Society for Endocrinology

Endocrine Oncology (2024) **4 e**240010
https://doi.org/10.1530/EO-24-0010

Received 27 March 2024
Accepted 30 July 2024
Available online 30 July 2024
Version of Record published 4 September 2024

RESEARCH

Differential utilization of thyroid lobectomy after the 2015 American Thyroid Association guideline update

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Abstract

Background: The 2015 American Thyroid Association (ATA) guidelines added thyroid lobectomy (TL) as the appropriate treatment for low-risk differentiated thyroid cancer (DTC). We aimed to investigate the population-level factors that influence the utilization of TL.

Methods: The Surveillance, Epidemiology and End Results (SEER) database was queried for all DTC patients fitting low-risk criteria as defined by the ATA. Trends in total thyroidectomy (TT) and TL were identified using a Cochrane–Armitage test. Multivariable logistic regression identified patient and socioeconomic characteristics associated with TL, and difference-in-difference analysis was used to control for secular trends over time.

Results: A total of 43,526 patients with low-risk DTC were identified in the SEER database; 39,411 pre-2015 and 4115 post-2015. After 2015, TT continued to outnumber TL (76.2% vs 23.8%), although the rate of TL increased significantly (11.6% to 23.8%, $P < 0.001$). However, difference-in-difference analysis found that age > 55 (OR 1.11, 95% CI 1.01–1.19, $P < 0.001$) and rurality (OR 1.16, 95% CI 1.05–1.28, $P < 0.001$) were independently associated with TT. TL was associated with T1 disease (OR 1.11, 95% CI 1.04–1.19, $P = 0.001$).

Conclusion: Although the 2015 ATA guideline update led to an increase in TL for low-risk DTC, most patients still underwent TT. Age and neighborhood significantly impact the odds of receiving guideline-appropriate TL for low-risk DTC, especially for T2 disease.

Keywords: guideline adherence; thyroid cancer; thyroid lobectomy; total thyroidectomy

Introduction

In October 2015, the American Thyroid Association (ATA) updated their guidelines on the treatment of differentiated thyroid cancer (DTC) with the strong recommendation that DTC < 4 cm without extrathyroidal extension or clinical lymph node involvement may be sufficiently treated by thyroid lobectomy (TL) alone (Haugen *et al.* 2016). This was in response to more recent data showing that for properly selected patients, there was no significant difference in survival after TL versus total thyroidectomy (TT) (Haigh *et al.* 2005, Mendelsohn *et al.* 2010, Barney *et al.* 2011, Matsuzu *et al.* 2014), and adjuvant radioactive iodine therapy after TT does

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not improve overall or disease-free survival (Schvartz *et al.* 2012). For example, Barney *et al.* found that of 23,605 patients diagnosed with DTC between 1983 and 2002 undergoing TT vs TL, there was no difference in 10-year overall survival or 10-year disease-specific survival (Barney *et al.* 2011). This was also demonstrated by Nixon *et al.*, who not only found no difference in 10-year overall or disease-specific survival but also no significant difference in local or regional recurrence (Nixon *et al.* 2012).

This change in national guidelines matters because multiple studies have shown that TL is associated with lower rates of complications, specifically lower rates of temporary vocal cord paralysis, temporary hypoparathyroidism, and permanent hypoparathyroidism (Chun *et al.* 2015, Gunn *et al.* 2020, Hsiao *et al.* 2022). A review of the National Surgical Quality Improvement Program database from 2016 to 2017 found that TT was an independent risk factor for recurrent laryngeal nerve injury (Gunn *et al.* 2020). In addition, after TL, patients may not require lifelong thyroid hormone replacement or may only require lower doses with quicker adjustment to euthyroidism, which has been proven to significantly improve quality of life (Kluijfhout *et al.* 2016).

Multiple studies have since demonstrated that the utilization of TL for low-risk DTC has risen after 2015, although it is still outnumbered by TT (Ullmann *et al.* 2019, Toumi *et al.* 2021). Gordon *et al.* found that it was primarily academic institutions that were adopting TL, suggesting there was still room for growth at the community level (Gordon *et al.* 2022). Meanwhile, Collins *et al.* found that the guidelines changed practice patterns toward TL in both urban and rural settings (Collins *et al.* 2023). Given variable findings in the current literature, we sought to perform a thorough investigation of a multitude of factors to determine what influences the uptake of TL for low-risk DTC at the population level.

Materials and methods

Data source

The SEER database comprises cancer incidence data from population-based cancer registries covering approximately 48% of the U.S. population. Unlike other cancer registries, the SEER database is not affiliated with specific hospitals or accredited programs. The registries collect data on patient demographics, primary tumor site, morphology, stage at diagnosis, first course of treatment, and follow-up for mortality statistics. The data are de-identified; thus, informed consent is not obtained. Of note, SEER collects data based on the North American Association of Central Cancer Registries' Data Standards. Patient race and ethnicity data are pulled directly from the medical record. The research database contains data from 1975 to 2019 and is accessible to the public.

Study population

The SEER database was queried for all thyroid cancer patients who underwent thyroid lobectomy or thyroidectomy between 2004 and 2018. This was identified using the following ICD-0-3 histology codes: 8050, 8260, 8330, 8331, 8332, 8335, 8339, 8340, 8342, 8343, 8344 with the primary site as c73.9-Thyroid gland. Patients with medullary or undifferentiated thyroid cancer, tumor <1 cm or >4 cm, locally advanced disease, or clinical lymph node involvement were excluded. Therefore, only patients diagnosed with papillary or follicular thyroid carcinoma meeting the low-risk criteria defined in the guideline update were included.

Covariates

Patient-level characteristics at the time of surgery were collected, including demographics, household income, and residence in a metropolitan area. Tumor characteristics were also collected, including tumor histology, pathologic lymph node status, and pathologic T stage. Pathologic lymph node status was stratified by SEER into negative nodes, positive nodes, no nodes examined, and not reported. Pathologic T stage was used because patients' clinical T stage was not available in SEER for most of the study period. The study period was stratified into two groups: patients undergoing surgery between 2004 and 2015 (pre-2015) and those undergoing surgery between 2016 and 2018 (post-2015). Within the two groups, the data were also stratified by surgical approach (TL vs TT).

Statistical analysis

The analysis was conducted using SAS 9.4 (SAS Institute) and R 4.2.1 (R Foundation for Statistical Computing). Descriptive statistics were used to summarize the data. Patient demographic and tumor characteristics of the pre-2015 and post-2015 cohorts were compared by the Wilcoxon rank sum test for continuous variables or the Chi-square test for categorical variables. The Cochran–Armitage test was used to assess the temporal trend of TT and TL. Multivariable logistic regression was used to model the probability of guideline compliance while accounting for measured confounders; study group (pre- and post-2015), age, sex, race, urban or rural residence, T stage, nodal status, and the two-way interactions of group with all the other covariates were included in the model. Household income was not included in the multivariable analysis as it was found to be collinear with living in a metropolitan area. The measure of the association between a covariate and guideline compliance was quantified by the odds ratio (OR) with a 95% confidence interval (CI) for each study group. Difference-in-difference analysis, a method of comparing changes in outcomes across an intervention by subtracting one from the other to control for confounding secular trends over time, was also performed. The results were

Endocrine Oncology (2024) **4** **e**240010
https://doi.org/10.1530/EO-24-0010

then presented as a plot of the adjusted probability of guideline compliance by each covariate over time. The influence of secular change was assessed by the Wald test for the interaction term. All tests were two-sided and a *P*-value < 0.05 was considered statistically significant.

Results

Demographics

A total of 46,116 patients with low-risk, well-differentiated thyroid cancer were identified. Of these, 39,130 were treated before 2015 and 6986 after. Compared to those who were treated after, those treated before 2015 were younger (age over 55, 32.7% vs 36.9%, *P* < 0.001), more likely to be White (81.7% vs 80.7%, *P* = 0.048), non-Hispanic (14.0% vs 17.5%, *P* < 0.001), and less likely to have a median household income >$50,000 (87.8% vs 89.5%, *P* < 0.001) (Table 1). Tumor characteristics were also significantly different between these two cohorts, with more follicular carcinoma in the pre-2015 cohort (9% vs 7.1%, *P* = 0.049) and more T1 tumors in the post-2015 cohort (64.1% vs 62.1%, *P* = 0.002). In terms of lymph node status, both groups had over 99% of patients with either no nodes examined or pathologic node negative. However, post-2015 patients were more likely to be pathologic node-negative (69.8% vs 41.6%, *P* < 0.001) (Table 1).

National trends

The Cochran–Armitage test showed that there was an increasing trend for lobectomy from 2004 to 2018 (*P* < 0.001), with an overall increase from 11.6% in 2004–2015 to 18.9% in 2016–2018 (*P* < 0.001). However, every year TT still outnumbered TL.

Disparities analysis

Univariate analysis of the pre-2015 cohort showed that patients who underwent TL were significantly older (age >55, 36.0% vs 32.3%, *P* < 0.001), less often White (80% vs 81.9%, *P* = 0.001), less likely to have a household income over $50,000 (85.6% vs 88.1%, *P* < 0.001), and less likely to live in a metropolitan area (88.9% vs 90.9%, *P* < 0.001) (Table 2). In the post-2015 cohort, those who underwent TL were also less often White (77.7% vs 81.4%, *P* = 0.002), but now more likely to have a median household income over $50,000 (92.1% vs 88.9%, *P* < 0.001) and more likely to live in a metropolitan area (92.8% vs 90.7%, *P* = 0.01), with no difference by ethnicity (Table 3).

Multivariable logistic regression was used to model the probability of undergoing TL while controlling for the significant differences identified in the univariate analysis, including age, metropolitan area, T stage, and histology. In the pre-2015 cohort, those who were older (OR 1.11, 95% CI 1.04–1.19, *P* < 0.001), lived in

Table 1 Patient demographics and tumor characteristics.

		Pre-2015	Post-2015	
		n = **39,130**	*n* = **6986**	***P***
Age (mean, s.d.)		48.9, 14.5	49.7, 14.7	<0.001*
Age older than 55 years		12,796 (32.7%)	2576 (36.9%)	<0.001*
Female sex		30,921 (79.0%)	5575 (79.8%)	0.14
Race	White	31,964 (81.7%)	5637 (80.7%)	<0.001*
	Black	2813 (7.2%)	385 (5.5%)	
	Asian or Pacific Islander	3716 (9.5%)	781 (11.2%)	
	American Indian/Alaska native	236 (0.6%)	55 (0.8%)	
	Unknown	401 (1.0%)	128 (1.8%)	
Race comparison	White	31,964 (81.7%)	5637 (80.7%)	0.048*
	Non-White	7166 (18.3%)	1349 (19.3%)	
Ethnicity	Hispanic	5465 (14.0%)	1222 (17.5%)	<0.001*
Median household income	$50,000+	34,367 (87.8%)	6253 (89.5%)	<0.001*
Urban/rural residence	Metropolitan area	35,434 (90.6%)	6355 (91.1%)	0.26
Histology	Follicular	3531 (9.0%)	494 (7.1%)	<0.001*
	Papillary	35,599 (91.0%)	6492 (92.9%)	
Lymph Nodes	Node positive	0 (0.0%)	34 (0.5%)	<0.001*
	Node negative	16,260 (41.6%)	4877 (69.8%)	
	No nodes examined	22,797 (58.3%)	2056 (29.4%)	
	Positive aspiration or core biopsy of lymph node(s)	0 (0.0%)	4 (0.1%)	
	Not documented	73 (0.2%)	15 (0.2%)	
Pathological T stage	T1	24,303 (62.1%)	4478 (64.1%)	0.002*
	T2	14,827 (37.9%)	2508 (35.9%)	

*indicates statistical significance.

Table 2 Demographics by surgical approach, pre-2015.

Variable		Lobectomy *n* = **4545**	Thyroidectomy *n* = **34,585**	*P*
Age (mean, s.d.)		50.0, 15.4	48.8, 14.4	<0.001*
Age 55 years or older		1637 (36.0%)	11,159 (32.3%)	<0.001*
Female sex		3466 (76.3%)	27,455 (79.4%)	<0.001*
Race	White	3634 (80.0%)	28,330 (81.9%)	<0.001*
	Black	403 (8.9%)	2410 (7.0%)	
	Asian or Pacific Islander	417 (9.2%)	3299 (9.5%)	
	American Indian/Alaska native	25 (0.6%)	211 (0.6%)	
	Unknown	66 (1.5%)	335 (1.0%)	
Race comparison	White	3634 (80.0%)	28,330 (81.9%)	0.001*
	Non-White	911 (20.0%)	6255 (18.1%)	
Ethnicity	Hispanic	592 (13.0%)	4873 (14.1%)	0.05
Median household income	$50,000+	3890 (85.6%)	30,477 (88.1%)	<0.001*
Urban/rural residence	Metropolitan area	4034 (88.9%)	31,400 (90.9%)	<0.001*

*indicates statistical significance.

a non-metropolitan area (OR 1.16, 95% CI 1.05–1.28, $P = 0.004$), or had follicular carcinoma (OR 2.30, 95% CI 2.11–2.52, $P < 0.001$) were more likely to undergo TL. Patients undergoing TL were also more likely to have T2 disease (OR 1.11, 95% CI 1.04–1.19, $P = 0.001$) on final pathology than those who underwent TT. After 2015, patients with follicular carcinoma were still more likely to receive TL, but those who were older (OR 0.88, 95% CI 0.76–0.95, $P = 0.006$) or lived in a non-metropolitan area (OR 0.71, 95% CI 0.57–0.90, $P = 0.004$) were now less likely to undergo TL (Table 4). Patients who underwent TL post-2015 were more likely to have pathologic T1 disease (OR 0.81, 95% CI 0.71–0.92, $P = 0.002$) than those who underwent TT.

Difference-in-difference analysis showed that after accounting for secular trends, which controls for both measured and unmeasured confounders over time, there were still several significant interactions. Comparing pre-2015 to post-2015, patients over 55 were significantly less likely to receive TL after 2015 ($P < 0.001$). Living in a metropolitan area also had a significant interaction, where those who lived in non-metropolitan areas were significantly less likely to receive TL after 2015 ($P < 0.001$). Difference-in-difference analysis also showed that after 2015, patients with T1 disease were more likely to receive TL than those with T2 disease ($P < 0.001$) (Fig. 1).

Discussion

In 2015, the ATA updated their recommendations to include thyroid lobectomy as the appropriate treatment for low-risk differentiated thyroid cancer. Several studies using national databases have demonstrated that since this guideline change, the rate of thyroid lobectomy has increased. For example, Ullmann *et al.* used the National Surgery Quality Improvement Program data and found a significant increase in the rate of TL after the guideline

Table 3 Demographics by surgical approach, post-2015.

		Lobectomy *n* = **1323**	Thyroidectomy *n* = **5663**	*P*
Age (mean, s.d.)		48.4, 15.2	50.0, 14.5	<0.001*
Age 55 years or older		1637 (36.0%)	11,159 (32.3%)	0.13
Female sex		464 (35.1%)	2112 (37.3%)	<0.001*
Race	White	1028 (77.7%)	4609 (81.4%)	0.007*
	Black	79 (6.0%)	306 (5.4%)	
	Asian or Pacific Islander	168 (12.7%)	613 (10.8%)	
	American Indian/Alaska native	11 (0.8%)	44 (0.8%)	
	Unknown	37 (2.8%)	91 (1.6%)	
Race comparison	White	1028 (77.7%)	4609 (81.4%)	0.002*
	Non-White	295 (22.3%)	1054 (18.6%)	
Ethnicity	Hispanic	208 (15.7%)	1014 (17.9%)	0.06
Median household income	$50,000+	1218 (92.1%)	5035 (88.9%)	<0.001*
Urban/rural residence	Metropolitan area	1226 (92.8%)	5129 (90.7%)	0.01*

*indicates statistical significance.

Table 4 Multivariable logistic regression model of thyroid lobectomy. The variables included in the model were age, residence type, T stage, nodal status, histology, and the interaction terms of time period (pre-/post-2015). Hence, the model estimates (OR and 95% CI) reported were stratified by time periods.

		Pre-2015				Post-2015			
Variable	**Comparison**	**OR**	**95% CI**		***P***	**OR**	**95% CI**		***P***
Age	>55 vs ≤55	1.11	1.04	1.19	0.001	0.84	0.73	0.95	0.006
Urban/rural	Non-metropolitan vs metropolitan	1.16	1.05	1.28	0.004	0.71	0.57	0.90	0.004
T stage	T2 vs T1	1.11	1.04	1.19	0.001	0.81	0.71	0.92	0.002
Histology	Follicular vs papillary	2.30	2.11	2.52	<0.001	2.26	1.83	2.78	<0.001

update without a concurrent increase in completion thyroidectomy (Ullmann *et al.* 2019). Toumi *et al.* used the IBM MarketScan Database and also found that the proportion of TT compared to TL dropped significantly after the guideline change, from 80% to 39% (Toumi *et al.* 2021). Our study confirmed this finding using the population-based SEER database, with a significantly increasing trend in TL from 2004 to 2018.

We also identified discrepancies in who received TL for appropriately low-risk DTC. Multivariable analysis showed that after 2015, age over 55 and living in a non-metropolitan area were both independently associated with not undergoing TL, and difference-in-difference analysis confirmed that this remained significant even after controlling for unmeasured secular confounders. It is worth emphasizing that this discrepancy was found using a population-based cancer registry, which is not restricted to Cancer-on-Commission accredited centers. Thus, these findings pertain to the general U.S. population of patients and surgeons, which were not necessarily represented in the findings published recently by Gordon *et al.* and Ginzberg *et al.*, who both used the National Cancer Database (NCDB) (Gordon *et al.* 2022, Ginzberg *et al.* 2023). Gordon *et al.* found that guideline compliance was significantly higher at academic centers but with no difference by patient age, sex, or race, whereas Ginzberg *et al.* showed that racial and ethnic disparities in treatment improved after the guideline update (Gordon *et al.* 2022, Ginzberg *et al.* 2023). In contrast, our study found significant differences in the utilization of TL for patients over 55 and those who live in non-metropolitan neighborhoods. Given that low-volume surgeons perform the majority of thyroidectomies in the US and may not be included in the NCDB (McDow *et al.* 2021*b*), these findings may be more representative of the general population.

Our findings complement those recently published by Collins *et al.*, as they also used the SEER database to evaluate patients with low-risk papillary thyroid carcinoma. They found that before 2015, patients in metropolitan areas were less likely to undergo TL than those in non-metropolitan areas (16.9% vs 20.1%). After the guideline change, this equalized to 25.7% and 24.5%, respectively (Collins *et al.* 2023). While our analysis was conducted differently, this general trend is consistent with our results. We found that before 2015, patients who underwent TL were less likely to live in a metropolitan area, whereas after 2015, they were more likely. Our difference-in-difference analysis showed that this shift towards TL in metropolitan areas was significant. This means we did not find as big of a shift towards TL in the non-metropolitan population as they did, which could be explained by the fact that Collins *et al.* included patients with tumors <1 cm and found that patients from rural settings were significantly

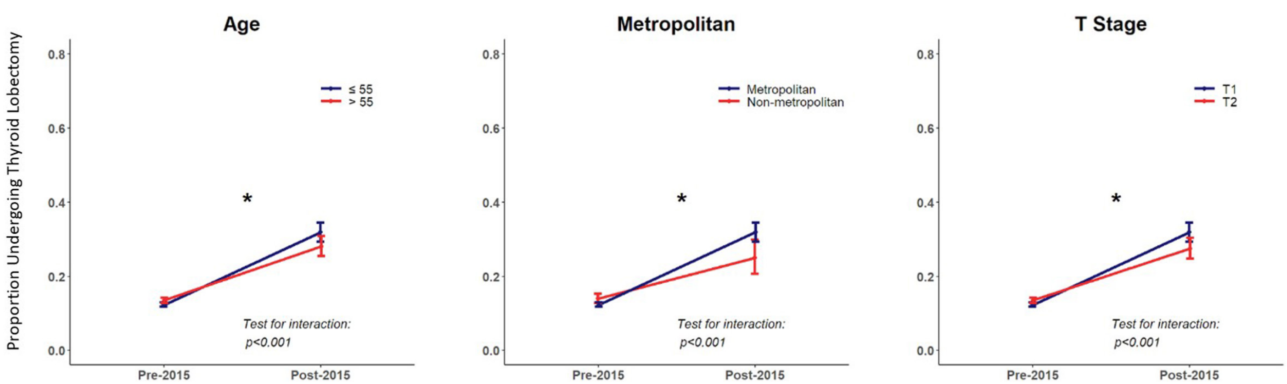

Figure 1

Difference-in-difference analysis of TL for low-risk DTC.

more likely to have subcentimeter tumors. We excluded patients with tumors <1 cm because the management of subcentimeter tumors did not change in the 2015 ATA guideline update.

We also found differences in T stage between the pre-2015 and post-2015 cohorts. Before 2015, patients who underwent TL were more likely to have T2 disease on final pathology, whereas post-2015, TL patients were more likely to have T1 disease. The significance of T1 vs T2 disease on final pathology is difficult to interpret given the absence of clinical T stage data; however, this is consistent with published data from CESQIP. Wrenn *et al.* found that from 2014 to 2019, TL for low-risk PTC was used 24% of the time in tumors <1 cm (T1a), 16% of the time in tumors 1–2 cm in size (T1b), and only 6% of the time for tumors 2–4 cm in size (T2) (Wrenn *et al.* 2021). This suggests that despite the guideline change, there is still a reluctance to pursue TL for T2 tumors.

These findings raise two pertinent questions: Why is TT still more commonly performed for low-risk DTC than TL? And why are there differences in who is offered TL? For the first question, McDow *et al.* surveyed over 300 surgeons registered with the American Medical Association in 2021 and found that low-volume surgeons were less likely than high-volume surgeons to be aware of the new ATA guidelines supporting TL for low-risk PTC and less likely to follow clinical practice guidelines at all (McDow *et al.* 2021*a*). In addition, nearly 20% of respondents believed recurrence is more likely after TL than TT, and only 12% believed that quality of life is better after TL (McDow *et al.* 2021*b*). Altogether, it is conceivable that surgeon preference and experience are superseding national guidelines, especially given that TT is still considered guideline-compliant therapy for low-risk DTC to enable radioactive iodine (RAI) therapy or to enhance follow-up based on disease features and/or patient preference (Haugen *et al.* 2016).

As for the sociodemographic differences, our study showed that older patients are less likely to receive TL for low-risk DTC. One possible reason for this is that younger patients may preferentially undergo TL to avoid lifelong thyroid hormone replacement therapy. While this concept may favor the younger patients who have a presumably longer time living without needing levothyroxine, retrospective studies have shown that up to 60-70% of patients still require thyroid hormone replacement after lobectomy for DTC (Kim *et al.* 2020, Schumm *et al.* 2021), and recent findings from the North American Thyroid Cancer Survivorship Study showed that patients with thyroid cancer report a worse quality of life than patients with breast or colorectal cancer, largely due to the impact of thyroid testing and symptoms related to hypothyroidism and hyperthyroidism (Aschebrook-Kilfoy *et al.* 2015). That said, if thyroid hormone replacement is required, TL is associated with lower doses of levothyroxine and fewer adjustments to reach euthyroidism (Kluijfhout *et al.* 2016). Thus, avoiding complete thyroid hormone replacement may be one of the greater benefits of TL in these low-risk DTC patients.

We also found that those living in non-metropolitan areas were less likely to undergo TL when guideline-appropriate. Living in a metropolitan area is likely correlated with receiving care at academic centers, which, as discussed before, are more guideline-compliant (Gordon *et al.* 2022). Even so, this finding carries its own significant implications. TT is associated with higher rates of temporary vocal cord paralysis and both temporary and permanent hypoparathyroidism compared to TL (Chun *et al.* 2015, Gunn *et al.* 2020, Hsiao *et al.* 2022). Expedient treatment of these complications may be more difficult to attain in rural locations and certainly may be more detrimental to the older population with less physical reserve. There are likely a multitude of factors contributing to this disparity that are not captured in the SEER database; these warrant further investigation and review.

There are several limitations to this study. Importantly, the SEER database only captures 48% of the US population, as cancer registries have not yet been established in every state. Additionally, it lacks data on patient insurance, hospital affiliation, and accreditation status, as well as follow-up data on whether patients underwent completion thyroidectomy or RAI therapy after their index operation. Clinical T stage for thyroid cancer was also only collected for select years, and so it could not be included in our analysis. Lastly, SEER provides data on residence in metropolitan vs non-metropolitan areas, but this may not always correlate with where the patient received care. In addition, only data up to 2018 were utilized as that was what was available at the time of study design. A more contemporary evaluation of the data may be more representative of current practice patterns. Lastly, as with any national database, there are also potential issues with data completeness, accuracy, and selection bias. However, this database captures all cancers in registered states and, as such, is primed for evaluating national trends in treatment.

Conclusions

In conclusion, rates of thyroid lobectomy increased significantly after the updated 2015 ATA guidelines, but more so for pathological T1 tumors and younger patients living in metropolitan areas. Older patients and those living in non-metropolitan areas were significantly less likely to undergo TL for low-risk DTC. There are a multitude of potential explanations for this; however, it is important to recognize that these guidelines were established to minimize risks associated with total thyroidectomy while ensuring appropriate oncologic outcomes and that not all patients are benefiting from this. This is an important area for growth in the field of surgery. There is a role for academic societies to take the lead in the dissemination of up-to-date research and guidelines. The integration of the ATA guidelines into the electronic medical record may also encourage compliance and consistency. Further work into how best to encourage guideline adherence is needed for surgeons and patients alike.

Declaration of interest

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the study reported.

Funding

This work did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author contribution statement

PGL helped conceive the study, interpreted data, and wrote the manuscript. ZVF helped with data analysis and interpretation and manuscript review. PTH, NW, and PAC assisted with manuscript review. YHC and ESL performed data collection and statistical analysis. CCS conceived the study, assisted with interpretation of the results, and edited the manuscript.

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