ORIGINAL RESEARCH

The cost of unnecessary test orders: a retrospective study

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*This study is derived from Adil Aydoğdu's master's thesis.

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Abstract

Background

Limited resources available to meet unlimited human needs necessitate the prevention of unnecessary use in the field of health. One of the unnecessary expenditures in health is the use of laboratory tests. The aim of this study is to determine the level of unnecessary laboratory test requests and the risk factors affecting unnecessary use in a university hospital.

Material and Methods

In the study, the 15 most frequently used biochemistry tests in a university hospital were evaluated retrospectively. The Rational Laboratory Test Request Procedure of the Ministry of Health was used to determine the use of unnecessary tests. Multivariate logistic regression analysis was used to identify factors affecting unnecessary test use.

Results

The analysis results showed that the ratio of unnecessary use of 15 biochemistry tests was 9.1%, and the cost of unnecessary tests was 584.186,3 TL (114.997,3 $). It was found that the probability of requesting unnecessary tests differed significantly according to the branches of the tests requested, the age and gender of the patients and the academic title of the physicians ($p<0.001$).

Conclusions

It is thought that the study will provide important clues in the development of managerial interventions to prevent unnecessary test usage and control costs.

Key words: physician ordering, rational use of laboratory tests, unnecessary laboratory tests, cost of unnecessary use.

Introduction

Today, millions of different tests are performed every year in healthcare institutions. These tests differ from each other in terms of various aspects such as their features, areas of use, reasons for use, ranges of meaningful results, and their costs. Physicians decide on the tests they will request for their patients by considering these features. As a result of these decisions, appropriate and necessary use may occur as well as inappropriate and unnecessary test use.

Although the concepts of unnecessary and inappropriate use can be used interchangeably in the related literature, these two concepts are fundamentally different from each other. Inappropriate use is a general concept that can include all the concepts of underuse, misuse, unnecessary use. The underuse laboratory tests is a type of error caused by the physicians' not requesting the necessary tests for patient complaints[1]. Demanding tests unrelated to the disease of the patients or requesting tests that can only be requested from patients with certain characteristics leads to the use of false tests. Unnecessary laboratory testing is the situation in which physicians consciously or unconsciously request tests that have no effect on the management of the disease by being affected by various factors[2].

It is known that the majority of diagnostic errors occur with inappropriate, excessive and misuse of laboratory tests[3]. Among these, the issue of unnecessary use is more prominent because it is frequently encountered and its medical and economic consequences are severe.

In the USA, which is the most remarkable country in health expenditures and where health care costs approach to 4.3 trillion dollars a year, approximately 60 billion dollars of expenditures are made up of laboratory and pathology expenditures. In addition, experts state that laboratory costs grow at a rate of about 15-20% per year, increasing more than other medical fields[4,5]. McGregor and Martin (2012) stated in their study on the subject that health expenditures have increased in Canada, and that the aging population is not the only reason for this, and that the increase in expenditures on laboratory tests is the most important reason. According to this study, laboratory expenditures between 2005 and 2006 increased by 37.4% and by 174 million dollars compared to 1996 and 1997[6]. In another study, it was stated that laboratory expenditures in the UK constituted 2.5 billion pounds and almost 4% of the total health expenditures[7], while it was stated that 4% of the total health expenditures in Europe was due to laboratory use[8]. The increase in laboratory test requests within healthcare expenditures in USA and Europe can be attributed to several factors such as technological advancements (have made tests more precise and varied, encouraging their use); aging population (requires more chronic disease monitoring); greater health awareness among individuals; emphasis on early diagnosis and prevention

https://dx.doi.org/10.4314/mmj.v37i1.4

strategies; and supportive health policies and insurance systems.

In a study conducted at a local hospital to identify unnecessary laboratory use in the USA, the cost of unnecessary laboratory testing was calculated to be $400,000 in 2013, and this figure was found to be well above government subsidies. It has also been concluded that at least 25% of all tests requested in the hospital are unnecessary or of limited clinical benefit[9]. In the Netherlands, researchers have shown that a total of 350.000 euros savings are achieved in a one -year period covering the 2008-2009 if test requests are controlled through electronic automation systems in a hospital[10].

Unnecessary use of laboratory tests, in addition to its negative economic consequences, causes unnecessary blood draw from the patient and the physician to make erroneous decisions. Although tests are an important mainstay in treatments, they do not work at 100% accuracy. Nearly all laboratory tests are based on a 95% confidence interval based on ± 2 standard deviations. This means that 5% of "normal" (healthy) individuals may naturally have test results outside this range[11]. Therefore, if the probability of a false positive for a test is 5%, the more tests requested, the higher the probability of false positives[12]. The most effective way to reduce the number of false positive test results is to reduce the number of unnecessary and arbitrary test requests[13]. Another consequence of unnecessary laboratory tests is that it lead to unnecessary interventions in patients 9. Unnecessary tests may confuse and delay or even prevent the correct diagnosis[14,15]. On the other hand, the increase in the number of laboratory tests also increases the risk of 'iatrogenic anomalies' for patients[11].

It is known in the literature that various studies have been carried out in order to reveal the use of unnecessary laboratory tests. In these studies, unnecessary test usage rates were found to be between 13.5% and 65%[9,16-19]. In Turkey, the Ministry of Health initiated the Rational Laboratory Use Project in 2018 in order to optimize the use of laboratory tests within health expenditures, and many hospitals have started to work in accordance with this Project[20]. According to the Rational Test Use Procedure, it is decided whether a test is unnecessary or not by examining the suitability of the same test applied to the same person for the duration. In Turkey, there is no study in this area, except for a few studies examining the level of unnecessary use of a few tests in a short period of one to two months. These studies also did not address the factors affecting the use of unnecessary laboratory tests. The aim of this study is to reveal the level of unnecessary laboratory test requests and risk factors for unnecessary use in a university hospital.

Material and Methods

Study Design

This study was conducted with a quantitative method and cross-sectional style at Muğla Sıtkı Koçman University Training and Research Hospital (MSKU TRH). The hospital is an affiliated hospital with a bed capacity of 567 and serves approximately one million people with 1801 healthcare workers[21].

In order to determine the most frequently used tests, hospital laboratory specialists were interviewed and a list was created by asking which tests could be requested by all departments. The tests on the created list were then sent back to the specialists and the most frequently used tests were listed. In the study, the 15 most frequently used biochemistry tests (LDH, CA-15-3, CA 19-9, FSH, HDL cholesterol, Prostate Specific Antigen PSA, Total IgA, Total IgG, Total IgM, HbA1C, 25-Hydroxy Vitamin D, Total IgE, Triglyceride, LDL cholesterol, Vitamin B12 tests) were retrospectively examined for the 18-month period between January 1, 2018 and June 31, 2019 in order to determine the level of unnecessary use.

Data Collection

Data on 15 biochemistry tests within the scope of the study were obtained from the hospital's information system and made ready for analysis (they were transferred to SPSS program for statistical analysis) after cleaning and editing the data in Microsoft Office Excel program.

In order to decide whether these tests are used unnecessarily, the criteria of the minimum time interval between two requests fort he same test in the Rational Test Request Procedure of the Ministry of Health were taken as a basis (Table 1). Accordingly, the day difference between the tests requested for the same patients was calculated, and tests that did not meet the time criteria were defined as unnecessary tests 20. The reimbursement prices of the Social Security Institution were taken as the basis for the calculation of unnecessary testing costs (Table 1). In the calculation of test costs, the unit prices valid and the average USD exchange rate (1$=5.08 TL) between January 1, 2018- June 31, 2019 were taken as reference[22,23].

Ethical Consideration

Ethics committee approval (Date: 28 May, 2019; Decision no: 16969557-1080) and institutional permissions (Date: 17 June, 2019; Decision no: 7325) were obtained before the study. It is committed that the data will not be used other than for scientific purposes.

Statistical Analysis

In the study, multivariate logistic regression analysis was used to identify risk factors associated with unnecessary laboratory testing. Logistic regression analysis can be used to estimate odds ratios for each of the independent variables in the model. In the logistic regression analysis, the variable indicating the necessity/unnecessity of the laboratory test was used as the dependent variable, and the state of being necessary was coded as (0), and the state of being unnecessary was coded as (1). In order to estimate the risk factors related to unnecessary test use, the variables related to the branches of the tests requested (internal-surgical), physicians requesting the test (academic title) and the variables related to the patients for whom test is requested (age and gender) were included as independent variables.

Results

As a result of the data analysis, the total number of requests for 15 tests between January 2018 and June 2019 was found to be 653.125, and the total number of unnecessary test requests was 59.685. The total cost of these tests was found to be 4.997.384,8 TL ($983.737,3) and the cost of unnecessary requests was 584.186,3 TL ($114.997,3). Unnecessary test ratio was 9.1% and the ratio of unnecessary test costs to total test cost was calculated as 11.7% (Table 2).

Among the 15 biochemistry tests within the scope of the study, the most requested tests were LDH, Vitamin B12, Triglyceride, HDL and LDL tests.

Table 1. Minimum Time Required to Request Tests and Costs of Tests

Tests	Times (Days)	Costs (TL)	Costs (USD)
LDH	365	21.76	4,28
CA-15-3	28	7.60	1,50
CA-19-9	28	7.60	1,50
FSH	13	5.70	1,12
HDL Cholesterol	13	1.52	0,30
PSA	28	6.17	1,21
IgA	28	4.75	0,94
IgG	28	4.75	0,94
IgM	28	4.75	0,94
HbA1C	60	3.80	0,75
25-Hydroxy Vitamin D	90	19.12	3,76
Total IgE	28	8.55	1,68
Triglyceride	13	1.14	0,22
LDL Cholesterol	365	2.38	0,47
Vitamin B12	365	4.75	0,94

Table 2. Unnecessary Requests and Costs of 15 Selected Biochemistry Laboratory Tests

Tests	Requests (A)	Total cost of requests (TL) (B)	Unnecessary requests (C)	Total cost of unnecessary requests (TL) (D)	Unnecessary requests (%) (C/A)
LDH	97741	2.126.844,2	18231	396.706,56	18.7
CA-15-3	13478	102.432,8	122	927,20	0.9
CA-19-9	17245	131.062,0	190	1.444,00	1.1
FSH	11035	62.899,5	61	347,70	0.6
HDL Cholesterol	91705	139.391,6	406	617,12	0.4
PSA	17671	109.030,1	415	2.560,55	2.3
IgA	5087	24.163,3	108	513,00	2.1
IgG	5015	23.821,3	112	532,00	2.2
IgM	4975	23.631,3	105	498,75	2.1
HbA1C	38893	147.793,4	175	665,00	0.4
25-Hydroxy Vitamin D	66568	1.272.780,2	2744	52.465,28	4.1
Total IgE	8215	70.238,2	67	572,85	0.8
Triglyceride	91725	104.566,5	408	465,12	0.4
LDL Cholesterol	90374	215.090,1	20126	47.899,88	22.3
Vitamin B12	93398	443.640,5	16415	77.971,25	17.6
Total (TL)	653.125	4.997.384,8	59.685	584.186,26	9.1
Total (USD)	653.125	983.737,2	59.685	114.997,3	9.1

Among the tests requested, it was seen that the most unnecessary tests were LDL, LDH and Vitamin B12 tests, while the tests with the lowest unnecessary use ratio were HbA1C, Triglyceride and HDL cholesterol tests. It was determined that the tests that caused the most unnecessary test costs were LDH, Vitamin B12 Vitamin D and LDL tests (Table 2).

Multivariate logistic regression analysis was used to reveal whether the branches of the tests requested, the age and gender of the patients, the academic title of the physician requesting the tests had a significant effect on unnecessary test use, and a statistically significant model was found ($\chi2(9)= 244.842$; $p<0.001$). The Hosmer-Lemeshow test result ($\chi2(3)=4699$; $p=0.195$) showed that the model had a good fit to the data (Table 3).

https://dx.doi.org/10.4314/mmj.v37i1.4

Table 3. Factors Affecting Unnecessary Laboratory Test Use

	β	S.E.	Wald	Sig.	Exp(B)	95% C.I. for EXP(B)	
						Lower	Upper
Branches (Internal; Ref: Surgical)	-0.078	0.019	17.653	<0.001	0.925	0.892	0.959
Patient Gender (M; Ref: F)	-0.029	0.01	8.017	0.005	0.972	0.953	0.991
Patient Age(Ref: ≤10)			618.115	<0.001			
11-40 age group	-0.409	0.039	112.524	<0.001	0.664	0.616	0.717
41-80 age group	-0.595	0.038	248.636	<0.001	0.552	0.512	0.594
>80 age group	-0.272	0.043	39.972	<0.001	0.762	0.7	0.829
Physician Title (Ref: GP)			1538.815	<0.001			
Physician Title(Assistant)	-0.334	0.09	13.864	<0.001	0.716	0.601	0.854
Physician Title(Specialist)	-1.028	0.026	1529.473	<0.001	0.358	0.34	0.377
Constant	-0.149	0.032	22.269	<0.001	0.862		

Chi-square= 244.842; p<0.001 GP: General Practitioner, M: Male, F: Female, Ref: Reference group

According to the model in Table 3, unnecessary laboratory test use was found to be statistically significantly affected by the branches of the tests requested, the title of the physicians who requested the tests, and the gender and age of the patients for whom the tests were requested (p<0.001).

When the relationship between the use of unnecessary tests and the clinical branches in which the tests are requested is examined, it has been observed that the probability of unnecessary tests required by internal medicine branches is 7.5% [(1-0.925)x100] more than surgical branches as the reference category.

When the relationship between the use of unnecessary tests and the characteristics of the patients is examined, it was found that the probability of requesting unnecessary tests for male patients was 2.8% [(1-0.972)x100] lower than female patients who were the reference category. In terms of the age groups of the patients, the probability of unnecessary tests requested for patients in the age categories over 10 years (11-40, 41-80 and >80 years old) is lower than the patients aged 10 years and younger, which is the reference category. For patients aged 11-40 years, the probability that the required tests are unnecessary is [(1-0.664)x100]=33.6% lower than for patients aged ≤10 years, which is the reference category. For patients aged 41-80 years, the probability of requesting unnecessary tests [(1-0.552)x100]=54.8% lower than for patients aged ≤10 years. And for patients aged >80 years, the probability of requesting unnecessary tests [(1-0.762) x100]=33.8% lower than for patients aged ≤10 years.

When the use of unnecessary tests was examined according to the academic titles of the physicians, it was found that the unnecessary tests requested by the assistant physicians were 28.4% [(1 -0.716)x100] and unnecessary tests requested by the specialist physician were 64.2% [(1-0.358)x100] less than the unnecessary tests requested by the general practitioners, the reference category.

Discussion

According to the findings of the study, a total of 653.125 requests for 15 different biochemistry tests were made for 133.612 patients during the 18 months within the scope of the study, and the total cost of the tests was calculated as 4.997.384,8 TL ($983.737,3). It was found that 59.685 (9.1%) of the tests requested were unnecessary and the cost of unnecessary requests was 584.186.,3 TL ($114.997,3 - 14.3%). When the literature on the subject was examined, in a retrospective study conducted in Mexico, it was seen that the tests requested for 65% of the patients were unnecessary while the required tests were not requested for 25% of the patients. The estimated cost of unnecessary tests was calculated as $1.129.552 per year 16. In a study conducted by Lanzoni et al. (2017) at a medical faculty hospital in Italy, it was determined that 8.1% of the vitamin D test and 37.1% of the total cholesterol were used unnecessarily and the cost of using the unnecessary test was 500.000 euros[24]. Similar to these results, in a study conducted in Canada by Morgen et al. (2015), the level of unnecessary use of six selected laboratory tests was examined and it was concluded that 16% of all tests were unnecessary[17]. In a study conducted by Kwok and Jones in 2005 on the immunology laboratory of a hospital in Honk Kong, the labor costs of repeated tests over a one year period were calculated and it was seen to be 16.78% of the total labor cost[25]. Similarly, a study conducted in a local hospital in the USA in 2013 indicated that at least 25% of all tests requested are unnecessary or have limited clinical benefit[9]. In two studies conducted in Turkey in 2016, 2018 and 2020. the ratio of requesting unnecessary tests was found as 13.5%, 16.2% and 30% respectively[18,19,26]. From this point of view, the ratio of unnecessary tests found in this study is lower than in these studies. It is thought that the reason for the difference in the results of the studies may be due to the different the hospitals where the studies were conducted, the differences between the levels of development in the laboratory order systems used in these hospitals, and the differences in the laboratory tests evaluated within the scope of the studies.

Similarly, in this study, the ratio of unnecessary test usage also differed according to the type of tests. The ratio of unnecessary test for 15 biochemistry tests ranged from 0.4% (for HDL cholesterol, Triglyceride, HbA1C tests) to 22.3% (for LDL cholesterol tests). In a study conducted by Chami et al. (2017) in Canada, it was found that unnecessary use was between 6% and 20% for 9 laboratory tests[27]. In this study, unnecessary use was examined according to the type of tests, and it was seen that the most unnecessarily requested test was the LDH test (63.5%), followed by the LDL test with 59.9%, and the Vitamin B12 test with 57.2%. When the costs of unnecessary tests were evaluated, it was found that the LDH test alone constituted 67.9% of the total unnecessary test

costs. The LDH test is used to measure the LDH enzymes found in almost every cell, and if it is found in abnormal numbers, it signals the presence of damage in the region[28]. The fact that it is used quickly and easily, especially in the detection of diseases related to internal departments, makes it frequently preferred by physicians[29].

When the relationship between the use of unnecessary tests and the branches of the tests requested examined, it was observed that surgical branches have a higher probability of requesting unnecessary tests. When the hospital departments in the surgical branches were examined, it was seen that the department with the highest number of test requests was the emergency department. Emergency services are special units that perform diagnosis and treatment for a suddenly emerging health problem. For this reason, the diagnostic methods applied in the emergency services are not questioned many times and it is possible to make various requests to meet the urgent need. In the literature, it has been seen that many studies have been conducted on applications to emergency services, and it is stated in these studies that emergency services are often used in non-emergency situations as inappropriate uses, and it is seen that these uses occur between 4.8% and 90% [30,31].

When the effect of the academic titles of the physicians on the use of unnecessary laboratory tests in the study was examined, it was determined that the majority of the test requests (95.3%) were made by specialist doctors, followed by general practitioners (4.4%) and assistant physicians (0.3%). As the hospital where the study was conducted is a university hospital, it is thought that the number of specialist physicians is higher than the number of general practitioners and assistant physicians, and this causes the number of tests requested by specialist physicians to be higher than the others. In the study, it was observed that general practitioners were more likely to use unnecessary tests than assistant physicians (28.4%) and specialist physicians (64.2%). Although requesting more tests will increase the possibility of requesting more unnecessary tests, general practitioners are more likely to request unnecessary tests than residents and specialists. It is thought that this result may related to the knowledge and experience levels of physicians. Eisenberg (1985) reported in a study that physicians' knowledge and experience levels had an effect on the use of laboratory and imaging tests[32]. In line with this view, in a study conducted by Miyakis et al. (2006) on hospitalized patients in Australia, it was seen that senior physicians requested less unnecessary tests compared to resident physicians, although they requested more tests[33]. In a study conducted by Campbell (1984) in the department of pediatrics, it was found that as the experience of physicians increased, they showed more detailed thinking and research behaviors about diseases and senior physicians requested more tests[34]. In a study conducted in the USA, Yager et al. (1986) examined the effect of physician characteristics on laboratory test orders and stated that physicians' test orders are not only dependent on the signs and symptoms of the patient, but also based on the personal habits and individual characteristics of physicians[35]. There are also findings in the literature indicating that the use of unnecessary laboratory tests is related to the gender of physicians. In a study by Robinson in 1994, it was found that the gender of the physician affected the test requests, that female physicians were more meticulous in their patient treatment processes and therefore ordered more tests wheras male physicians adhered more to treatment guidelines[36]. In a study conducted by Grytten and Sorensen (2003) in Norway to investigate the effect of physician characteristics on physician practices, it was stated that physician' thoughts and beliefs were effective on diagnosis and treatment decisions[37]. In addition, Mast et al. (2007) reported that the diagnosis and treatment habits of physicians differ according to the genders of physicians, and revealed that female physicians treat patients more gently and maternally than male physicians[38]. Veloski et al. (2005) in a study in which they examined physician behaviors related to the use of mammography, suggested that female physicians screen for breast cancer more than male physicians, and that this result may show that female physicians may exhibit different behaviors due to gender-based concerns[39].

When the use of unnecessary tests was examined in terms of demographic characteristics of the patients, it was seen that the probability of requesting unnecessary tests for patients over the age of 10 years was lower than for patients aged 10 years and younger. And the mean age of patients for whom unnecessary tests were requested was found to be 52.2 years. The reason why unnecessary tests are used more for patients under the age of 10 can be explained by the fact that the pediatric patients have difficulties in explaining their problems to their physicians, and the physicians have to perform more tests than necessary to understand the cause of the disease. When age groups are compared, it was seen that the age group with the lowest probability of unnecessary testing compared to pediatric patients is the adult age group, between 41 to 80. Contrary to the findings of this study, a study by Duckett and Romanes (2016) found that unnecessary tests are mostly requested for elderly patients[40]. In a study conducted by Barber et al. (2017) in Canada, it was reported that the mean age of patients who requested unnecessary testing was 43.4 years[41]. It is thought that the reasons why the findings of the studies 19 differ from the findings of our study may be due to the different patient profiles of the studies and the different conditions in the hospital where the studies were conducted.

The study showed that another patient characteristic that significantly affected the use of unnecessary tests was the gender of the patients. The probability of unnecessary tests among the tests requested for male patients was found to be lower than for female patients, in line with statistics on unnecessary use (61.3% of the unnecessary tests were requested for female patients and 38.7% for male patients). Like these results, a Canadian study revealed that more unnecessary laboratory tests were requested for female patients (58.4%)[41]. In a study by Shalev et al. (2009), it was found that 59.6% of the laboratory tests used unnecessarily were for female patients[42]. Contrary to this study, in the study conducted by Kılınçarslan (2018), it was seen that the probability of requesting unnecessary tests was higher in male patients 19. It is thought that the reasons why the findings of the studies 19 differ from the findings of our study may be due to the different patient profiles of the studies, the different conditions in the hospital where the studies were conducted, the different periods in which the studies were conducted, and the different laboratory tests evaluated within the scope of the studies.

Conclusion

As a result, the study showed that the surgical branches, female and older patients, and non-specialist physicians are important risk factors for unnecessary testing. The study provides important clues for decision makers to understand

https://dx.doi.org/10.4314/mmj.v37i1.4

the factors that cause unnecessary testing and control costs. However, considering that the study was conducted only in a university hospital larger-scale studies including the Ministry of Health and private hospitals should be conducted in order to achieve results with stronger external validity. In terms of internal validity, studies that include risk factors that may cause unnecessary use other than the explanatory variables included in this study should be designed.

Limitations and Recommendations

This study was conducted in a university hospital in Turkey, in a specific period, with specific tests. It is recommended that the study be conducted in different types of hospitals and in different periods in order to generalize the study to a larger population.

Acknowledgements

We thank the Muğla Sıtkı Koçman University Training and Research Hospital for their consent and cooperation.

Disclosure statement

The authors report there are no competing interests to declare.

Funding

The author(s) reported there is no funding associated with the work featured in this article.

Authors' Contributions

AA - BŞ: Conceptualization, Data curation, Formal Analysis, Methodology, Project administration Writing – review & editing. AA - BŞ: Writing – original draft, Conceptualization, Formal Analysis. AA - BŞ: Conceptualization, Writing – original draft.

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