Research Article

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Frequency and pattern of test utilization rate in clinical biochemistry laboratory: two different large hospital examples

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Abstract

Objectives: Clinical biochemistry laboratories (CBL) are the most frequently utilized laboratory group in healthcare, and their significance in patient care is indisputable. This study investigated the frequency and pattern of test utilization rate in CBL at two large hospitals' outpatient and inpatient clinics.
Methods: A total of 43,732,428 CBL tests, including clinical chemistry, immunoassay, coagulation, specific proteins, CBC, and urinalysis, were conducted for 12,182,382 patients across two large hospitals in different settings between 2018 and 2022. These tests were analyzed alongside patient admissions data, with a focus on the distribution across various clinics.
Results: A total of 94 % and 93 % of those admitted to Hospitals 1 and 2 were outpatients. They had applied to CBL laboratories for 27.1–30.3 % of outpatients and 81.2–88.7 % of inpatients for at least one test. When analyzing the rates at which laboratory tests were requested for outpatients, it was found that emergency departments had the highest test-requesting rates, ranging from 19.99 to 45.36 %. This was followed by internal medicine clinics, with rates ranging from 13.77 to 14.8 %, and inpatient intensive care units, with rates between 24.31 and 30.14 %. Outpatients had 10–11 test requests for each patient and 16–31 for inpatients. The most frequently requested laboratory tests were CBC, glucose, creatinine, urea, AST and ALT in two hospitals.
Conclusions: Despite significant variations in location, structure, medical staff, and patient demographics, approximately one-third of outpatients and 85 % of inpatients at these hospitals undergo testing in CBL. CBLs are essential for screening, diagnosis, prognosis, and healthcare treatment.

Keywords: test ordering; frequency of laboratory testing; outpatients; inpatients; clinical biochemistry laboratory

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Introduction

The contribution of clinical laboratories to clinical practice in diagnosis, screening, risk analysis, treatment, prognosis, and treatment follow-up is indisputable. Although laboratory tests influence 70 % of medical decisions, this information is often based on observations and lacks sufficient evidence [1–4]. Surveys by Rohr et al. in oncology and cardiology clinics in Germany and the United States revealed that *in vitro* diagnostic products (IVD) were used in 75 % of patients, while laboratory tests affected clinical decisions in 66 % of cases. In this study, IVD products were utilized in 88 % of initial diagnoses, 77 % in treatment follow-up, and 72 % in post-treatment follow-up. Moreover, research on evidence-based clinical guidelines indicates that at least 80 % of guidelines for diagnosis or disease management require laboratory testing [5].

We have limited detailed information regarding the utility rate and pattern of clinical biochemistry laboratory (CBL) tests. Some study results have indicated that

laboratory tests were used in 41 % of emergency room cases requiring IVD products [6], 38 % of general internist visits, 29 % of family physician visits [7, 8], and 33.9 % of primary care physician visits [9].

This study aimed to find out how often CBL tests are used in hospitals, which departments request them the most, and what types of tests are commonly requested. We looked at how inpatients and outpatients from different departments use these tests. We also explored how CBL test distributions vary across departments. Additionally, we investigated the link between test requests and insurance reimbursement.

Materials and methods

This study included two major public hospitals, which were distinct in their geographical locations and clinical infrastructures. Hospital 1, known as Dışkapı Yıldırım Beyazıt Education and Research Hospital, is situated in Ankara, in the Central Anatolia region of Turkey. The hospital has a total capacity of 760 beds, with approximately 127 dedicated to intensive care. It employs around 1,090 physicians, of which about 440 are specialists, and has a total staff of approximately 5,300. In its emergency department, 17 specialists work 24-h shifts. Notably, Hospital 1 does not include obstetrics, maternity, and children's inpatient wards, as there are specialized hospitals for these services in the nearby area. Between 2018 and 2021, Hospital 1 attended to 9,986,792 patients and processed 32,615,152 clinical biochemistry test results.

Hospital 2, also known as Evliya Çelebi Training and Research Hospital, is located in Kütahya, Turkey, within the Aegean Region. This hospital has a total of 770 beds, 200 of which are dedicated to intensive care. It employs approximately 460 doctors (122 of them are specialist physicians) and has a total workforce of 2,200 employees. Between 2020 and 2021, Hospital 2 conducted 11,117,276 CBL tests for 2,195,590 patients.

The study was approved by the Ethics Committee of the University of Health Sciences, Dişkapi Training and Research Hospital. It was conducted according to the Declaration of Helsinki (25.04.2022, 136/17).

In this study, 85 tests (such as clinical chemistry, immunoassay, coagulation, specific proteins, complete blood count CBC, and urinalysis) were examined among those conducted by CBL. These tests are also shown in Supplementary Material 1.

The data were collected from the Hospital Information System (HIS) named Origo and the Laboratory Information System (LIS) named ALIS, both of which are commercial products of Ventura Software Inc. Data were queried by authorized and expert personnel using Oracle Database 11g Enterprise Edition Release 11.2.0.4, SQL, and PLSQL for both hospitals. The study data does not include any personal information about the patients. Additionally, Microsoft Excel was used for descriptive analysis and graphical representations.

Results

The data for Hospitals 1 and 2 includes numbers of patient visits, clinical distributions of CBL tests, percentages of patients requiring lab tests, and average test requests per patient, as detailed in Tables 1 and 2, and Figures 1 and 2.

Analyzing Hospital 1's data from 2018 to 2021, we find that 94 % of patients were outpatients. Twenty-seven percent of outpatients and 81.2 % of inpatients sought at least one CBL test. On average, outpatients required 10 tests each, while inpatients needed 16 biochemistry tests (Table 1, Figure 1A). When examining the CBL test requests, it was found that 19.99 % of outpatients were referred to the emergency department, 14.08 % to internal medicine, and 9.33 % to family medicine. Among inpatients, the top three departments requesting CBL tests were intensive care (30.14 %), emergency services (8.82 %), and chest diseases (5.30 %). At Hospital 1, it was noted that an average of 10 tests per outpatient and 16 tests per inpatient were requested.

Hospital 2's data shows that 93 % of their patients were outpatients. Among these, 30.3 % of outpatients and 88.7 % of inpatients requested a CBL test. Additionally, 45.36 % of outpatient CBL test requests came from the emergency department, 13.77 % from internal diseases, and 5.58 % from pediatric services. The top three inpatient departments requesting CBL tests were intensive care (24.31 %), infectious diseases (15.01 %), and internal diseases (14.19 %). On average, Hospital 2 requested 11 tests per outpatient and 31 for inpatients (see Table 2, Figure 1B).

The COVID-19 pandemic significantly impacted test requests in Hospital 1, particularly for CRP, d-dimer, and additional tests like ferritin and fibrinogen (Figure 3). These tests saw a 2- to 100-fold increase, significantly affecting hospital operations, costs, and reimbursements.

In Hospitals 1 and 2, the intensive care units had the highest number of test requests per patient (77 and 109 tests, respectively). CBL tests were ordered for almost all patients (>99 %) in these units.

Our review of CBL test requests found notable patterns in Hospitals 1 and 2. For outpatients at Hospital 1, the most frequently requested tests were CBC, creatinine and ALT, with request rates of 6.4 , 6.1, and 5.6 %, respectively. In contrast, inpatients at this hospital most often required CBC, creatinine, urea and K tests, with rates of 6.4 , 6.0, 5.9 and 5.9 %, respectively (see Supplementary Material 2A, Hospital 1).

At Hospital 2, the most common tests for outpatients were glucose, creatinine, and CBC, with rates of 7.76 , 6.89, and 6.1 %, respectively. The inpatient group showed a similar trend, with glucose, creatinine, and CBC being the most requested at rates of 6.6 , 6.3, and 4.9 %, respectively (Supplementary Material 2B, Hospital 2).

However, we observed a shift in test importance when comparing the number of tests performed with their financial reimbursement (see Supplementary Material 3). At

Table 1: For Hospital 1, the number of patients, % of patients for whom laboratory testing is ordered, the number of patient tests, clinical distribution, and average number of tests per patient.

Hospital 1	Number of patients[a]	Outpatient ratio	% of patients for whom laboratory testing is ordered		Number of CBL tests		CBL test ratio, %		Number of average test per patients	
			Outpatient	Inpatients	Outpatient	Inpatients	Outpatient	Inpatients	Outpatient	Inpatients
Total patients	9,986,792	0.94	27.0	81.2	24,595,478	8,019,674	100	100	10	16
Anesthesiology and reanimation (algology)	266,966	0.46	18.9	71.4	94,971	99,564	0.39	1.24	4	1
Brain and nerve surgery	228,574	0.95	12.9	75.1	261,777	140,093	1.06	1.75	9	16
Cardiac surgery	118,127	0.93	25.5	76.5	302,335	244,705	1.23	3.05	11	39
Cardiology	384,556	0.93	37.5	94.7	897,433	231,525	3.65	2.89	7	9
Chest diseases	287,753	0.92	29.9	91.9	313,263	424,895	1.27	5.30	4	20
Child health and diseases	229,383	1	18.5		472,738		1.92		11	
Ear nose throat diseases	545,299	0.97	12.6	61.1	469,188	178,168	1.91	2.22	7	18
Emergency medicine	1,563,371	0.97	27.0	92.1	4,915,684	707,611	19.99	8.82	12	16
Endocrinology and metabolic diseases	372,660	0.98	41.0	98.4	1,329,905	64,069	5.41	0.80	9	9
Eye diseases	341,716	0.96	10.9	42.0	76,999	12,868	0.31	0.16	2	2
Family medicine	667,070	1	27.3		2,294,852		9.33		13	
Gastroenterology	220,748	0.97	30.2	95.7	869,317	190,257	3.53	2.37	13	30
General surgery	413,619	0.93	32.1	77.7	1,193,444	432,420	4.85	5.39	10	19
Gynecology and obstetrics	26,929	1	41.3		51,483		0.21		5	
Hematology	110,275	0.95	57.2	90.3	643,265	283,643	2.62	3.54	11	57
Infectious diseases	337,397	0.94	16.5	98.0	485,791	466,308	1.98	5.81	9	24
Intensive care	31,853	0		99.0		2,417,375		30.14		77
Internal diseases	705,634	0.98	44.5	98.1	3,462,688	396,808	14.08	4.95	11	29
Medical oncology	95,156	0.96	53.9	94.6	736,803	196,942	3.00	2.46	15	55
Nephrology	178,209	0.92	50.5	98.4	877,064	211,881	3.57	2.64	17	15
Neurology	339,961	0.96	28.2	97.7	930,970	226,469	3.79	2.82	10	17
Occupational diseases	7,187	1	81.1		36,581		0.15		6	
Orthopedics and traumatology	573,544	0.96	10.1	79.5	429,253	462,224	1.75	5.76	8	25
Physical medicine and rehabilitation	370,215	0.99	24.8	94.3	996,357	109,499	4.05	1.37	11	31
Plastic, reconstructive surgery	83,053	0.93	9.7	66.5	92,914	83,625	0.38	1.04	12	22
Psychiatry	332,682	0.98	12.9	97.9	233,206	54,346	0.95	0.68	6	8
Radiation oncology	27,430	0.98	10.9		33,104		0.13		11	
Rheumatology	143,596	0.99	49.1	98.6	491,207	1,201	2.00	0.01	7	1
Skin and venereal diseases	427,279	0.99	22.0	89.9	641,349	45,793	2.61	0.57	7	12
Thoracic surgery	15,672	0.76	25.9	96.1	19,874	11,602	0.08	0.14	6	3
Urology	363,018	0.96	45.2	69.4	871,911	321,254	3.55	4.01	6	32
Others[b]	227,284	0.98	13.0	69.5	69,752	4,529	0.28	0.06	2	1

[a]Number of patients: the person who applied to this hospital or department. [b]Others: dental clinics, radiology, medical genetics, immunology and allergy diseases, undersea and hyperbaric medicine etc.

Table 2: For Hospital 2, the number of patients, % of patients for whom laboratory testing is ordered, the number of patient tests, clinical distribution, and average number of tests per patient.

Hospital 2	Number of patients[a]	Outpatient ratio	% of patients for whom laboratory testing is ordered		Number of CBL tests		CBL test ratio, %		Number of average test per patients	
			Outpatient	Inpatients	Outpatient	Inpatients	Outpatient	Inpatients	Outpatient	Inpatients
Total patients	2,195,590	0.93	30.3	88.7	6,811,351	4,305,925	100	100	11	31
Anesthesiology and reanimation (algology)	26,040	0.54	91.2	96.6	17,005	107,776	0.25	2.50	1	9
Brain and nerve surgery	33,096	0.94	8.5	89.8	13,961	15,130	0.20	0.35	5	8
Cardiac surgery	15,658	0.85	29.7	90.9	20,724	114,120	0.30	2.65	5	53
Cardiology	76,901	0.82	37.8	95.7	148,173	115,293	2.18	2.68	6	8
Chest diseases	37,103	0.8	33.4	95.6	61,153	110,499	0.90	2.57	6	15
Child health and diseases	122,309	0.91	34.2	90.7	379,929	207,056	5.58	4.81	10	20
Ear nose throat diseases	78,125	0.96	14.4	71.7	49,506	44,806	0.73	1.04	5	20
Emergency medicine	871,388	0.97	26.7	92.6	3,089,651	334,386	45.36	7.77	13	13
Endocrinology and metabolic diseases	28,249	0.96	59.7	82.9	204,981	4,547	3.01	0.11	12	5
Eye diseases	97,057	0.97	9.8	46.4	27,752	12,557	0.41	0.29	3	9
Family medicine	33,379	1	41.0		211,183		3.10	0.00	15	
Gastroenterology	22,559	0.87	39.5	95.0	131,200	94,918	1.93	2.20	16	34
General surgery	59,272	0.88	38.2	86.6	155,449	237,566	2.28	5.52	7	38
Gynecology and obstetrics	81,640	0.91	53.7	89.6	271,074	91,440	3.98	2.12	6	14
Hematology	19,271	0.75	60.1	72.6	115,600	76,621	1.70	1.78	13	22
Infectious diseases	93,742	0.9	7.7	96.2	50,317	646,157	0.74	15.01	7	71
Intensive care	9,654	0		99.1		1,046,756	0.00	24.31		109
Internal diseases	110,200	0.9	59.5	83.3	937,678	610,847	13.77	14.19	15	66
Medical oncology	22,057	0.96	45.2	81.5	151,360	17,401	2.22	0.40	15	24
Nephrology	14,770	0.86	55.3	93.7	182,521	5,564	2.68	0.13	26	3
Neurology	65,662	0.9	35.8	76.3	190,845	149,456	2.80	3.47	9	29
Occupational diseases	5,136	1	84.2		7,086		0.10		1	
Orthopedics and traumatology	88,174	0.94	12.3	89.6	40,445	161,492	0.59	3.75	4	34
Physical medicine and rehabilitation	6,708	0.8	48.0	99.5	1891	24,898	0.03	0.58	1	18
Plastic, reconstructive surgery	7,179	0.83	8.4	37.8	3,435	3,683	0.05	0.09	6	8
Psychiatry	24,749	0.97	32.9	72.2	5,593	721	0.08	0.02	1	1
Radiation oncology	6,787	0.97	39.6	75.0	39,772	2,998	0.58	0.07	15	19
Rheumatology	8,666	0.96	63.4	69.0	102,253	1,287	1.50	0.03	19	5
Skin and venereal diseases	41,534	0.99	22.7		61,804		0.91	0.00	6	
Thoracic surgery	4,210	0.7	35.1	95.8	2,259	13,065	0.03	0.30	2	10
Urology	50,818	0.91	48.3	65.2	126,767	51,739	1.86	1.20	5	17
Others[b]	33,497	0.98	5.2	70.8	9,984	3,146	0.15	0.07	5	6

[a]Number of patients: the person who applied to this hospital or department. [b]Others: dental clinics, radiology, medical genetics, immunology and allergy diseases, undersea and hyperbaric medicine etc.

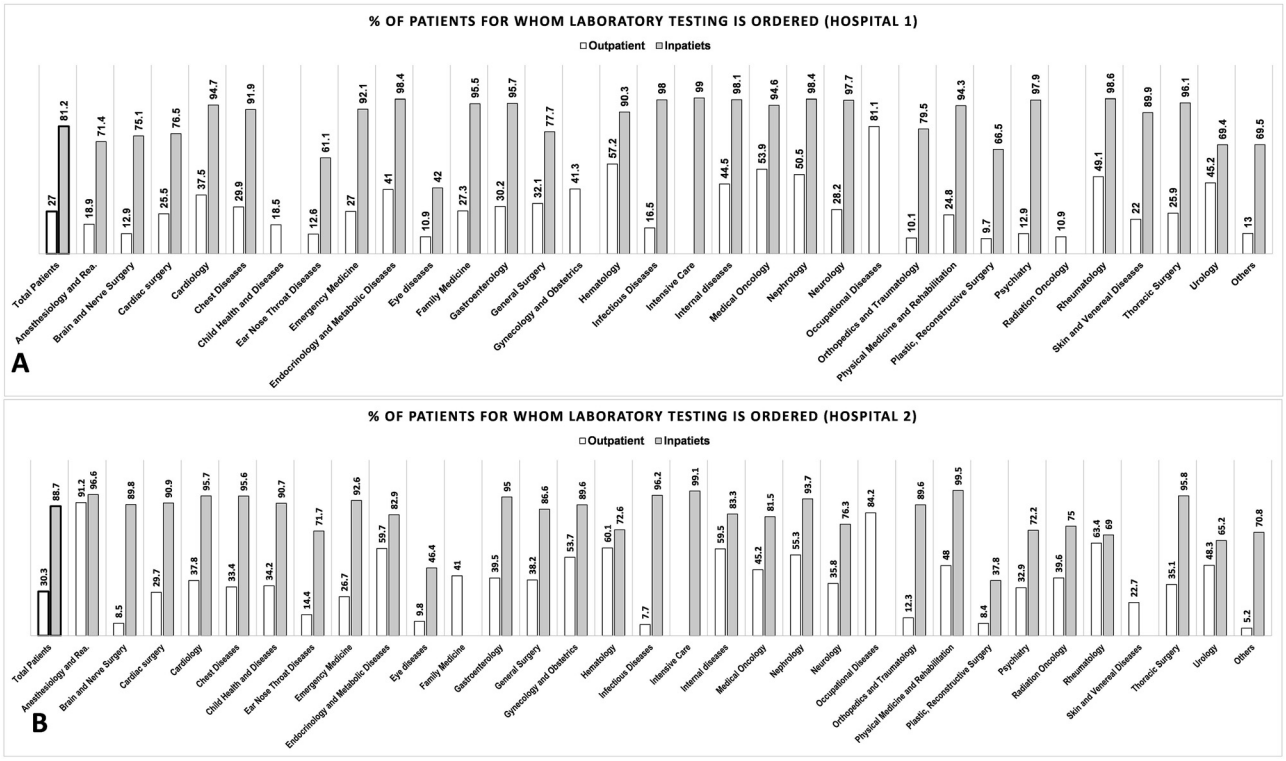

Figure 1: Percentage of patients for whom laboratory testing is ordered for Hospital 1 (A) and Hospital 2 (B).

Hospital 1, around 50 % of the reimbursements were for tests like 25-hydroxycholecalciferol (25(OH)D3), CBC, HbA_{1c}, PT, aPTT, TSH, BGA, procalcitonin, d-dimer, urinalysis, and vitamin B12. Similarly, at Hospital 2, half of the reimbursements were attributed to tests like d-dimer, CBC, PT, troponin, CRP, aPTT, BGA, 25(OH)D3, ferritin, HbA_{1c}, and glucose.

Discussion

The value of laboratory work within a healthcare system is multifaceted, encompassing disease prevention, early detection, accurate diagnosis, selection of appropriate treatment, minimization of treatment delays, support in recovery, reduction of disability, prevention or delay of disease progression, and decreasing the reliance on long-term care. These objectives are central to the purpose of laboratory testing, as these tests play a crucial role in guiding clinical decisions at each of these stages [10].

Various studies have examined utilizing laboratory tests in healthcare [11, 12]. In a study by Ngo et al., it was found that 35 % of patients had at least one laboratory test ordered. However, this percentage varied significantly depending on the patient care area. The study reported that 98 % of inpatients, 56 % of emergency room patients, and 29 % of outpatients requested at least one laboratory test. In Ngo et al.'s study, the focus was on diagnostic tests, while all non-diagnostic tests were excluded. A 'diagnostic test' was defined as a procedure used to investigate a patient's physiological state, with the results helping doctors determine a diagnosis or treatment plan. Diagnostic tests in this context included radiology, vital signs, respiratory tests, invasive cardiology tests, vascular laboratory tests, and pathology laboratory tests. In contrast, non-diagnostic tests, which do not influence a clinician's diagnosis or medical judgment (such as requests for medication, diet, or physical rehabilitation), were not considered. The study found that the most common diagnostic tests were vital signs (53 %), laboratory tests (26 %), and respiratory tests (18 %). For outpatients, the most frequently used diagnostic tests were laboratory tests (70 %), vital signs (18 %), and radiology tests (7 %). According to the study, at least one of these diagnostic tests was requested for 29 % of outpatients, 56 % of emergency room admissions, and 98.2 % of inpatients [12]. Unfortunately, in this study, since there was no information on which tests were conducted in the laboratory, we could not compare them with our findings.

The group of patients in outpatient services who require laboratory tests for treatment monitoring typically includes those with chronic diseases needing regular laboratory tests, infectious diseases with mild symptoms, and

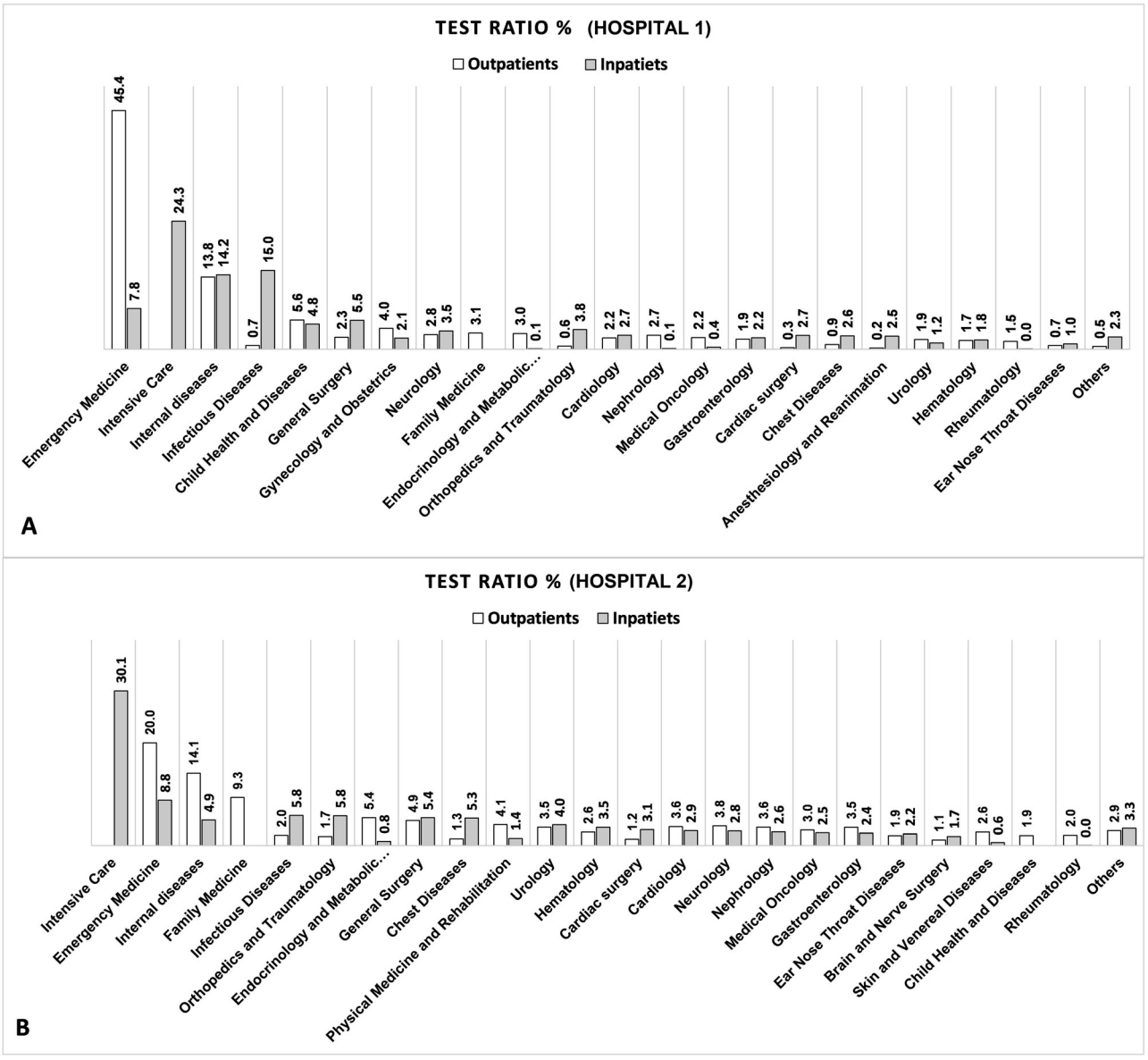

Figure 2: Total test ratio of each department for Hospital 1 (A) and Hospital 2 (B).

individuals undergoing cancer follow-ups. However, not all services necessitate laboratory testing; physical checkups, routine outpatient follow-ups, and elective procedures often do not require such tests [9]. The frequency of lab test requests made by family physicians and general internists in outpatient treatment varies, ranging between 29 and 38 % [13]. These figures align with the findings of our study. Additionally, our study provides detailed information about the test request rates specific to each clinic.

In a study by Mwape et al. involving interviews with 80 clinicians, 96.2 % reported using laboratory tests in patient management. Additionally, 77.5 % of these clinicians consistently rely on laboratory results to guide their decisions in managing patient care. However, the study also found that many physicians doubted the reliability of these laboratory test results. This finding underscores the need for better communication and interaction between laboratory and clinical departments to bolster clinicians' confidence in laboratory data [14]. In a separate study by Moyo et al., which surveyed 216 physicians, 70 % of the respondents said they used laboratory tests. Moreover, they reported that 91 % of the laboratory tests requested by clinicians were directly related to patient management [15].

In our study, we focused exclusively on CBL tests. Other types of laboratory tests, such as microbiology, pathology, genetics, and radiology, were not included. We selected

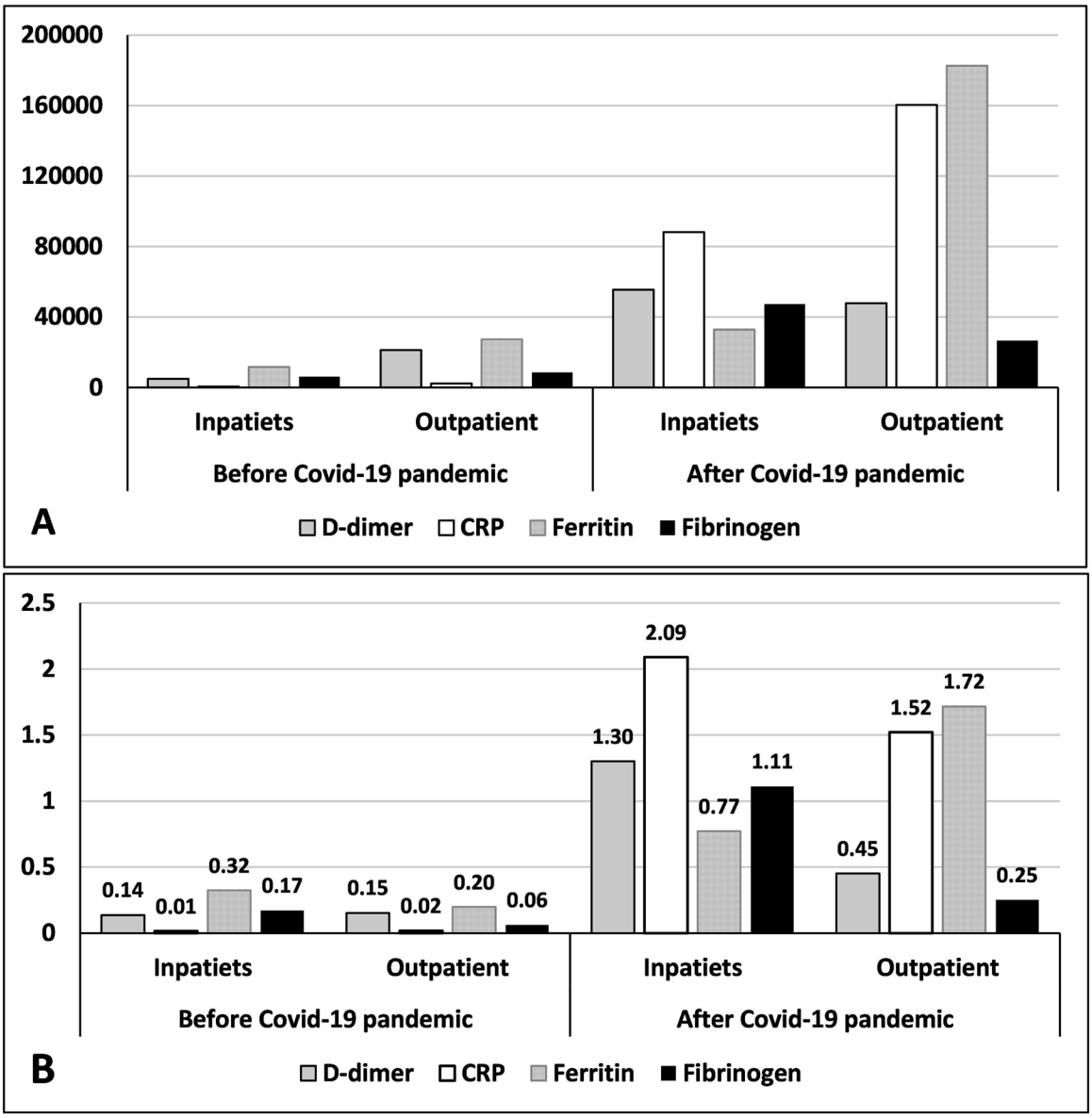

Figure 3: Change of d-dimer and CRP, ferritin, and fibrinogen test numbers (A) and rates (B) for Hospital 1 before and after the Covid 19 pandemic.

nearly all the tests that the CBL could perform. Our findings showed that at least one CBL test was ordered for 27.0–30.3 % of outpatients, between 81.2 and 88.7 % of inpatients, and 19.9–44.7 % of emergency department patients. These data highlight that clinical laboratory tests are among the most frequently requested types in a laboratory setting. Additionally, our study provides detailed information regarding the specific tests requested by various clinics.

Research on CBL test ordering is limited. Furthermore, factors such as the country where the tests are ordered, the structure of the health system, the impact of the pandemic, hospital characteristics, healthcare provider status, economic conditions, and other variables can vary greatly. Our study was conducted in two hospitals, where we observed significant differences in the frequency and pattern of test utilization rate in CBL. Notably, in emergency services, there was a marked difference in clinical laboratory admissions (19.9 % in Hospital 1 and 45.36 % in Hospital 2). These variations could be attributed to the hospital's location, its structure, and particularly the impact of the Covid-19 pandemic. While Hospital 1 provided data from both pre- and post-COVID-19 periods, Hospital 2's data were solely from the post-pandemic period. These findings demonstrate that varying circumstances can significantly affect CBL test orders. Despite these differences, the overall percentage of patients for whom laboratory tests were ordered in both

hospitals was similar (27.0–30.3 % for outpatients and 81.2–88.7 % for inpatients). In other studies, the rates of laboratory test orders for patients have been reported as 41 and 56 % [8, 16]. However, our study is distinct in terms of the definition of tests, duration, the breadth of data, distribution across clinics, and being multicentric. These results are vital for shaping the interaction between laboratories and clinics. Based on this data, laboratory specialists will be better positioned to understand which tests and clinics require more focus. Particularly, CBL specialists should establish strong communication channels with departments like emergency medicine, intensive care, internal medicine, endocrinology, and infectious diseases. Our study is the most comprehensive in terms of CBL test utilization in the existing literature.

The habits of physicians regarding laboratory test usage in a country are intricately linked to that country's health system. In the case of Turkey, the health system reveals some key figures. The per capita health expenditure is around $665. Both private and public health systems operate in the country, with 98 % of the population covered by health insurance. The health resources are primarily funded by taxes, with 7.5 % collected from employees and 5 % from employers. Approximately 75.2 % of health expenditures are financed by the public sector [17]. Within this framework, medical examinations, treatments, and laboratory tests are provided free of charge.

The clinics that most frequently require laboratory tests include emergency services and internal medicine for outpatients, as well as intensive care and internal diseases for inpatients. Notably, the data from Hospital 2, which is based on the post-Covid-19 pandemic period, shows a significant increase in test requests for infectious diseases. A critical finding of our study is that intensive care units, on average, request a remarkably high number of Clinical Biochemistry Laboratory (CBL) tests, ranging from 77 to 109 per patient, for virtually all (>99 %) patients. This high frequency of repeated and numerous CBL tests in the monitoring of patients underscores the essential role of CBL laboratories in patient care.

When analyzing the average number of tests requested per patient, we found that 7.5 tests were ordered per patient overall, with this number rising to 9.5 for those visiting the internal medicine department. A similar study conducted in America reported an average of 9.67 tests per inpatient, highlighting that CBC was the most commonly requested test [10, 18]. Our study yielded comparable results, with an average of 10–11 tests for outpatients and CBC also being among the most frequently used tests. However, our research provided these data with more detailed breakdowns across different clinics. Regarding the emergency department, the patient population is diverse, including cases of minor injuries, infectious diseases, severe acute illnesses such as stroke and acute myocardial infarction, and severe trauma. This wide range of conditions, from simple to life-threatening, suggests that laboratory use in the emergency department may be less than that in inpatient services. Studies indicate a variance in the data, with 56 and 41 % of individuals seeking emergency department care requiring laboratory tests [8, 12]. Factors influencing this include the population served, hospital location, the nature of the emergency department, the economic structure of the health system, and the choice of laboratory tests. In light of this data, health policies can be developed regarding which tests and units can be used for corrective and preventive actions in health expenditures.

Upon examining the test requests in CBL (see Supplementary Material 1), it is evident that about half of the laboratory tests in both hospitals are comprised of CBC, glucose, creatinine, urea, ALT, AST, sodium, potassium, bilirubins, and calcium. These tests are fundamental to most CBL laboratories, offering high sensitivity for various conditions and are primarily used for monitoring purposes in patient care. However, a different picture emerges when looking at the reimbursement data, which reflects the laboratory's income. Approximately 50 % of Hospital 1's laboratory income comes from tests like 25(OH)D, CBC, HbA_{1c}, PT, aPTT, TSH, BGA, procalcitonin, d-dimer, urinalysis, and vitamin B12. In Hospital 2, the main contributors to reimbursement d-dimer, CBC, PT, troponin, CRP, aPTT, BGA, 25(OH)D, ferritin, HbA_{1c}, and glucose. These findings are significant in understanding the tests performed by hospitals and their relationships with reimbursement. They should be carefully considered in cost analysis and the calculation of health expenditures.

Despite their clinical importance, laboratory tests contribute only between 2 and 5 % to the overall healthcare budget from an economic perspective, yet they are highly profitable. Clinical laboratories are not just crucial for patient care; they also serve as a significant economic asset for healthcare systems. Some cost-analysis studies have debated the need to de-emphasize the role of laboratory medicine. These studies suggest that public laboratory services could be reduced or that services could be outsourced to private institutions outside of hospitals [19]. In line with this, efforts are underway in Turkey to shift towards larger central laboratories, separate from hospitals.

Conducting studies on the effectiveness of laboratory tests is challenging, especially as different countries implement varied health system procedures. The task of determining the value of *in vitro* diagnostic products (IVDs) has been particularly complex.

Despite the clinical value of laboratory tests, from an economic point of view, the impact of laboratory tests on the healthcare budget is between 2 and 5 %. However, its profitability is very high. Clinical laboratories are not only vital to patient care but also represent a valuable economic resource for healthcare systems. In some cost studies, the concepts that will reduce the importance of laboratory medicine and that public laboratory services can be reduced or services can be obtained from private institutions other than hospitals are discussed (19). Similarly, in Turkey, efforts to turn to large central laboratories other than hospitals have begun.

Studying the effectiveness of laboratory tests is complex because health system practices vary across different countries. The effectiveness of IVD products is defined by their ability to deliver highly accurate (reliable and reproducible) results within an optimal turnaround time. Efficiency is measured by the ratio of clinical decisions made (clinical benefit) to the costs incurred. Here, 'costs' refer to the resources utilized for a specific process, while 'utility' is defined as the most accurate result achievable based on the available evidence for a diagnostic test [20, 21]. Unfortunately, funding calculations for laboratory medicine often prioritize the cost of tests over their clinical value [22]. Our study did not include a cost analysis, which requires detailed studies. Our knowledge in this area is extremely limited. However, even the reimbursement data indicate that laboratory tests contribute significantly to hospital finances.

Our study has certain limitations, a primary one being that we did not evaluate the appropriateness of laboratory test requests. According to a meta-analysis by Zhi, inappropriate requests might constitute about 20.6 % of cases, with a range between 16.2 and 24.9 % [19]. It's possible that our study aligns with these figures. We noted in particular that tests such as Na, Cl, urea, and direct bilirubin may not be necessary in certain clinical scenarios. This observation leads us to believe that, especially in outpatient environments and clinics where such tests are not typically warranted, these requests might be superfluous.

Nearly half of the malpractice cases due to diagnostic errors are caused by not ordering the right diagnostic test, with about a third resulting from diagnosis misinterpretation [23, 24]. This has led to a belief that to avoid malpractice, doctors in our country might be recommending more lab tests than necessary. To understand this better, studies focusing on the reasons behind such trends are recommended. While lab tests don't greatly burden health system finances, the costs of unnecessary tests are still significant [25]. Reducing these unneeded tests could boost trust in laboratory services. Too many test requests may cause 'Ulysses syndrome', where a minor finding triggers a costly and potentially harmful chain of further tests and procedures, adding stress to healthcare systems [26]. Our study is only a descriptive study. However, when the test frequencies and patterns in our study are examined according to clinical units, it shows that more comprehensive studies on inappropriate tests or excessive test orders are needed.

Our study had a notable limitation: it only examined 85 laboratory tests listed in Supplementary Material 1. These tests represent about 98 % of the workload in CBL at both hospitals. Including additional tests would have made the study and data analysis more complex. Since nearly every patient is likely to have at least one of these tests, omitting others does not greatly impact the percentage of patients using laboratory services. We did not include tests from microbiology, molecular genetics, pathology, or radiology. In our country, as in many others, the areas of expertise, operating procedures, and procurement systems in CBL vary significantly. Due to these differences and limitations in our current software infrastructure, it was not feasible to add these tests to our study. Moreover, our goal was to focus on the use of CBL tests, about which there is limited literature.

Easy access to laboratory tests does not guarantee that their use will result in sufficient health outcomes. They need to be combined with the expertise of healthcare professionals. Just adding a test to a healthcare system without proper integration won't yield the expected benefits. For instance, in one study, point-of-care systems were introduced to speed up tuberculosis diagnosis. While the detection of drug-resistant tuberculosis increased by 3–8 times, there was no decrease in illness or death rates. This shows that healthcare is complex and involves many factors. Simply improving diagnostic tests isn't enough to enhance patient outcomes [24, 27]. It is essential to have a holistic view of health systems and to keep communication between each unit of this system at a high level at all times.

Our study had a limitation where some patients were moved between different clinics in the hospital, especially to intensive care units. We counted these as separate visits to each clinic.

In 2011, the Ministry of Health established the 'Department of Laboratory Services.' This department conducted significant work and later expanded to include microbiology, genetics, pathology, radiology, tissue typing, and nuclear medicine, renaming itself the 'Department of Examination and Diagnosis Services.' To enhance and standardize laboratory practices in Turkey, various 'Good Laboratory Practices' were introduced. These include autoverification, laboratory consultation, reflex and reflective testing, encouraging reasonable test requests and reducing

unnecessary ones, standardizing critical value applications, harmonizing measurement units, and standardizing test reports. These practices are ongoing, and all laboratories are regularly inspected to ensure compliance.

As a result, CBL is the most active and most frequently tested laboratory group. Despite their low costs, CBL tests are of vital importance for patient care. Clinicians, particularly in internal medicine, intensive care and emergency services, frequently and consistently rely on these tests for decision-making. However, the use and frequency of these tests vary greatly among hospitals and clinics. We need more comprehensive studies on the effective use of CBL tests, their clinical value and their effects on outcomes.

Research ethics: The local Institutional Review Board deemed the study exempt from review. The study was approved by the Ethics Committee of the University of Health Sciences, Dişkapi Training and Research Hospital. It was conducted according to the Declaration of Helsinki (25.04.2022, 136/17).

Informed consent: Informed consent was obtained from all individuals included in this study.

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