2018

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Received: 16 August 2017 | Revised: 29 September 2017 | Accepted: 2 October 2017

DOI: 10.1111/jep.12846

WILEY Journal of Evaluation in Clinical Practice
International Journal of Public Health Policy and Health Services Research

ORIGINAL ARTICLE

Analysis of current thyroid function test ordering practices

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Funding information
Defense Health Agency

Abstract

Rationale: Current guidelines recommend thyroid stimulating hormone (TSH) alone as the best test to detect and monitor thyroid dysfunction, yet free thyroxine (FT4) and free triiodothyronine (FT3) are commonly ordered when not clinically indicated. Excessive testing can lead to added economic burden in an era of rising healthcare costs, while rarely contributing to the evaluation or management of thyroid disease.

Objective: To evaluate our institution's practice in ordering thyroid function tests (TFTs) and to identify strategies to reduce inappropriate FT4 and FT3 testing.

Methods: A record of all TFTs obtained in the San Antonio Military Health System during a 3-month period was extracted from the electronic medical record. The TFTs of interest were TSH, FT4, thyroid panel (TSH + FT4), FT3, total thyroxine (T4), and total triiodothyronine (T3). These were categorized based on the presence or absence of hypothyroidism.

Results: Between August 1 and October 31, 2016, there were 38 214 individual TFTs ordered via 28 597 total laboratory requests; 11 486 of these requests were in patients with a history of hypothyroidism. The number (percent) of laboratory requests fell into these patterns: TSH alone 14 919 (52.14%), TSH + FT4 7641 (26.72%), FT3 alone 3039 (10.63%), FT4 alone 1219 (4.26%), TSH + FT4 + FT3 783 (2.74%), and others 996 (3.48%); 36.0% of TFTs ordered were free thyroid hormones. Projected out to a year, using Department of Defense laboratory costs, $317 429 worth of TFTs would be ordered, with free thyroid hormone testing accounting for $107 720.

Conclusion: Inappropriate ordering of free thyroid hormone tests is common. In an era of rising healthcare costs, inappropriate thyroid function testing is an ideal target for efforts to reduce laboratory overutilization, which in our system, could save up to $120 000 per year. Further evaluation is needed to determine strategies that can reduce excessive thyroid hormone testing.

Disclaimer: The views expressed in this article are those of the authors and do not reflect the official policy or position of the US Air Force, Department of Defense, or the US Government.

KEYWORDS
laboratory utilization, resource stewardship, thyroid function test

1 | INTRODUCTION

Rising healthcare costs in the United States are having significant economic impact. Healthcare expenditure was $3 trillion in 2014 (17.5% of the gross domestic product [GDP]) and estimated to increase to $4.4 trillion by 2018 (20.3% of the GDP).[1,2] Wasted healthcare expenditure accounts for approximately 30% of healthcare costs in the United States, roughly $750 billion.[3] Spending on laboratory testing is rising and accounts for over $8 billion dollars in Medicare spending alone.[4] Laboratory tests are an important tool in the healthcare practitioner's tool box; however, overutilization is a concern with estimates of 10% to 50% of laboratory tests being unnecessarily ordered.[5,6] The Institute of Medicine estimates that $210 billion of healthcare spending is spent on unnecessary services.[3] This trend is likely driven by numerous factors including defensive medicine, costing $45.6 billion annually.[7] Redundant laboratory testing alone accounts for $5 billion in waste.[8] Furthermore, downstream effects of unnecessary testing can lead to excessive costs, to include patient distress, unnecessary referrals, and overtreatment.[9-13]

Thyroid function tests (TFTs) are among the most commonly ordered laboratory tests. In 2008, an estimated 59 million serum thyrotropin (TSH) and 18 million free thyroxine (FT4) measurements were performed in the United States.[14] TSH is the eighth most common laboratory test ordered under Medicare, costing $469 million per year.[15] Despite the large number of TFTs ordered, the prevalence of thyroid dysfunction is only 3.82% with an incidence of 259.12 cases per 100 000 per year.[16] Previous studies suggest that TFTs are commonly ordered for non-specific symptoms, which has negligible value in the diagnostic process, thus contributing to higher costs.[17,18] TSH is a sensitive assay that allows for accurate evaluation of thyroid function and is often the only test required for screening thyroid dysfunction and managing hypothyroidism.[19-21] Despite this, studies have shown that ordering free thyroid hormones is common but often inappropriate.[22-25] Reduction of excess TFTs could offer a distinctive opportunity to assist in stemming the tide of rising healthcare costs.

While there have been numerous efforts to reduce excessive TFT ordering over the past 3 decades, our knowledge of current patterns of thyroid function testing within the United States remains limited.[26] This project evaluated the current ordering practices of TFTs at a regional military healthcare system to determine if changes are needed to reduce excessive thyroid laboratory testing.

2 | METHODS

The San Antonio Military Health System (SAMHS) provides primary and subspecialty care on a budget of $1.2 billion. It has 12 000 staff that serve more than 240 000 Department of Defense (DoD) beneficiaries, including active duty service members, retired military, and dependents.[27] Healthcare is provided in 9 outpatient community-based locations, an ambulatory surgical centre, and a 425-bed inpatient facility. Providers primarily order laboratory tests via the DoD's electronic medical record (EMR) system.

The DoD maintains the Comprehensive Ambulatory Provider Encounter Record (CAPER), which logs every outpatient appointment at each Military Treatment Facility. The CAPER file has tracked all diagnoses for patients that have had an outpatient encounter at a Military Treatment Facility since 2003. The Defense Health Agency Health Information Technology division provided data for this project. Using the diagnoses stored in the CAPER system, each TFT ordered in the setting of either a history of hypothyroidism of any type (including subclinical hypothyroidism), or no history of hypothyroidism was classified.

The TFTs of interest were TSH, FT4, thyroid panel (TSH + FT4), free triiodothyronine (FT3), total thyroxine (T4), and total triiodothyronine (T3). The laboratory reflexively orders FT4 when a TSH results is outside the reference range (0.27-5.00 mcIU/mL). When a thyroid panel is ordered, the laboratory runs both a TSH and an FT4 regardless of TSH level. We analysed all TFT orders for outpatients in the SAMHS over 3 months using Excel.

3 | RESULTS

Between August 1 and October 31, 2016, there were 38 214 individual thyroid function laboratory tests ordered via 28 597 total laboratory requests for 25 142 patients; providers can order multiple TFTs with each laboratory test request. In total, 11 486 (40.2%) of all thyroid function laboratory requests were made in patients with a history of hypothyroidism. The age range of the population evaluated was 18 to 98, and 66.4% of the subjects were female. The number of laboratory requests fell into these patterns: TSH alone 14 919 (52.14%), TSH + FT4 7641 (26.72%), FT3 alone 3039 (10.63%), FT4 alone 1219 (4.26%), TSH + FT4 + FT3 783 (2.74%), and other patterns 996

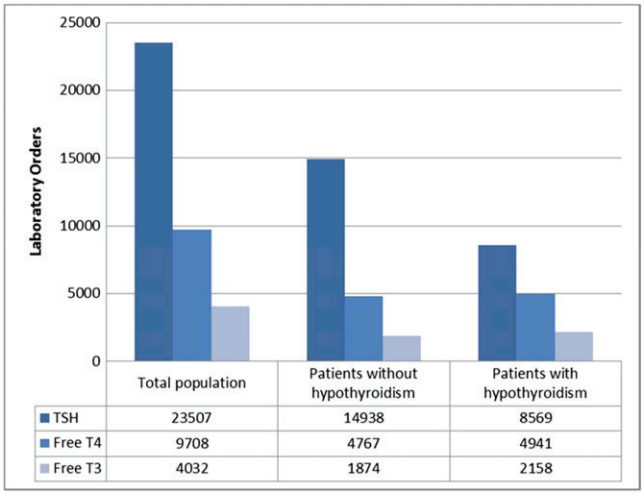

FIGURE 1 Sum of thyroid function laboratory tests ordered over 3 months in patients with and without hypothyroidism. Orders of interest were thyroid stimulating hormone (TSH), free thyroxine (FT4), and free triiodothyronine (FT3)

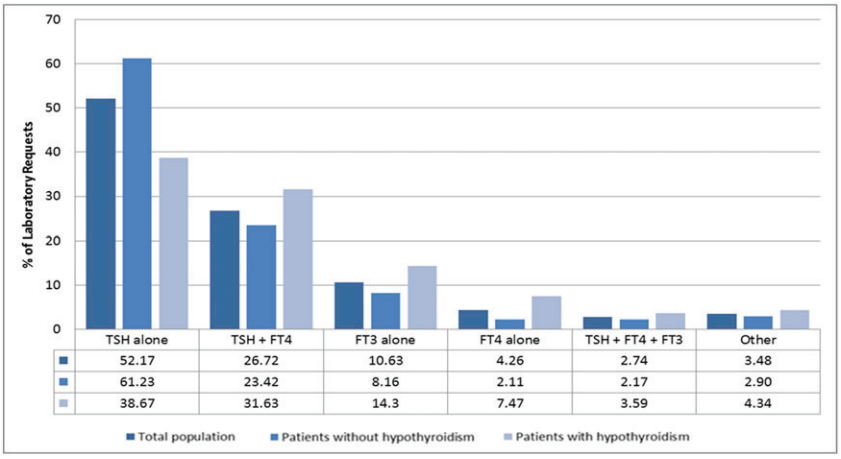

FIGURE 2 Percent of total laboratory requests by ordering pattern in patients with and without hypothyroidism. When evaluating thyroid function, providers may order one or multiple laboratory tests in their laboratory request. Ordering patterns included combinations of thyroid stimulating hormone (TSH), free thyroxine (FT4), and/or free triiodothyronine (FT3). Patterns including total triiodothyronine and/or total thyroxine are counted in "other"

(3.48%). Of all ordered TFTs, 36.0% were free thyroid hormones; 25.4% were FT4 and 10.6% were FT3. Of all FT4 ordered, 86.8% included a TSH and 34.2% were part of a thyroid panel (TSH + FT4). Most (75.4%) FT3 orders did not include a TSH (Figures 1 and 2).

Comparing patients with a history of hypothyroidism versus those without: 61.3% vs 38.8% of all TFT requests included a laboratory test other than TSH alone; 43.9% vs 30.1% of all TFTs ordered were free thyroid hormones. Of all FT4 laboratory tests ordered, 26.4% vs 42.3% were ordered as part of a thyroid panel (TSH + FT4). FT3 alone accounted for 14.3% vs 8.2% of TFTs ordered (Figure 2).

Projected out to a year, using Department of Defense laboratory costs, $317 429 worth of TFTs would be ordered, with free thyroid hormone testing accounting for $107 720. FT4 spending projects to $65 626 annually, $22 313 (34%) of this is estimated to be ordered via a thyroid panel (Table 1). In review of TFT ordering in patients with a history of hypothyroidism, it is estimated that $65 804 worth of TFTs other than TSH are ordered yearly. In those without hypothyroidism, this spending projects to $61 688 annually (Table 2). Overall, 47.8% of all TFT requests included a laboratory test other than TSH alone leading to $196 884 in costs (Table 3).

4 | DISCUSSION

Our analysis demonstrated that free thyroid hormone laboratory tests are ordered excessively and at significant cost in patients with or without a history of hypothyroidism. These results indicate that providers at our institute are often relying on free thyroid hormones as an adjunct to TSH for screening or management of thyroid disorders. These findings are largely consistent with known literature from other

TABLE 1 Projected annual cost of thyroid laboratory test orders for the total population

Laboratory test	Projected yearly test total[a]	Local testing cost ($)[b]	Projected yearly cost ($)
TSH	94 028	2.02	189 937
Free T4	38 832	1.69	65 626
Free T3	16 128	2.61	42 094
Total T3	3280	5.72	18 762
Total T4	588	1.72	1011
Total tests	152 856		317 430

Note: Orders of interest were thyroid stimulating hormone (TSH), free thyroxine (FT4), free triiodothyronine (FT3), total triiodothyronine (T3), and total thyroxine (T4).

[a]Based on extrapolation of totals collected over 3-month period of analysis.

[b]Pricing per local DoD laboratory. Does not include labour costs.

TABLE 2 Projected annual cost of thyroid laboratory test orders in patients with and without hypothyroidism

Laboratory test	Patients without hypothyroidism ($)[a,b]	Patients with hypothyroidism ($)[a,b]
TSH	120 699	69 238
Free T4	32 225	33 401
Free T3	19 565	22 530
Total T3	9472	9289
Total T4	427	585
Total cost	182 387	135 042

Note: Orders of interest were thyroid stimulating hormone (TSH), free thyroxine (FT4), free triiodothyronine (FT3), total triiodothyronine (T3), and total thyroxine (T4)

[a]Based on extrapolation of totals collected over 3-month period of analysis.

[b]Pricing per local DoD laboratory per Table 1. Does not include labour costs.

TABLE 3 Projected annual cost of thyroid function test ordering patterns for the total population

Laboratory ordering pattern	Projected yearly test requests[a] n (%)	Local testing cost ($)[b]	Projected yearly cost ($)
TSH alone	59 676 (52.17)	2.02	120 546
TSH + FT4	30 564 (26.72)	3.71	113 392
FT3 alone	12 156 (10.63)	2.61	31 727
FT4 alone	4876 (4.26)	1.69	8240
TSH + FT4 + FT3	3132 (2.74)	6.32	19 794
Other[c]	3984 (3.48)	5.96	23 730
Total requests	114 388		317 430

Note: When evaluating thyroid function, providers may order one or multiple laboratory tests in their laboratory request. Ordering patterns included combinations of thyroid stimulating hormone (TSH), free thyroxine (FT4), and/or free triiodothyronine (FT3). Patterns including total triiodothyronine and/or total thyroxine are counted in "other."

[a]Based on extrapolation of totals collected over 3-month period of analysis.

[b]Pricing per local DoD laboratory. Does not include labour costs.

[c]Includes requests made in pattern not otherwise explicitly listed in table.

countries, which show similar rates of free or total thyroid hormone testing.[22-25]

The TSH is very sensitive to even mild changes in serum FT4 and is known to develop abnormal levels before FT4 abnormalities are detectable.[28] The American Thyroid Association (ATA) has recommended that TSH alone is the optimal test for screening for thyroid dysfunction.[29] Despite this, our analysis showed that 47.8% of all TFT requests included a laboratory test other than TSH alone (Figure 2). The ATA also recommends TSH as the test of choice when monitoring or adjusting therapy of hypothyroidism.[20] Despite guideline recommendations, our project finds that 61.3% of TFT laboratory requests made in patients with a history of hypothyroidism included TFTs other than TSH alone. Remarkably, 21.8% of TFT requests in these patients did not even include a TSH (Figure 2).

There are some conditions in which TSH alone may be inadequate for diagnosis or management of thyroid dysfunction. Examples include hypothalamic or pituitary disease, presence of heterophile antibodies, resistance to thyroid hormone, pregnancy, and TSH secreting adenoma. However, true hypothyroidism in the setting of a normal TSH is rare, with an estimated prevalence of 1 per 1500 patients.[19] Because of low incidence and prevalence of hyperthyroidism in the general population, our project did not separate out these patients for analysis. Many patients with hyperthyroid disorders have received definitive treatment with I-131 ablation or thyroidectomy that most often results in development of hypothyroidism. In patients treated with either I-131 or anti-thyroid drugs, TSH may remain suppressed in the initial post-treatment months. FT4 and total T3 may be used in this setting to monitor for development of hypothyroidism and for initial titration of levothyroxine therapy.[21]

Our analysis demonstrated a surprising number of FT3 orders with 75.4% of them ordered with no other TFTs. Because assays for estimating FT3 are less widely validated than those of FT4, the ATA prefers total T3 over FT3.[21] Current guidelines do not recommend the routine use of either FT3 or total T3 for screening for thyroid dysfunction. In our analysis, 15.9% of TFTs drawn in a patient with a history of hypothyroidism were either FT3 or Total T3. The Endocrine Society and the American Association of Clinical Endocrinologists formed a joint task force for submission of 5 recommendations to the Choosing Wisely campaign; included was the recommendation that neither total or FT3 be used in assessing levothyroxine dosing in hypothyroid patients.[30] In regard to total thyroid hormones, they may have a role to play in investigating the aetiology of thyrotoxicosis as the ratio of total T3 to total T4 may differ between thyroiditis and Graves' hyperthyroidism.[31]

The DoD has significantly reduced costs of laboratory testing compared to the civilian sector. While each TSH laboratory test costs the DoD $2.02, the Medicare laboratory fee schedule cost is $23.00, and patients without insurance may pay up to $60.00.[32] Our analysis found that, despite the inherent cost savings in the military health system, a significant dollar amount is spent on TFTs in our system. Much of this cost is spent on unnecessary testing. Despite TSH being the only test needed for monitoring therapy in patients with a history of hypothyroidism, our analysis projected that $65 804 worth of TFTs other than TSH are ordered annually for these patients. In those without hypothyroidism, this spending projected to $61 688 annually. Given that a recent study determined that the diagnostic yield of TSH screening is only 2.1% in the general population, we can posit that the vast majority of these costs are unnecessary.[17] A cost savings programme focusing on eliminating all unnecessary FT4, FT3, and total thyroid hormone testing orders could save the SAMHS upwards of $120 000 yearly. Unnecessary laboratory testing also has consequences beyond financial implications via increased laboratory workload, further unnecessary tests, patient distress, and increased referrals to subspecialists. Furthermore, increasing use of TFTs has been shown to lead to inappropriate or excessive treatment of marginal degrees of hypothyroidism.[33]

Numerous studies over the past 3 decades have evaluated the effectiveness of interventions aimed at reducing orders of unnecessary TFTs. Interventions have included distribution of guidelines and testing protocols, audit and feedback, decision-making tools, changes to funding policy, and educational programmes. While several of these interventions are thought to be effective in reducing the volume of unnecessary TFTs, it remains unclear which specific methods are superior.[26] At our institute, the laboratory reflexively performs an FT4 analysis with any TSH that results outside the reference range. Reflex testing has long been used as a means to optimize the use of laboratory tests; automatic addition of FT4 reflexively for abnormal TSH laboratory results has been shown to be accurate and effective at reducing unnecessary testing.[23,34-36] Interestingly, our review found that there was widespread use of the thyroid panel order (TSH + FT4), which would negate the benefit of reflex testing. A possible explanation for this discrepancy is that the presence of reflex testing may not be widely known in our system. Furthermore, it is not clearly stated that there is reflex testing when ordering thyroid labs in the EMR. Restriction of the availability of the thyroid panel order may offer a new method for reduction of unnecessary testing. Adding educational messages to the EMR ordering screen, which address the availability and benefits of TFT reflex testing, may offer an additional means to reduce unnecessary orders. Another possible explanation for the extensive use of the thyroid panel is that patients themselves will often demand their providers to order TFTs other than TSH alone. This may be driven by an impression that multiple tests are required to diagnose or manage thyroid disease. As such, a programme encouraging providers to educate patients on the benefits of a TSH-centred approach may also help to reduce extraneous orders.

The SAMHS presents a unique location to assess current TFT ordering practices because of the large patient population, diverse collection of primary care and medical subspecialty clinics, and the standard use of the AHLTA EMR system. The retrospective design of this review allowed us to review ordering practices, which ultimately serve as a snapshot of real world ordering patterns. The diversity of providers and the large sample size allow for a more robust evaluation of TFT ordering practices that has not previously been done in similar studies.

The unique military nature of our facility does yield some limitations. These results may not be generalizable to a civilian medical system. Military system providers and patients are largely unaware of laboratory costs. In addition, the cost per test within the SAMHS is considerable lower than comparable civilian laboratories. Thus, the cost savings may be substantially more in a civilian medical facility even if the ordering patterns are not comparable. Our analysis is that of ordering practices and does not report on laboratory tests that were

actually completed by the patient. As such, this analysis is unable to fully demonstrate the real world economic impact of TFT ordering practices in our facility.

In conclusion, free thyroid hormone tests are excessively, and most often inappropriately, ordered. In an era of rising healthcare costs, inappropriate thyroid function testing is an ideal target for efforts to reduce laboratory overutilization and reduce costs. Further evaluation is needed to determine the optimal strategies that can reduce unnecessary thyroid hormone testing.

ACKNOWLEDGEMENTS

We would like to acknowledge the outstanding support provided by the Defense Health Agency in providing data for this project. In particular, Laura Nuhn, MPH, was instrumental in collecting our deidentified data. Furthermore, the support of the laboratory staff at San Antonio Military Healthcare Center is also greatly appreciated. Lastly, we would like to acknowledge Dr Tom Sauerwein, Director of the Diabetes Center of Excellence (DCoE) at Wilford Hall Ambulatory Surgical Center. His leadership has fostered an environment of intellectual curiosity that was an inspiration for this project.

CONFLICT OF INTEREST

The authors declare no conflict of interest. No funding was received for the conduct of this project.

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How to cite this article: Kluesner JK, Beckman DJ, Tate JM, et al. Analysis of current thyroid function test ordering practices. *J Eval Clin Pract*. 2018;24:347–352. https://doi.org/10.1111/jep.12846