

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to the Department of Defense, Executive Service Directorate (0704-0188). Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ORGANIZATION.					
1. REPORT DATE (DD-MM-YYYY) 10-18-2017		2. REPORT TYPE Poster		3. DATES COVERED (From - To) 10-22-2017	
4. TITLE AND SUBTITLE Analysis of current thyroid function testing practices				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Maj Joseph Kluesner				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) 59th Clinical Research Division 1100 Willford Hall Loop, Bldg 4430 JBSA-Lackland, TX 78236-9908 210-292-7141				8. PERFORMING ORGANIZATION REPORT NUMBER 17307	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) 59th Clinical Research Division 1100 Willford Hall Loop, Bldg 4430 JBSA-Lackland, TX 78236-9908 210-292-7141				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release. Distribution is unlimited.					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Clarice Longoria
					19b. TELEPHONE NUMBER (Include area code) 210-292-7141

Analysis of Current Thyroid Function Test Ordering Practices

Joseph K. Kluesner, MD^{1,4}; Darrick J. Beckman, MD^{2,4}; Joshua M. Tate, MD^{1,4}; Alexis A. Beauvais, MD^{1,4};
Maria I. Kravchenko, MD^{1,4}; Jana L. Wardian, PhD^{3,6}; Sky D. Graybill, MD^{2,4}; Jeffrey A. Colburn, MD^{2,4};
Irene Folaron, MD^{2,5}; Mark W. True, MD^{2,5}

¹Endocrinology Fellow
Endocrinology Service
San Antonio Military Medical Center
3551 Roger Brooke Dr.
Joint Base San Antonio - Fort Sam Houston, TX 78234

²Staff Endocrinologist
Endocrinology Service
San Antonio Military Medical Center
3551 Roger Brooke Dr.
Joint Base San Antonio - Fort Sam Houston, TX 78234

³Research Director
Diabetes Center of Excellence
Wilford Hall Ambulatory Surgical Center
1100 Wilford Hall Loop, Bldg 4554
Joint Base San Antonio - Lackland, TX 78236

⁴Assistant Professor of Medicine
Uniformed Services University
4301 Jones Bridge Rd
Bethesda, MD 20814

⁵Associate Professor of Medicine
Uniformed Services University
4301 Jones Bridge Rd
Bethesda, MD 20814

⁶Assistant Professor of Research
Uniformed Services University
4301 Jones Bridge Rd
Bethesda, MD 20814

Suggested Title: Analysis of Current Thyroid Function Test Ordering Practices

Keywords: quality improvement, thyroid function test, resource stewardship, military, laboratory utilization, thyroid

Corresponding author:
Joseph K. Kluesner
Endocrinology Service, San Antonio Military Medical Center

3551 Roger Brooke Dr., Joint Base San Antonio – Ft. Sam Houston, TX 78234

Phone: 210-916-8589

Fax: 210-916-3877

E-mail: joseph.k.kluesner.mil@mail.mil

Conflict of Interest Statements/Financial Disclosures:

The authors have nothing to disclose. No funding was received for the conduct of this project.

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 U.S. Government.

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: (1) To evaluate our institution's practice in ordering thyroid function tests (TFTs) and (2) to identify strategies to help reduce inappropriate FT4 and FT3 testing.

Methods: A record of all TFTs obtained in the San Antonio Military Health System (SAMHS) during a three month period in 2016 was extracted from the electronic medical record (EMR). TFTs of interest were: TSH, FT4, thyroid panel (TSH + FT4), FT3, total thyroxine (T4), and total triiodothyronine (T3). These were also categorized based on the presence or absence of hypothyroidism.

Results: Between 1 August and 31 October 2016 there were 38,214 individual thyroid labs ordered via 28,597 total lab requests. 11,486 of these requests were in patients with a history of hypothyroidism. The number (percent) of lab requests fell into these patterns: TSH alone 14,919 (52.14%), TSH + FT4 7,641 (26.72%), FT3 alone 3,039 (10.63%), FT4 alone 1,219 (4.26%), TSH + FT4 + FT3 783 (2.74%), and others 996 (3.48%). 35.96% of all thyroid function tests 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. Further research is needed to determine strategies that can reduce excessive thyroid hormone testing.

Introduction

Rising health care costs in the United States are having significant economic impact. Health care 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]. It has been estimated that wasted health care expenditure accounts for 30% of health care costs in the United States, roughly \$750 billion [3]. While laboratory testing is a small percentage (~4.0%) of total health costs, 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 health care practitioner's tool box; however overutilization is a concern with estimates of 10-50% of laboratory tests being unnecessarily ordered [5,6]. The Institute of Medicine

estimates that \$210 billion of health care 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, referrals, and overtreatment [9-13].

Thyroid function tests (TFTs) are among the most common laboratory tests ordered by providers. 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 8th most common laboratory test ordered under Medicare, costing \$469 million per year in payments [15]. Despite the large number of thyroid function tests 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 of thyroid dysfunction and management of hypothyroidism [19-21]. Despite this, studies have shown that ordering of free thyroid hormones is common and inappropriate in these scenarios [22-25]. Reduction of excess TFTs could offer a distinctive opportunity to assist in stemming the tide of rising health care costs.

While there have been numerous efforts to reduce excessive ordering of TFTs over the past three 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 health care system to determine if changes are needed to reduce excessive thyroid laboratory testing.

Methods

Primary care and subspecialty services are provided at the San Antonio Military Health System (SAMHS) which operates on a budget of \$1.2 billion and 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 nine outpatient community-based locations, an ambulatory surgical center, as well as a 425-bed inpatient facility, the only Level I trauma center in the DoD. Providers primarily order laboratory tests, including TFTs, by entering them into the Composite Health Care System (CHCS) via the Armed Forces Health Longitudinal Technology Application (AHLTA), the DoD's electronic medical record (EMR) system.

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

TFTs of interest were: TSH, FT4, thyroid panel (TSH + FT4), free triiodothyronine (FT3), total thyroxine (T4), and total triiodothyronine (T3). In the SAMHS, if a TSH results outside of the laboratory reference range (0.27-5.00 mIU/mL), a FT4 will be reflexively ordered by the laboratory. When a thyroid panel is ordered, both a TSH and a FT4 are run by the laboratory, regardless of TSH level. Using the de-identified data provided by DHA, totals for all TFTs ordered in the outpatient setting at the SAMHS over 3 months, between 1 August and 31 October 2016, were calculated using an Excel spreadsheet.

Results

Between 1 August and 31 October 2016 there were 38,214 individual thyroid function laboratory tests ordered via 28,597 total laboratory requests for 25,142 patients (providers can order one or more TFTs with each laboratory test request) (Figure 1). 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 18-98 and 66.37% of the subjects were female. The number of laboratory requests fell into these patterns: TSH alone 14,919 (52.14%), TSH + FT4 7,641 (26.72%), FT3 alone 3,039 (10.63%), FT4 alone 1,219 (4.26%), TSH + FT4 + FT3 783 (2.74%), and others 996 (3.48%) (Table 2, Figure 2). 35.96% of all TFTs ordered were free thyroid hormones; FT4 and FT3 accounted for 25.4% and 10.6% respectively. Of all FT4 ordered, 86.8% included a TSH and 34.2% were ordered as part of a thyroid panel (TSH + FT4). FT3 accounted for 10.6% of TFTs ordered; 75.4% of FT3 orders did not include a TSH.

Comparing patients with a history of hypothyroidism versus those without, 61.33% vs. 38.77% of all TFT requests included a laboratory test other than TSH alone. 43.93% vs. 30.11% of all TFTs ordered were free thyroid hormones. Of all FT4 laboratory tests ordered, 26.41% vs. 42.27% were ordered as part of a thyroid panel (TSH + FT4). FT3 alone accounted for 14.3% vs. 8.16% 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 of this is estimated to be ordered via a thyroid panel (34%). Overall, 47.83% of all TFT requests included a laboratory test other than TSH alone leading to \$196,884.16 in costs. 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 1, Table 2).

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

There are very few situations in which free thyroid hormone testing yields added diagnostic or management information beyond the assessment of TSH alone. Despite this, 47.83% of all TFT requests included a laboratory test other than TSH alone. 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]. 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 61.33% 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.

There are some conditions in which TSH alone may be inadequate for diagnosis or management of thyroid dysfunction. Hypothalamic or pituitary disease, presence of heterophile antibodies, resistance to thyroid hormone, pregnancy, and TSH secreting adenoma are some examples. Overall, true hypothyroidism in the setting of a normal TSH is rare, with an estimated prevalence of 1 per 1500 patients [19]. Due to 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 robust than those of FT4, the ATA recommends that total T3 is preferred 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 (AACE) formed a joint task force for submission of five 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 etiology 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 not covered by 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 program 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 three decades have been performed to evaluate 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 programs. While several of these interventions are thought to be effective in reducing the volume of unnecessary TFTs, it remains unclear which specific types are superior[26]. At our institute, FT4 is reflexively tested with any ordered TSH that results outside the laboratory 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. 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 which address the availability and benefits of TFT reflex testing may offer an additional means to reduce unnecessary orders.

SAMHS presents a unique location to assess current TFT ordering practices due to 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, as well as patients, are largely

unaware of the cost for these tests. 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.

Conclusion

Free thyroid hormone tests are excessively 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 research is needed to determine the optimal strategies that can reduce unnecessary thyroid hormone testing.

Acknowledgements

DHA

Laboratory staff

Dr. Sauerwein

References

1. Sisko A, Truffer C, Smith S, et al. Health Spending Projections Through 2018: Recession Effects Add Uncertainty To The Outlook. *Health Affairs*. 2009;28(2):W346-W357.
2. Statistics NCfH. *Health, United States, 2015: with special feature on racial and ethnic health disparities*. Hyattsville, MD2016.
3. JM McGinnis LS, R Saunders, M Smith, Editors; Committee on the Learning Health Care System in America; Institute of Medicine. *Best Care at Lower Cost: The Path to Continuously Learning Health Care in America*. Washington, D.C.: The National Academies Press; 2013.
4. Commission MPA. *June 2016, A Data Book: Health Care Spending and the Medicare Program*. Washington DC: Medicare Payment Advisory Commission; 2016.
5. Lewandrowski K. Managing utilization of new diagnostic tests. *Clinical leadership & management review: the journal of CLMA*. 2002;17(6):318-324.
6. Zhi M, Ding EL, Theisen-Toupal J, Whelan J, Arnaout R. The landscape of inappropriate laboratory testing: a 15-year meta-analysis. *PLoS One*. 2013;8(11):e78962.
7. Mello MM, Chandra A, Gawande AA, Studdert DM. National costs of the medical liability system. *Health Aff (Millwood)*. 2010;29(9):1569-1577.
8. Jha AK, Chan DC, Ridgway AB, Franz C, Bates DW. Improving safety and eliminating redundant tests: cutting costs in US hospitals. *Health affairs*. 2009;28(5):1475-1484.
9. May TA, Clancy M, Critchfield J, et al. Reducing unnecessary inpatient laboratory testing in a teaching hospital. *Am J Clin Pathol*. 2006;126(2):200-206.
10. Stuebing EA, Miner TJ. Surgical vampires and rising health care expenditure: reducing the cost of daily phlebotomy. *Arch Surg*. 2011;146(5):524-527.
11. Owens DK, Qaseem A, Chou R, Shekelle P, Clinical Guidelines Committee of the American College of P. High-value, cost-conscious health care: concepts for clinicians to evaluate the benefits, harms, and costs of medical interventions. *Ann Intern Med*. 2011;154(3):174-180.
12. Krasowski MD, Chudzik D, Dolezal A, et al. Promoting improved utilization of laboratory testing through changes in an electronic medical record: experience at an academic medical center. *BMC Med Inform Decis Mak*. 2015;15:11.
13. Rang M. The Ulysses syndrome. *Can Med Assoc J*. 1972;106(2):122-123.
14. Thienpont LM, Van Uytanghe K, Poppe K, Velkeniers B. Determination of free thyroid hormones. *Best Pract Res Clin Endocrinol Metab*. 2013;27(5):689-700.
15. Kandilov AMG, Pope GC, Kautter J, Healy D. The national market for Medicare clinical laboratory testing: implications for payment reform. *Medicare & medicaid research review*. 2012;2(2).
16. Garmendia Madariaga A, Santos Palacios S, Guillen-Grima F, Galofre JC. The incidence and prevalence of thyroid dysfunction in Europe: a meta-analysis. *J Clin Endocrinol Metab*. 2014;99(3):923-931.
17. Werhun A, Hamilton W. Thyroid function testing in primary care: overused and under-evidenced? A study examining which clinical features correspond to an abnormal thyroid function result. *Family practice*. 2015;32(2):187-191.
18. Koch H, van Bokhoven MA, ter Riet G, et al. Ordering blood tests for patients with unexplained fatigue in general practice: what does it yield? Results of the VAMPIRE trial. *Br J Gen Pract*. 2009;59(561):e93-e100.
19. Sheehan MT. Biochemical testing of the thyroid: TSH is the best and, oftentimes, only test needed—a review for primary care. *Clinical medicine & research*. 2016;14(2):83-92.

20. Jonklaas J, Bianco AC, Bauer AJ, et al. Guidelines for the treatment of hypothyroidism: prepared by the american thyroid association task force on thyroid hormone replacement. *Thyroid*. 2014;24(12):1670-1751.
21. Ross DS, Burch HB, Cooper DS, et al. 2016 American Thyroid Association Guidelines for Diagnosis and Management of Hyperthyroidism and Other Causes of Thyrotoxicosis. *Thyroid*. 2016;26(10):1343-1421.
22. Gupta S, Verma M, Gupta AK, Kaur A, Singh K. Are we using Thyroid Function Tests Appropriately? *Indian Journal of Clinical Biochemistry*. 2011;26(2):178-181.
23. Gilmour JA, Weisman A, Orlov S, et al. Promoting resource stewardship: Reducing inappropriate free thyroid hormone testing. *J Eval Clin Pract*. 2017;23(3):670-675.
24. Roti E, Gardini E, Magotti MG, et al. Are thyroid function tests too frequently and inappropriately requested? *J Endocrinol Invest*. 1999;22(3):184-190.
25. Eskelinen SI, Isoaho RE, Kivela SL, Irjala KM. Actual practice vs guidelines in laboratory monitoring of older patients with primary hypothyroidism in primary care. *Aging Clin Exp Res*. 2006;18(1):34-39.
26. Zhelev Z, Abbott R, Rogers M, et al. Effectiveness of interventions to reduce ordering of thyroid function tests: a systematic review. *BMJ Open*. 2016;6(6):e010065.
27. San Antonio Military Health System. <https://health.mil/Military-Health-Topics/Access-Cost-Quality-and-Safety/Access-to-Healthcare/Multi-Service-Markets/San-Antonio-Military-Health-System>. Accessed May 30, 2017.
28. Spencer CA, LoPresti JS, Patel A, et al. Applications of a new chemiluminometric thyrotropin assay to subnormal measurement. *J Clin Endocrinol Metab*. 1990;70(2):453-460.
29. Ladenson PW, Singer PA, Ain KB, et al. American Thyroid Association guidelines for detection of thyroid dysfunction. *Arch Intern Med*. 2000;160(11):1573-1575.
30. Society E. Five Things Physicians and Patients Should Question. 2013; <http://www.choosingwisely.org/societies/endocrine-society/>. Accessed June 28, 2017.
31. Carlé A, Knudsen N, Pedersen IB, et al. Determinants of serum T4 and T3 at the time of diagnosis in nosological types of thyrotoxicosis: a population-based study. *European Journal of Endocrinology*. 2013;169(5):537-545.
32. Services CfMaM. Clinical laboratory Fee Schedule. 2017; <https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/ClinicalLabFeeSched/index.html>. Accessed July 3, 2017.
33. Taylor PN, Iqbal A, Minassian C, et al. Falling threshold for treatment of borderline elevated thyrotropin levels-balancing benefits and risks: evidence from a large community-based study. *JAMA Intern Med*. 2014;174(1):32-39.
34. Srivastava R, Bartlett WA, Kennedy IM, Hiney A, Fletcher C, Murphy MJ. Reflex and reflective testing: efficiency and effectiveness of adding on laboratory tests. *Ann Clin Biochem*. 2010;47(Pt 3):223-227.
35. Feldkamp CS, Carey JL. An algorithmic approach to thyroid function testing in a managed care setting. 3-year experience. *Am J Clin Pathol*. 1996;105(1):11-16.
36. Nordyke RA, Reppun TS, Madanay LD, Woods JC, Goldstein AP, Miyamoto LA. Alternative sequences of thyrotropin and free thyroxine assays for routine thyroid function testing. Quality and cost. *Arch Intern Med*. 1998;158(3):266-272.

Table 1. Projected Annual Cost of Thyroid Laboratory Test Orders

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	3,280	5.72	18,762
Total T4	588	1.72	1,011
Total Tests	152,856		317,430
^a Based on extrapolation of totals collected over 3 month period of analysis			
^b Pricing per local DoD laboratory. Does not include labor costs.			

Figure 1. Thyroid Laboratory Tests Ordered over Three Months

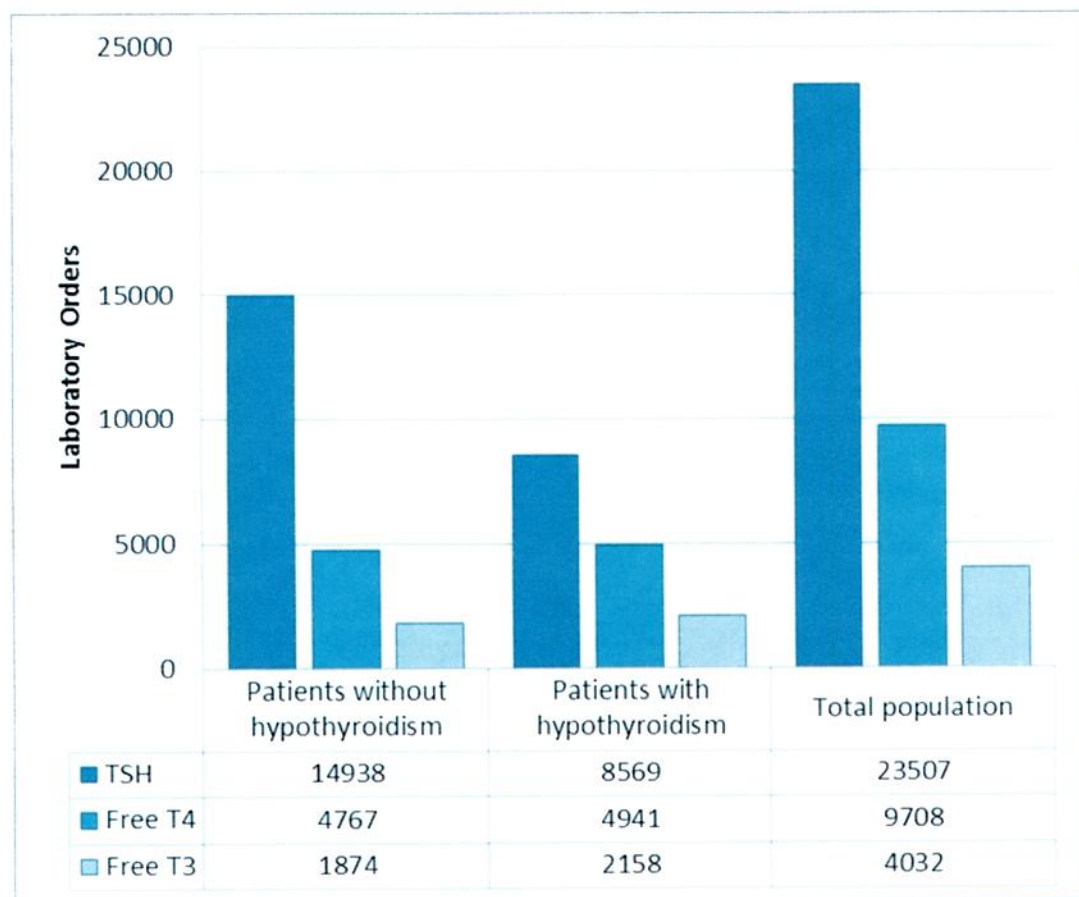
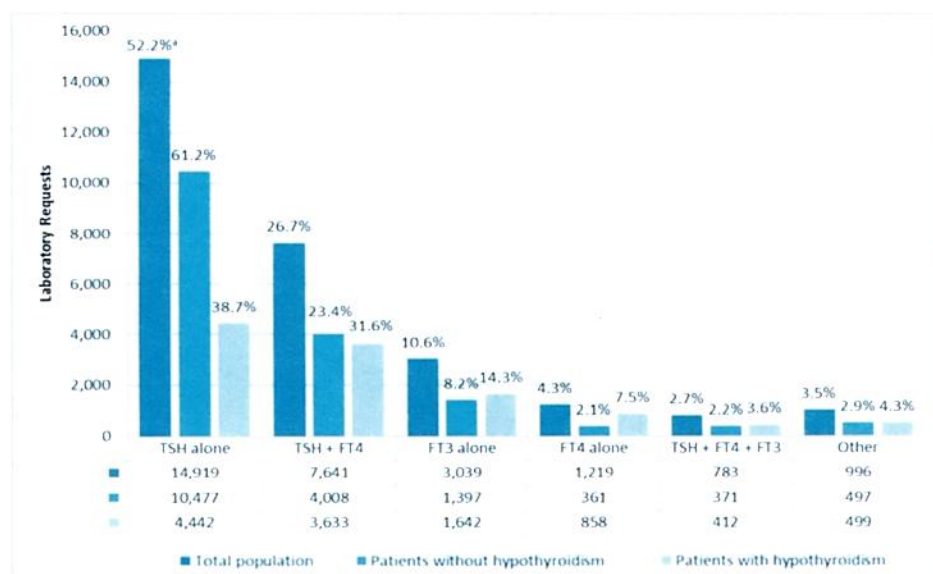


Table 2. Projected Annual Cost by Provider Ordering Pattern

Laboratory request	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	4,876 (4.26)	1.69	8,240
TSH + FT4 + FT3	3,132 (2.74)	6.32	19,794
Other ^c	3984 (3.48)	5.96	23,730
Total Requests	114,388		317,430

^aBased on extrapolation of totals collected over 3 month period of analysis
^bPricing per local DoD laboratory. Does not include labor costs
^cIncludes requests made in pattern not otherwise explicitly listed in table

Figure 2. Thyroid Function Testing Patterns Ordered over Three Months



*Number above bar is % of total requests within each of three populations analyzed (total, without hypothyroidism, and with hypothyroidism)



Analysis of Current Thyroid Function Test Ordering Practices

Joseph K. Kluesner, MD¹; Darrick J. Beckman, MD¹; Joshua M. Tate, MD¹; Alexis A. Beauvais, MD¹; Maria I. Kravchenko, MD¹; Jana L. Wardian, PhD²; Sky D. Graybill, MD¹; Jeffrey A. Colburn, MD¹; Irene Folaron, MD¹; Mark W. True, MD¹

¹Department of Medicine, Endocrinology Service, San Antonio Military Medical Center, Joint Base San Antonio – Fort Sam Houston, TX
²Department of Medicine, Diabetes Center of Excellence, Wilford Hall Ambulatory Surgical Center, Joint Base San Antonio – Lackland AFB, TX



Introduction

- Rising health care costs in the United States are having significant economic impact.
- Wasted health care expenditure accounts for estimated 30% of health care costs in the United States.
- Free thyroxine (FT4) and free triiodothyronine (FT3) are commonly ordered when not clinically indicated.
- TSH is sensitive to mild changes in serum FT4 and is known to develop abnormal levels before FT4 abnormalities are detectable.
- The American Thyroid Association (ATA) recommends TSH alone is the optimal test for monitoring or adjusting hypothyroidism treatment and for screening for thyroid dysfunction.
- 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

This project sought to evaluate our institution's providers' practice in ordering thyroid function tests (TFTs) to determine if changes are needed to reduce excessive laboratory testing.

Methods

- SAMHS serves more than 240,000 Department of Defense (DoD) beneficiaries.
- Healthcare is provided in nine outpatient community-based locations, an ambulatory surgical center, as well as a 425-bed inpatient facility.
- Outpatient TFT ordering patterns at the San Antonio Military Health System (SAMHS) during a three month period (Aug-Oct) in 2016 were analyzed.
- Inclusion: Adults ≥18 years old with or without history of hypothyroidism.
- FTIs of interest were: TSH, FT4, thyroid panel (TSH + FT4), FT3, total thyroxine (T4), and total triiodothyronine (T3).
- TFT order totals and testing patterns were calculated and analyzed using an Excel spreadsheet.

Table 1. Projected Annual Cost of Thyroid Laboratory Test Orders

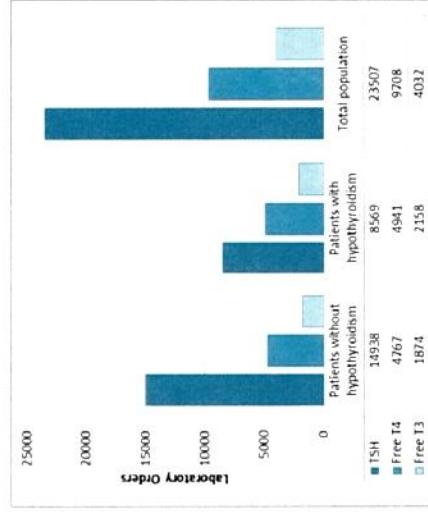
Laboratory test	Projected yearly test total ^a	Local testing cost (\$) ^b	Projected yearly cost (\$)
TSH	94,028	2.02	189,937
Free T4	38,832	1.69	65,626
Free T3	16,128	2.61	42,094
Total T3	3,280	5.72	18,762
Total T4	588	1.72	1,011
Total Tests	152,856		317,430

^aBased on extrapolation of totals collected over 3 month period of analysis
^bPricing per local DoD laboratory. Does not include labor costs.

Results

- 35.0% of all TFTs ordered were free thyroid hormones
 - FT4 and FT3 accounted for 25.4% and 10.6% respectively
 - 75.4% of FT3 orders did not include a TSH
- 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)
- Annual projections: \$317,430 worth of TFTs would be ordered, with free thyroid hormone testing accounting for \$107,720
 - Overall, 47.8% of all TFT requests included a laboratory test other than TSH alone leading to \$196,884 in costs

Figure 1. Thyroid Laboratory Tests Ordered over Three Months



References

- Sisko A, Truller C, Smith S, et al. Health Spending Projections Through 2018: Recession Effects Add Uncertainty To The Outlook. *Health Affairs*. 2009;28(2):W346-W357.
- Spencer JC, LoPresti JS, Patel JA, et al. Applications of a new chemiluminometric thyrotropin assay to subnormal measurement. *J Clin Endocrinol Metab*. 1996;70(2):453-460.
- Thompson LM, Van Wydinghe K, Poppe K, Valenzuela B. Determination of free thyroid hormones. *Best Pract Res Clin Endocrinol Metab*. 2013;27(5):669-700.
- Sheehan MT. Biochemical testing of the thyroid: TSH is the best and, oftentimes, only test needed—a review for primary care. *Clinical Medicine & Research*. 2016;14(2):83-92.
- Jontela J, Bianco AC, Bauer AJ, et al. Guidelines for the treatment of hypothyroidism: prepared by the American Thyroid Association task force on thyroid hormone replacement. *Thyroid*. 2014;24(12):1670-1751.
- Ladenheim PW, Singer PA, Ahn KB, et al. American Thyroid Association guidelines for detection of thyroid dysfunction. *Arch Intern Med*. 2000;160(11):1573-1575.

Table 2. Projected Annual Cost by Provider Ordering Pattern

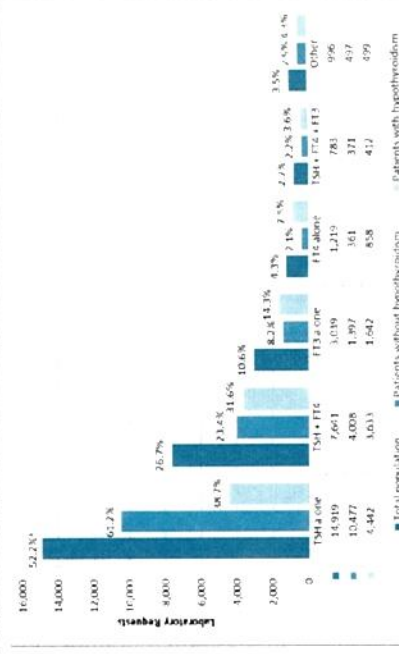
Laboratory ordering pattern	Projected yearly test requests ^a n (%)	Local testing cost (\$) ^b	Projected yearly cost (\$)
TSH alone	59,676 (52.17)	2.02	120,546
TSH + FT4	30,564 (26.72)	3.71	113,392
FT3 alone	12,156 (10.63)	2.61	31,727
FT4 alone	4,876 (4.26)	1.69	8,240
TSH + FT4 + FT3	3,132 (2.74)	6.32	19,794
Other ^c	3984 (3.48)	5.96	23,730
Total Requests	114,388		317,430

^aBased on extrapolation of totals collected over 3 month period of analysis

^bPricing per local DoD laboratory. Does not include labor costs

^cIncludes requests made in pattern not otherwise explicitly listed in table

Figure 2. Thyroid Function Testing Patterns Ordered over Three Months



^aNumber above bar is % of total requests within each of these populations; analytic (TSH, FT4, FT3, and FT4) and non-analytic (Other)

Discussion

- Free thyroid hormone tests are ordered excessively at significant cost.
- Providers at our institute are often relying on free thyroid hormones as an adjunct to TSH for screening or management of thyroid disorders.
- Our institute automatically reflexes a FT4 if TSH is abnormal. Despite this, the thyroid panel (TSH + FT4) is often ordered.
- A cost savings program focusing on eliminating all unnecessary FT4, FT3, and total thyroid hormone testing orders could save the SAMHS upwards of \$120,000 yearly.
- In an era of rising healthcare costs, inappropriate thyroid function testing is an ideal target for efforts to reduce laboratory overutilization.

Disclaimer: The views expressed herein are those of the author(s) and do not reflect the official policy or position of Brooke Army Medical Center, the U.S. Army Medical Department, the U.S. Army, the Department of Defense, the Department of the Army, the Department of the Air Force and Department of Defense or the U.S. Government.