design. Jinke Li, Lu Zhou and Liang Hao participated in acquisition, analysis, or interpretation of data and draft the manuscript. All authors read and approved the final manuscript.

Funding

This study was funded by a Study on the molecular immune mechanism of ultrasound-guided microwave implantation ablation for thyroid cancer.

Declarations

Ethics approval and consent to participate

The study was carried out after the protocol was approved by the Shandong Wendeng Osteopathic Hospital Ethics Committees and Yantai Affiliated Hospital of Binzhou Medical University Ethics Committees (F-KY-0022-200220325-01). I confirm that all methods were performed in accordance with the relevant guidelines. All procedures were performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments, and informed consent was obtained from all participants.

Competing interests

The authors declare no competing interests.

Additional information

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1038/s41598-025-08044-9.

Correspondence and requests for materials should be addressed to S.W. or S.Y.

Reprints and permissions information is available at www.nature.com/reprints.

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.