







Thyroid testing in primary hypothyroidism

**Authors:**

Anshula Ambasta¹ 
Guillaume Grenet¹ 
Jessica Otte¹ 
Wade Thompson¹ 
Kenneth Bassett¹ 
Thomas Perry¹ 

Affiliations:

¹Department of Anaesthesiology, Pharmacology and Therapeutics, Faculty of Medicine, University of British Columbia, Vancouver, Canada

Corresponding author:

Anshula Ambasta,
anshula.ambasta@ubc.ca

Dates:

Received: 12 May 2025

Accepted: 15 May 2025

Published: 30 June 2025

How to cite this article:

Ambasta A, Grenet G, Otte J, et al. Thyroid testing in primary hypothyroidism. Afr J Prm Health Care Fam Med. 2025;17(1), a5043. <https://doi.org/10.4102/phcfm.v17i1.5043>

Copyright:

© 2025. The Authors.
Licensee: AOSIS. This work is licensed under the Creative Commons Attribution License.

Thyroid hormones regulate essential metabolic processes and development. The hypothalamic–pituitary–thyroid axis regulates hormone production, with thyroid-stimulating hormone (TSH) levels being a key indicator of thyroid function in primary hypothyroidism. This therapeutic letter emphasises a TSH-centred approach to the diagnosis and management of primary hypothyroidism (dysfunction at the level of the thyroid gland) in adults. It discourages routine thyroid function screening in asymptomatic individuals due to a lack of demonstrated benefit and potential harm from overdiagnosis and overtreatment. It outlines appropriate diagnostic strategies, including when to use TSH, free T4 (thyroxine), and free T3 (triiodothyronine) tests, and outlines indications for antibody testing. Special considerations are provided for subclinical hypothyroidism and hypothyroidism during pregnancy.

Keywords: diagnostic tests; hypothyroidism; mass screening; overdiagnosis; thyroid function tests; pregnancy; thyroid diseases.

Vignette

A 40-year-old woman presents to your clinic with symptoms of weight gain, constipation, fatigue, cold intolerance and brittle nails. Physical exam shows dry skin with excoriations and thin hair. She is concerned about thyroid disease and based on her internet research is requesting you to check her 'complete thyroid panel'. What test(s) would you order for her?

Thyroid hormones

Thyroid hormones are necessary for the development of human tissues and metabolic regulation of nearly all cells.¹ Hormone production is regulated by a feedback loop along the hypothalamus–pituitary–thyroid axis. The hypothalamus produces thyrotropin-releasing hormone (TRH) which controls production of thyroid-stimulating hormone (TSH) by the anterior pituitary gland. Thyroid-stimulating hormone regulates production and secretion of the two forms of thyroid hormone, thyroxine (T4) and the more bioactive triiodothyronine (T3) by the thyroid gland.¹ The thyroid gland secretes mainly T4, whereas other tissues convert T4 to T3 at the cellular level.² Intracellular T3 levels regulate pituitary secretion and blood levels of TSH.³ Most circulating T4 and T3 is bound to transport proteins in plasma; it is the small free fraction (soluble hormone) that is measured through diagnostic tests.^{4,5}

Thyroid-stimulating hormone, free T4 and free T3, ordered in a stepwise fashion, are used to diagnose and monitor disorders of thyroid function: clinical conditions of thyroid hormone deficiency (hypothyroidism) or excess (hyperthyroidism).^{1,5} Tests assess abnormal function of the thyroid gland itself (primary dysfunction) or of its regulation by the pituitary gland or hypothalamus (central dysfunction).^{1,6}

Antibody tests can help investigate immune-mediated thyroid dysfunction. Thyroid peroxidase (TPO) antibodies can help confirm a diagnosis of Hashimoto's thyroiditis as a cause of primary hypothyroidism.³ However, this test seldom changes clinical management. There are some clinical situations where measurement of anti-TPO antibody level may be useful.⁵ For example, anti-TPO antibodies may indicate the presence of autoimmune thyroiditis in patients with a goitre or mildly elevated TSH. Being positive for anti-TPO antibodies increases the risk of developing overt hypothyroidism in people with subclinical hypothyroidism or those at risk of developing thyroid dysfunction such as people with autoimmune diseases (e.g. type 1 diabetes), chromosomal disorders (e.g. Turner syndrome or Down syndrome) and people on certain medications such as

Read online:

Scan this QR code with your smart phone or mobile device to read online.

lithium or amiodarone.^{3,5,7} If performed, and a person is anti-TPO antibody positive, there is no reason to repeat anti-TPO antibody testing.⁵

Use a thyroid-stimulating hormone-centred approach to diagnose and monitor primary hypothyroidism

Diagnosis of primary hypothyroidism

Because TSH is regulated by thyroid hormones, TSH levels reliably predict thyroid hormone function.⁸ Unless there is clinical evidence to suspect central thyroid dysfunction (at the hypothalamus or pituitary level), which is rare, TSH should be the principal test to assess for primary thyroid gland dysfunction.⁹ If 'suspected hypothyroidism or hyperthyroidism' is selected on the standard out-patient requisition, some clinical laboratories first measure plasma TSH; they proceed to measure free T4 only if TSH is abnormal.⁵ Usually, the free T4 level confirms a diagnosis of hypothyroidism or hyperthyroidism. Free T3 is ordered only in clinically suspected hyperthyroidism when the TSH is suppressed, but the free T4 is not elevated.⁵ The TSH alone is not reliable in the diagnosis of central causes of hypothyroidism (e.g. hypopituitarism).^{6,10}

Monitoring primary hypothyroidism

For a patient with established primary hypothyroidism on levothyroxine monotherapy, TSH is sufficient to monitor replacement therapy. As TSH values change slowly, it is better to wait for at least 6 weeks following a change in thyroid hormone replacement dose before re-checking TSH and dose.^{3,11} Once TSH normalises under treatment, annual repeat TSH suffices, unless there is a clinical change that might impact levothyroxine pharmacokinetics (e.g. pregnancy, significant weight changes, gastrointestinal disorders, food supplements containing calcium and iron).¹²

Serum TSH can vary by up to 40% between measurements – even when sampled at the same time of day – yet not indicate any change in thyroid function.¹³ Thyroid-stimulating hormone also varies by time of day.¹⁴ Thus, one should expect changes within the reference range that reflect inherent biological variability, but are not clinically meaningful. Thyroid-stimulating hormone also tends to rise with age, although most laboratories do not report age-specific reference ranges. Among 16 533 participants in the 1988–1994 US National Health and Nutrition Survey III, there was a shift towards higher serum TSH in older people. For example, the 97.5th percentile for TSH in people aged 20 to 29 was 3.56 mU/L but rose to 7.49 mU/L for people over age 80. In this older group, 70% of people with TSH > 4.5 mU/L were within the reference range for their age.¹⁵

Do not screen routinely with thyroid function tests

A 2019 systematic review aiming to evaluate benefits and harms of screening to detect thyroid dysfunction found no

studies on screening for thyroid disease.¹⁶ Screening in asymptomatic adults can lead to unnecessary blood draws, further tests, and treatments that do not confer clinical benefit.¹⁷ As such, some guidelines recommend against 'routine' thyroid function testing in adults.¹⁷ The Practical Approach to Care Kit (PACK) guideline for adults recommends testing for patients with symptoms suggestive of thyroid dysfunction such as: weakness, tiredness, weight gain, low mood, dry skin or cold intolerance.¹⁸ Strong recommendations from the Society for Endocrinology, Metabolism and Diabetes of South Africa (SEMDSA) and Association of Clinical Endocrinologists of South Africa (ACE-SA) guideline for the management of hypothyroidism in adults, encourage a high index of suspicion and at the same time recognise that many of the clinical features of hypothyroidism are nonspecific, especially in the elderly.¹⁹ In addition, guidelines suggest consideration of testing for patients with symptoms and signs that suggest thyroid disease or for people with specific risk factors which include advanced age (men over 60 or women over 50 years), personal or family history of thyroid disease, coexisting autoimmune diseases, history of neck irradiation, prior thyroid surgery or radioactive iodine ablation, drug therapies such as lithium and amiodarone, dietary factors (iodine excess or deficiency) and certain chromosomal or genetic disorders (Turner syndrome, Down syndrome and mitochondrial disease).^{5,19} If initial TSH testing is normal, repeat testing is usually unnecessary unless there is a change in clinical condition.^{5,19}

Subclinical hypothyroidism

Subclinical hypothyroidism refers to the clinical situation where plasma TSH is elevated despite a normal plasma free T4.³ Typically, this is associated with nonspecific clinical symptoms, or no symptoms whatsoever.^{3,20} While elevated TSH levels (particularly > 10 mU/L) are associated with increased cardiovascular and mortality risks, there is insufficient evidence to show that treatment meaningfully affects clinical endpoints.^{19,21,22,23,24,25,26,27,28} Furthermore, the TSH of many patients who initially display biochemical subclinical hypothyroidism will normalise without intervention.^{29,30,31}

Of asymptomatic people with an elevated TSH, 62% had normal TSH levels at the second determination, versus only 2.9% who had a second highly elevated TSH.³¹ In addition, thyroid overtreatment can be associated with harms including cognitive dysfunction, atrial fibrillation and bone loss in postmenopausal women.^{3,32} The treatment of asymptomatic adults for screen-detected hypothyroidism is controversial,¹⁹ and according to the SEMDSA and ACE-SA guideline, treatment of patients with cardiovascular disease (CVD), increased risk for CVD, presence of thyroid peroxidase antibodies (TPO Abs), psychiatric illness, type 2 diabetes, dyslipidaemia or symptoms can be considered.¹⁹ The British Medical Journal Rapid Recommendations also discourage thyroid hormone therapy for patients with subclinical hypothyroidism.³³ Treatment for subclinical

hypothyroidism is generally recommended when TSH rises above 10 mU/L in patients less than 70 years of age.^{1,5} This is based on a subgroup analysis of a meta-analysis which suggested lower all-cause and cardiovascular mortality with thyroid hormone therapy in that age group.²⁵

Hypothyroidism in pregnancy

If a woman has risk factors for developing thyroid dysfunction, TSH should be tested early in pregnancy.⁷ There is clear evidence of benefit for treating a pregnant woman known to be hypothyroid.^{7,21} Treatment reduces adverse pregnancy outcomes including preterm delivery or miscarriage, and neuropsychological impairment of the offspring associated with hypothyroidism.^{34,35} However, evidence is insufficient to support universal screening for thyroid disease during pregnancy.^{36,37,38} Early studies suggested that subclinical hypothyroidism during pregnancy might increase adverse pregnancy outcomes, including preterm delivery or miscarriage, and neuropsychological impairment of a child.^{35,39} However, treatment for subclinical hypothyroidism failed to show clinical benefit in randomised placebo-controlled trials.³⁷ A meta-analysis of three randomised trials in women with subclinical hypothyroidism diagnosed in pregnancy also found no evidence for benefits of levothyroxine therapy on obstetrical, neonatal, childhood intellectual quotient or neurodevelopmental outcomes.⁴⁰ A recent retrospective Canadian cohort study showed that the current pattern of thyroid testing in pregnant women can contribute to overdiagnosis of hypothyroidism and over-treatment during pregnancy and postpartum.⁴¹ In addition, over-treatment of pregnant women can increase harms such as preterm labour.^{42,43} Hence, in pregnancy, we lack evidence both for universal screening for thyroid disease, and for treatment of subclinical hypothyroidism and both decisions require considered clinical judgement in the context of the patient and their risk factors.

Recommendations

- Do not perform routine thyroid function screening in asymptomatic adults.
- Use TSH as the initial test for suspected primary thyroid dysfunction and as the test to monitor levothyroxine monotherapy for primary hypothyroidism.
- Wait six weeks before re-checking TSH after therapy adjustments; once stable, annual testing is sufficient.
- Avoid treating asymptomatic screen-detected subclinical hypothyroidism, except when TSH > 10 mU/L in patients under 70 years of age.
- In pregnancy, test TSH only in high-risk women; treat overt hypothyroidism, but avoid routine treatment of subclinical cases.

Vignette resolution

You share the patient's concern about hypothyroidism. Finding nothing to suggest hypothalamic or pituitary dysfunction, you reassure her that the most useful test is a TSH, which you order,

checking 'suspected hypothyroidism' on the requisition. The TSH result is high, and the lab automatically reports a low free T4. You diagnose primary hypothyroidism, explain why testing for anti-TPO antibodies is not useful, and start levothyroxine, with a plan to re-check TSH and clinical status in 6–12 weeks.

Summary and conclusions

- Routine screening with thyroid function tests is unnecessary in asymptomatic adult patients.
- If thyroid dysfunction is suspected, clinicians should generally begin diagnostic testing with a TSH test alone.
- Use TSH alone to monitor therapy for people taking levothyroxine monotherapy for primary hypothyroidism. Once TSH is within the normal range for age, annual re-checks are appropriate in the absence of clinical changes.

Acknowledgements

The article was originally published as a therapeutic letter⁴⁴ (Letter 154) by the University of British Columbia with authors, Anshula Ambasta, Guillaume Grenet, Jessica Otte, Wade Thompson, Kenneth Bassett, Thomas Perry; refer: <https://www.ti.ubc.ca/2025/04/22/154-thyroid-testing-for-primary-hypothyroidism/>.⁴⁴ It has been edited for the *African Journal of Primary Health Care & Family Medicine* by Prof. Michael Pather and is published with permission from *The Therapeutics Initiative* at the University of British Columbia, Vancouver.

Disclaimer

The views and opinions expressed in this article are those of the authors. It does not necessarily reflect the official policy or position of any affiliated institution, funder, agency or that of the publisher. The authors are responsible for this article's results, findings and content.

References

1. Chaker L, Razvi S, Bensenor IM, et al. Hypothyroidism. *Nat Rev Dis Primers*. 2022;8:30. <https://doi.org/10.1038/s41572-022-00357-7>
2. Kopp P, Werner & Ingbar's the thyroid: A fundamental and clinical text. Philadelphia, PA, USA: Wolters Kluwer/Lippincott Williams & Wilkins; 2021, Ch. 6, p. 97–126.
3. Garber JR, Cobin RH, Gharib H, et al. Clinical practice guidelines for hypothyroidism in adults: Cosponsored by the American Association of Clinical Endocrinologists and the American Thyroid Association. *Endocr Pract*. 2012;18(6):988–1028. <https://doi.org/10.4158/EP12280.GL>
4. Schweizer U, Johannes J, Bayer D, Braun D. Structure and function of thyroid hormone plasma membrane transporters. *Eur Thyroid J*. 2014;3(3):143–153. <https://doi.org/10.1159/000367858>
5. Province of British Columbia. Thyroid function testing in the diagnosis and monitoring of thyroid function disorder [homepage on the Internet]. 2022 [cited 2025 May 12]. Available from: <https://www2.gov.bc.ca/gov/content/health/practitioner-professional-resources/bc-guidelines/thyroid-testing#eleven>
6. Persani L. Clinical review: Central hypothyroidism: Pathogenic, diagnostic, and therapeutic challenges. *J Clin Endocrinol Metab*. 2012;97(9):3068–3078. <https://doi.org/10.1210/jc.2012-1616>
7. Alexander EK, Pearce EN, Brent GA, et al. Guidelines of the American Thyroid Association for the diagnosis and management of thyroid disease during pregnancy and the postpartum. *Thyroid*. 2017;27(3):315–389. Erratum in: *Thyroid*. 2017;27(9):1212. <https://doi.org/10.1089/thy.2016.0457.correx>
8. Dufour DR. Laboratory tests of thyroid function: Uses and limitations. *Endocrinol Metab Clin North Am*. 2007;36(3):579–594. <https://doi.org/10.1016/j.ecl.2007.04.003>
9. Jameson JL, Weetman AP. Disorders of the thyroid gland. In: Anthony F, Eugene B, Dennis K, et al, editors. *Harrison's principles of internal medicine*. 17th ed. New York: McGraw-Hill, 2008; p. 2224–2247.

10. Jonklaas J, Bianco AC, Bauer AJ, et al; American Thyroid Association task force on thyroid hormone replacement. Guidelines for the treatment of hypothyroidism: prepared by the American Thyroid Association Task Force on Thyroid Hormone Replacement. *Thyroid*. 2014;24(12):1670–1751. <https://doi.org/10.1089/thy.2014.0028>
11. Kaplan MM. Clinical perspectives in the diagnosis of thyroid disease. *Clin Chem*. 1999;45(8 pt 2):1377–1383. PMID.
12. Colucci P, Yue CS, Ducharme M, Benvenia S. A review of the pharmacokinetics of levothyroxine for the treatment of hypothyroidism. *Eur Endocrinol*. 2013;9(1):40–47. <https://doi.org/10.17925/EE.2013.09.01.40>
13. Karmisholt J, Andersen S, Laurberg P. Variation in thyroid function tests in patients with stable untreated subclinical hypothyroidism. *Thyroid*. 2008;18(3):303–308. <https://doi.org/10.1089/thy.2007.0241>
14. Caron PJ, Nieman LK, Rose SR, Nisula BC. Deficient nocturnal surge of thyrotropin in central hypothyroidism. *J Clin Endocrinol Metab*. 1986;62(5):960–964. <https://doi.org/10.1210/jcem-62-5-960>
15. Hollowell JG, Staehling NW, Flanders WD, et al. Serum TSH, T(4), and thyroid antibodies in the United States population (1988 to 1994): National Health and Nutrition Examination Survey (NHANES III). *J Clin Endocrinol Metab*. 2002;87(2):489–499. <https://doi.org/10.1210/jcem.87.2.8182>
16. Reyes Domingo F, Avey MT, Doull M. Screening for thyroid dysfunction and treatment of screen-detected thyroid dysfunction in asymptomatic, community-dwelling adults: A systematic review. *Syst Rev*. 2019;8(1):260. <https://doi.org/10.1186/s13643-019-1181-7>
17. Birtwhistle R, Morissette K, Dickinson JA, et al. Recommendation on screening adults for asymptomatic thyroid dysfunction in primary care. *Can Med Assoc J*. 2019;191(46):E1274–E1280. <https://doi.org/10.1503/cmaj.190395>
18. Knowledge Translation Unit. Practical Approach to Care Kit (PACK): Primary care guideline for adults. Cape Town: University of Cape Town Lung Institute and Western Cape Government; 2023.
19. Dave JA, Klisiewicz A, Bayat Z, et al. SEMDSA/ACE-SA guideline for the management of hypothyroidism in adults. *S Afr Fam Pract*. 2015;57(6):4–11. <https://doi.org/10.4102/safp.v57i6.4399>
20. Pearce SH, Brabant G, Duntas LH, et al. 2013 ETA guideline: Management of subclinical hypothyroidism. *Eur Thyroid J*. 2013;2(4):215–228. <https://doi.org/10.1159/000356507>
21. Hak AE, Pols HA, Visser TJ, et al. Subclinical hypothyroidism is an independent risk factor for atherosclerosis and myocardial infarction in elderly women: The Rotterdam study. *Ann Intern Med*. 2000;132(4):270–278. <https://doi.org/10.7326/0003-4819-132-4-200002150-00004>
22. Chaker L, Baumgartner C, Den Elzen WP, et al; Thyroid studies collaboration. Subclinical hypothyroidism and the risk of stroke events and fatal stroke: An individual participant data analysis. *J Clin Endocrinol Metab*. 2015;100(6):2181–2191. <https://doi.org/10.1210/jc.2015-1438>
23. Cappola AR, Fried LP, Arnold AM, et al. Thyroid status, cardiovascular risk, and mortality in older adults. *J Am Med Assoc*. 2006;295(9):1033–1041. <https://doi.org/10.1001/jama.295.9.1033>
24. Rodondi N, Den Elzen WP, Bauer DC, et al. Thyroid studies collaboration. Subclinical hypothyroidism and the risk of coronary heart disease and mortality. *J Am Med Assoc*. 2010;304(12):1365–1374. <https://doi.org/10.1001/jama.2010.1361>
25. Peng CC, Huang HK, Wu BB, et al. Association of thyroid hormone therapy with mortality in subclinical hypothyroidism: A systematic review and meta-analysis. *J Clin Endocrinol Metab*. 2021;106(1):292–303. <https://doi.org/10.1210/clinem/dgaa777>
26. Mooijaart SP, Du Puy RS, Stott DJ, et al. Association between levothyroxine treatment and thyroid-related symptoms among adults aged 80 years and older with subclinical hypothyroidism. *J Am Med Assoc*. 2019;322(20):1977–1986. <https://doi.org/10.1001/jama.2019.17274>
27. Stott DJ, Rodondi N, Kearney PM, et al. TRUST study group. Thyroid hormone therapy for older adults with subclinical hypothyroidism. *N Engl J Med*. 2017;376(26):2534–2544. <https://doi.org/10.1056/NEJMoa1603825>
28. Jabbar A, Ingole L, Junejo S, et al. Effect of levothyroxine on left ventricular ejection fraction in patients with subclinical hypothyroidism and acute myocardial infarction: A randomized clinical trial. *J Am Med Assoc*. 2020;324(3):249–258. <https://doi.org/10.1001/jama.2020.9389>
29. Díez JJ, Iglesias P, Burman KD. Spontaneous normalization of thyrotropin concentrations in patients with subclinical hypothyroidism. *J Clin Endocrinol Metab*. 2005;90(7):4124–4127. <https://doi.org/10.1210/jc.2005-0375>
30. Díez JJ, Iglesias P. Spontaneous subclinical hypothyroidism in patients older than 55 years: An analysis of natural course and risk factors for the development of overt thyroid failure. *J Clin Endocrinol Metab*. 2004;89(10):4890–4897. <https://doi.org/10.1210/jc.2003-03261>
31. Meyerovitch J, Rotman-Pikielny P, Sherf M, et al. Serum thyrotropin measurements in the community: Five-year follow-up in a large network of primary care physicians. *Arch Intern Med*. 2007;167(14):1533–1538. <https://doi.org/10.1001/archinte.167.14.1533>
32. Adams R, Oh ES, Yasar S, et al. Endogenous and exogenous thyrotoxicosis and risk of incident cognitive disorders in older adults. *JAMA Intern Med*. 2023;183(12):1324–1331. <https://doi.org/10.1001/jamainternmed.2023.5619>
33. Bekkering GE, Agoritsas T, Lytvyn L, et al. Thyroid hormones treatment for subclinical hypothyroidism: A clinical practice guideline. *Br Med J*. 2019;365:l2006. <https://doi.org/10.1136/bmj.l2006>
34. Vissenberg R, Van Den Boogaard E, Van Wely M, et al. Treatment of thyroid disorders before conception and in early pregnancy: A systematic review. *Hum Reprod Update*. 2012;18(4):360–373. <https://doi.org/10.1093/humupd/dms007>
35. Haddow JE, Palomaki GE, Allan WC, et al. Maternal thyroid deficiency during pregnancy and subsequent neuropsychological development of the child. *N Engl J Med*. 1999;341(8):549–555. <https://doi.org/10.1056/NEJM199908193410801>
36. Nazarpour S, Ramezani Tehrani F, Rahmati M, et al. Effects of isolated maternal hypothyroxinemia on adverse pregnancy outcomes. *Arch Gynecol Obstet*. 2022;305(4):903–911. <https://doi.org/10.1007/s00404-021-06226-0>
37. Casey BM, Thom EA, Peaceman AM, et al. Treatment of subclinical hypothyroidism or hypothyroxinemia in pregnancy. *N Engl J Med*. 2017;376(9):815–825. <https://doi.org/10.1056/NEJMoa1606205>
38. Lazarus JH, Bestwick JP, Channon S, et al. Antenatal thyroid screening and childhood cognitive function. *N Engl J Med*. 2012;366(6):493–501. Erratum in: *N Engl J Med*. 2012;366(17):1650. <https://doi.org/10.1056/NEJMoa1106104>
39. Allan WC, Haddow JE, Palomaki GE, et al. Maternal thyroid deficiency and pregnancy complications: Implications for population screening. *J Med Screen*. 2000;7(3):127–130. <https://doi.org/10.1136/jms.7.3.127>
40. Yamamoto JM, Benham JL, Nerenberg KA, Donovan LE. Impact of levothyroxine therapy on obstetric, neonatal and childhood outcomes in women with subclinical hypothyroidism diagnosed in pregnancy: A systematic review and meta-analysis of randomised controlled trials. *BMJ Open*. 2018;8(9):e022837. <https://doi.org/10.1136/bmjopen-2018-022837>
41. Yamamoto JM, Metcalfe A, Nerenberg KA, et al. Thyroid function testing and management during and after pregnancy among women without thyroid disease before pregnancy. *Can Med Assoc J*. 2020;192(22):E596–E602. <https://doi.org/10.1503/cmaj.191664>
42. Korevaar TI, Muetzel R, Medici M, et al. Association of maternal thyroid function during early pregnancy with offspring IQ and brain morphology in childhood: A population-based prospective cohort study. *Lancet Diabetes Endocrinol*. 2016;4(1):35–43. [https://doi.org/10.1016/S2213-8587\(15\)00327-7](https://doi.org/10.1016/S2213-8587(15)00327-7)
43. Lemieux P, Yamamoto JM, Nerenberg KA, et al. Thyroid laboratory testing and management in women on thyroid replacement before pregnancy and associated pregnancy outcomes. *Thyroid*. 2021;31(5):841–849. <https://doi.org/10.1089/thy.2020.0609>
44. Therapeutics Initiative. Thyroid testing in primary hypothyroidism. *Therap Lett* [serial online]. 2025 [cited 2025 Apr 23];154. Available from: <http://www.ti.ubc.ca/letter154>