

Inappropriate laboratory test utilization in outpatient tertiary care

Implications for value-based healthcare

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ABSTRACT

الأهداف: تقييم معدل التكرار غير المناسب للاختبارات المعملية وتقدير تكلفتها. الاختبارات المدروسة: اختبار هرمون منبه للغدة الدرقية (TSH) والكوليسترول الكلي وفيتامين د ومخزون الحديد وفيتامين B12.

المنهجية: تم إجراء دراسة تحليلية بأثر رجعي في قسم طب الأسرة والعيادة في مستشفى الملك فيصل التخصصي ومركز الأبحاث. تم جمع البيانات السريرية والمخبرية بين عامي 2018 و 2021م للاختبارات المعملية الأربعة. تم تحديد تعريف التكرار الغير المناسب للاختبارات وفقاً للمبادئ التوجيهية الدولية، وتم حساب التكاليف باستخدام أسعار المستشفى.

النتائج: تم تضمين مجموعه 109,929 اختباراً معملياً تم إجراؤها على 23,280 مريضاً في هذه الدراسة. قدرت نسبة الاختبارات غير المناسبة حسب معايير الدراسة ب 6.1% من جميع الاختبارات المتكررة. كما بلغت التكلفة الإجمالية المهدرة التقديرية 2,364,410 ريال سعودي. أظهر العمر ارتباطاً إيجابياً ضعيفاً مع العدد الإجمالي للاختبارات غير المناسبة ($r=0.196$, $p=0.001$). وعلاوة على ذلك، لوحظت فروق ذات دلالة إحصائية في متوسطات العدد الإجمالي للاختبارات غير الملائمة بين الجنسين والجنسيات ($p<0.001$).

الخلاصة: حددت الدراسة معدلات عالية بشكل ملحوظ من التكرار غير المناسب للاختبارات المعملية ونسبة عالية من التكاليف المهدرة. ولذلك، فإن اتخاذ إجراءات تجاه التغلب على هذه المسألة أمر مطلوب للتوفير الاقتصادي في الرعاية الصحية.

Objectives: To assess the rate of inappropriate repetition of laboratory testing and estimate the cost of such testing for thyroid stimulating hormone (TSH), total cholesterol, vitamin D, and vitamin B12 tests.

Methods: A retrospective cohort study was carried out in the Family Medicine and Polyclinic Department at King Faisal Specialist Hospital and Research Center, Riyadh, Saudi Arabia. Clinical and laboratory data were collected between 2018-2021 for the 4 laboratory tests. The inappropriate repetition of tests was defined according to international guidelines and the costs were calculated using the hospital prices.

Results: A total of 109,929 laboratory tests carried out on 23,280 patients were included in this study. The percentage of inappropriate tests, as per the study

criteria, was estimated to be 6.1% of all repeated tests. Additionally, the estimated total cost wasted amounted to 2,364,410 Saudi Riyals. Age exhibited a weak positive correlation with the total number of inappropriate tests ($r=0.196$, $p=0.001$). Furthermore, significant differences were observed in the medians of the total number of inappropriate tests among genders and nationalities ($p<0.001$).

Conclusion: The study identified significantly high rates of inadequate repetitions of frequently requested laboratory tests. Urgent action is therefore crucial to overcoming such an issue.

Keywords: laboratory tests utilization, TSH, Vitamin B12, Vitamin D, lipid profile

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Laboratory testing is a cornerstone of medical practice, serving crucial roles in screening, diagnosis, and prognosis.¹ However, the misuse of laboratory tests, characterized by unnecessary repetitions, has become a pervasive issue in many medical institutes.² Despite the relatively low cost per test, the cumulative impact on overall healthcare expenditures becomes substantial when carried out in large numbers.³ In the United States alone, an astonishing 4-5 billion tests are carried out



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annually, resulting in an estimated cost of \$65 billion.⁴ This overutilization not only represents a significant waste of resources but also places a substantial financial burden on healthcare institutions.⁴

In contrast, international variations in healthcare spending patterns are evident, as exemplified by the United Kingdom spending only £3 billion annually on tests.⁵ Studies carried out in various countries, including Italy, Canada, and Greece, have shed light on the overutilization of specific tests such as thyroid stimulating hormone (TSH), lipid profile, vitamin D, vitamin B12, and ferritin.⁶⁻¹⁰ These studies reveal a notable trend of excessive ordering and repetition of these tests, indicating a need for more prudent utilization.

The impact of overutilization is not confined to developed countries, as exemplified by a study in Jeddah, Saudi Arabia, which identified a 30% increase in test ordering in 2015 alone. This surge in testing resulted in an estimated cost of \$43,200 for the overutilization of vitamin D testing within just 3 months.¹¹ Recognizing the global implications of wasteful healthcare resource utilization, there is a growing need to identify areas of overutilization, advocate for adherence to international guidelines, and raise awareness among healthcare providers regarding their test-ordering patterns.

In alignment with this global concern, the Saudi Ministry of Health introduced a healthcare transformation plan in 2018 as part of the Saudi Vision 2030 strategic goals.¹² This initiative aims to deliver value-based healthcare services, emphasizing the need for efficient resource utilization. Understanding the extent of overutilization in laboratory testing, particularly in the repetition of tests, could potentially save millions of dollars by promoting guideline adherence and fostering awareness among physicians regarding their test-ordering practices.

This study specifically focuses on assessing the rate of inappropriate test repetition and estimating the associated costs for tests such as TSH, total cholesterol, vitamin D, and vitamin B12. By examining these specific tests, we aim to contribute valuable insights into the extent of overutilization in diverse healthcare settings and provide evidence-based recommendations to optimize test utilization. Additionally, we will explore the potential benefits of adhering to international guidelines for test repetition intervals as a means

to mitigate overutilization and reduce healthcare expenditures.¹³⁻¹⁶

Methods. A retrospective cohort study was carried out in the Family Medicine and Polyclinic Department at King Faisal Specialist Hospital and Research Center (KFSHRC), Riyadh, Saudi Arabia, approved by the research ethics committee at King Faisal Specialist Hospital and Research Centre (RAC 2211130) and a waiver of informed consent was granted.

We obtained clinical and laboratory data from the hospital database. Four laboratory tests (namely, TSH, vitamin D, vitamin B12, and lipid panel [including low-density lipoprotein, high-density lipoprotein, total cholesterol, and triglycerides]), which were ordered in a primary care outpatient setting from 2018-2021 were considered for analyses. Tests were ordered by family medicine board-certified physicians (American, Canadian, and British). Data were gathered electronically and inappropriately repeated tests were recognized based on fixed intervals between the tests. International guidelines were used to define the inappropriate repetition of lab tests. The American Association of Clinical Endocrinologists recommends against repeating the TSH test within an 8-week period.¹³ The Canadian Cardiovascular Society guidelines suggest a 13-week interval before repeating lipid profile tests.¹⁴ Also, the Best Practice in Primary Care Pathology advises against repeating Vitamin B12 tests within a 13-week timeframe (**Table 1**).¹⁵ Similarly, as per the Osteoporosis Canada Guidelines, a 13-week interval is advised before considering a repeat of Vitamin D tests.¹⁶

There is a variation in the prices of laboratory tests between government-run establishments like KFSHRC and private institutions. At KFSHRC, a TSH test costs 410 Saudi Riyals (~109 USD), a lipid profile test costs 510 Saudi Riyals (136 USD), a vitamin B12 test costs 410 Saudi Riyals (~109 USD), and a single vitamin D test costs 900 Saudi Riyals (~240 USD).

Statistical analysis. The Statistical Package for the Social Sciences, version 20.0 (IBM Corp., Armonk, NY, USA) was used. Descriptive statistics for the continuous variables were reported as mean \pm standard deviation (SD), and the categorical variables were summarized as frequencies (n) and percentages (%). Continuous variables were compared using the non-parametric Mann-Whitney test and Kruskal-Wallis test, while categorical variables were compared using the Chi-square test. The analysis of the sociodemographic variables revealed the presence of missing data. However, given the minimal extent of missingness (less than

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Table 1 - Definition of an inappropriate test.

Tests	Inappropriate repetitions	References
TSH	Repeated testing within 8 weeks	AACE hypothyroidism guidelines ¹²
Lipid profile	Repeated testing within 3 months	CCS dyslipidemia guidelines ¹³
Vitamin B12	Repeated testing within 3 months	Best practice in primary care pathology ¹⁴
Vitamin D	Repeated testing within 3 months	Osteoporosis Canada guidelines ¹⁵

TSH: thyroid-stimulating hormone,
AACE: American Association of Clinical Endocrinologists,
CCS: Canadian Cardiovascular Society

1%), a complete case analysis was deemed appropriate. Furthermore, a p -value of < 0.05 and 95% confidence interval value were considered for determining statistical significance.

Results. A retrospective analysis of 109,929 laboratory tests from 23,280 patients across all ages, carried out between 2018-2021, was obtained. The mean age of the participants was 38.75 ± 20.78 that ranged from 0-107, and most of the sample population was female (61.6%) and married (52.5%). **Table 2** summarizes the sociodemographic characteristics of the participants. In addition, according to the standard guidelines, the percentage of inappropriate testing was estimated to be 6.1% of all repeated tests (**Table 3**). **Figure 1** presents the annual change in the percentages of inappropriate tests during the study period, wherein the laboratory tests showed an observable decrease over the years. The estimated amount of money wasted on such inappropriate repetition was 2,364,410 Saudi Riyals, which was based on hospital prices, for the whole study period. Notably, the lipid profile test contributed to approximately half of the estimated monetary waste (**Table 4**).

Furthermore, age positively correlated with the total number of inappropriate tests ($r=0.196$, $p=0.001$). The medians of the total number of inappropriate tests among the categories of gender, marital status, and nationality were statistically significant. Gender disparity emerged in inappropriate testing, with females undergoing more tests compared to males ($p=0.001$). Similarly, marital status influenced testing rates, with separated patients receiving fewer tests ($p=0.001$). Notably, Saudis underwent a significantly higher number of inappropriate tests compared to non-Saudis ($p=0.003$). In contrast, residence in Riyadh did not show a significant association with inappropriate testing ($p=0.574$).

Discussion. Laboratory testing holds great importance in medical practice. However, a considerable

proportion of medical institutions carry out unnecessary repeated testing, resulting in a substantial increase in overall healthcare costs. In our study, the rate of inappropriate laboratory test repetition for 4 commonly ordered tests (TSH, lipid profile, vitamin B12 level, and vitamin D level) over 4 years is estimated to be 6.1%. Similarly, multiple studies have investigated the rate of inappropriate test repetitions. For instance, Chami et al⁶ found a 6-20% rate of inappropriate test repetition for 9 tests (TSH, hemoglobin A1C [HbA1c], lipid profile, serum protein electrophoresis, immunofixation, quantitative immunoglobulins, vitamin D, vitamin B12, and folate) over a 5-year period using information from a large governmental database in Ontario. Bozyigit et al¹⁷ assessed 7 tests (TSH, Free T4, Free T3, Vitamin D, iron, ferritin, and total cholesterol) over 3 years and reported a rate of 4.2-15.5%. Moreover, Morgen et al⁹ analyzed the laboratory database from Calgary to determine the inappropriate repetition of 6 tests (cholesterol, HbA1c, TSH, Vitamin B12, Vitamin D, and ferritin), which was estimated to be 16%. Lanzoni et al¹⁰ examined the inappropriateness of 6 tests (total cholesterol, ferritin, vitamin B12, folate, 25-OH vitamin D, and 1,25-OH vitamin D) over 3 years in Italy and reported a rate of 14.6%. Furthermore, a 15-year meta-analysis by Zhi et al² reported an inappropriate repetition rate of 7.4%, which is consistent with the current study. Discrepancies in rates between our study and previous reports may be attributed to several factors: I) the ordering physician's level of experience, as KFSHRC is a tertiary hospital and research center where a training resident might have ordered tests instead of a senior consultant; II) the setting in which the test was ordered, with outpatient settings potentially differing from inpatient settings; III) the study period, which encompassed the COVID-19 lockdown, leading to a decline in hospital visits for blood insurance tests; IV) variations in study parameters compared to prior studies; and V) the availability of insurance approvals for ordered tests. Since KFSHRC is a governmental

Table 2 - Sociodemographic characteristics (N=23,280).

Variables	n (%)	Median number of inappropriate repetition	P-values
Age, mean±SD*	38.75±20.78	r=0.196	0.001
Gender*			
Female	14,336 (61.6)	2	0.001
Male	8,939 (38.4)	0	
Marital status*			
Single	10,398 (44.7)	2	0.001
Married	12,198 (52.5)	2	
Separated	660 (2.8)	1.5	
Nationality			
Non-Saudi	5,871 (25.2)	1	0.003
Saudi	17,409 (74.8)	2	
Resident of Riyadh			
No	1,381 (5.9)	2	0.574
Yes	21,899 (94.1)	1	

Values are presented as numbers and percentages (%). *Missing data of <1%.
SD: standard deviation

Table 3 - Numbers and rates of repeated tests.

Tests	Total number of repeated tests	Inappropriate repetitions
TSH	24,359	1,531 (6.3)
Lipid profile	23,840	2,166 (9.1)
Vitamin B12	11,722	804 (6.9)
Vitamin D	18,751	336 (1.8)
Total	78,672	4,837 (6.1)

Values are presented as numbers and percentages (%). TSH: thyroid-stimulating hormone

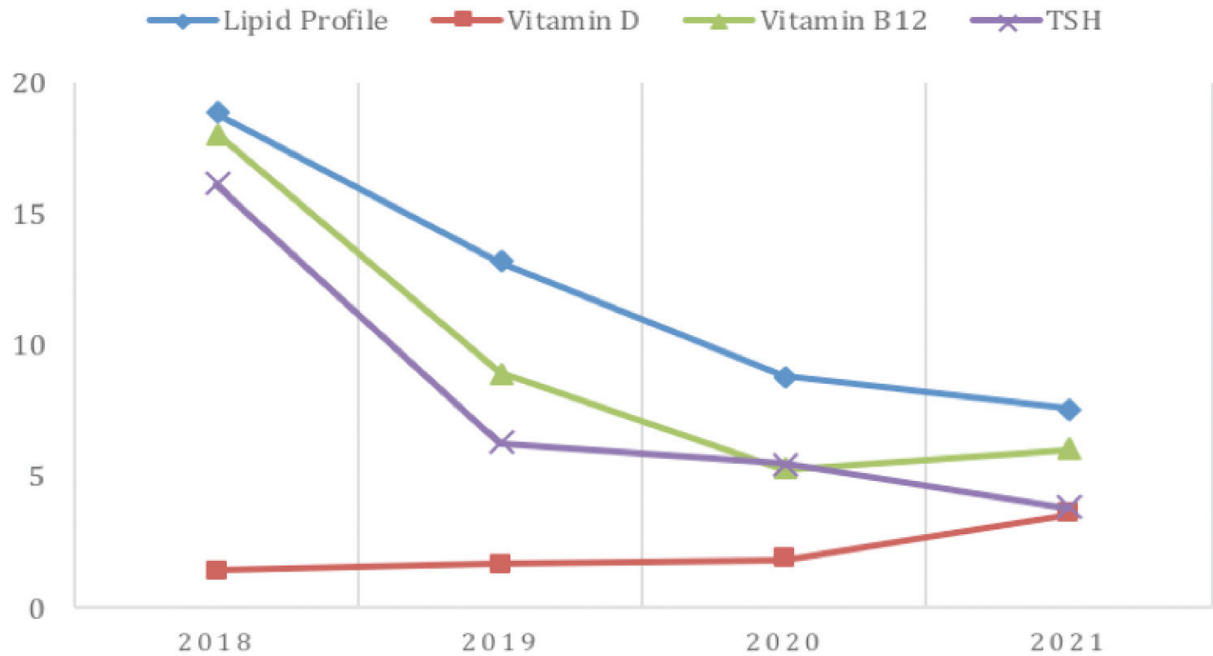


Figure 1 - Annual percentages of inappropriate testing. TSH: thyroid-stimulating hormone

Table 4 - Estimated money waste.

Tests	Numbers of inappropriate repeated tests	Prices (Saudi Riyals)	Estimated monetary wastes (Saudi Riyals)
TSH	1,531	410	627,710
Lipid profile	2,166	510	1,104,660
Vitamin B12	804	410	329,640
Vitamin D	336	900	302,400
Total	4,837		2,364,410

TSH: thyroid-stimulating hormone

hospital, most tests are covered by the government, eliminating the need for insurance approval.

We observed in our study a positive correlation between age and the total number of inappropriate tests, suggesting that as individuals grow older, there is an increased likelihood of undergoing unnecessary testing. This finding aligns with the broader discourse on healthcare practices, emphasizing the need for targeted interventions and education campaigns tailored to different age groups.^{2,5}

Our investigation revealed that females tended to undergo more tests compared to males. While the reasons for this gender discrepancy warrant further exploration, it may be influenced by various factors such as differences in healthcare-seeking behavior, prevalence of certain medical conditions, or even healthcare provider practices.

Additionally, our study uncovered a significant disparity in inappropriate testing between Saudi and non-Saudi patients. The reasons behind this discrepancy could be multifaceted, involving cultural factors, variations in healthcare utilization patterns, or differences in the prevalence of specific health conditions among these populations.

Thyroid stimulating hormone was revealed to have the highest rate of inappropriate repetition in the study population, wherein, out of 24,359 repeated TSH tests, 1,531 were inappropriately repeated (6.3%). Similarly, Chami et al⁶ reported a TSH inappropriate testing rate of 6% in Ontario, and Bozyigit et al¹⁷ reported a rate of 4.2% in Turkey.

The lipid profile ranked the first among the inappropriately repeated tests in our sample, with 2,166 inappropriately repeated tests out of 23,840 tests (9.1%). Compared to previous studies, Chami et al⁶ reported 10.2%, Bozyigit et al¹⁷ reported 55.5%, and Lanzoni et al¹⁰ reported 37.1%.

Vitamin B12 was repeated 11,722 times, of which 804 (6.9%) were inappropriate. Compared to previous studies, Chami et al⁶ reported 8.2% in Canada and Bozyigit et al¹⁷ reported 10% in Turkey.

Finally, Vitamin D testing was repeated inappropriately 336 (1.8%) times out of 18,751. A study at KFSHRC, Jeddah branch, Saudi Arabia, examined the ordered Vitamin D tests over 10 months and revealed that, out of the 68 repeated tests, 38 were unnecessary.¹¹ Chami et al⁶ reported 6.88% in Canada, Bozyigit et al¹⁷ reported 14.6% in Turkey, and Lanzoni et al¹⁰ reported 8.1% in Italy.

Study strengths & limitations. Our study revealed a higher percentage of inappropriate laboratory testing compared to existing literature, attributing the disparities to specific factors. The focused approach on test orders solely from family medicine physicians might have led to an underestimation of the overall rate, as patients often receive lab requests from multiple specialties. Differences in the purpose of testing and methodological variations across studies contribute to the observed discrepancies. Moreover, the subjective nature of defining inappropriateness introduces an element of subjectivity, further influencing the reported rates. The findings underscore the need for a nuanced understanding of inappropriate testing dynamics and highlight the importance of standardized criteria and methodologies in future research to ensure accurate comparisons and a comprehensive grasp of this multifaceted issue.

In conclusion, high rates of inappropriate test repetitions of commonly ordered laboratory tests were observed in family medicine practice at a tertiary hospital, which resulted in vast monetary and resource wastage. Therefore, strategies such as increasing physicians' awareness of the appropriate guidelines for testing intervals could be suggested to address this issue. Moreover, the integration of an electronic system can alert physicians to repeat orders, and even prevent physicians from re-ordering recently completed lab tests within a specific time period. As an example, the electronic system might reject any lab requests for Vitamin B12 or Vitamin D dated within 13 weeks of the previous lab results. Thus, the implementation of such strategies could save millions of Riyals and provide value-based healthcare services for patients.

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