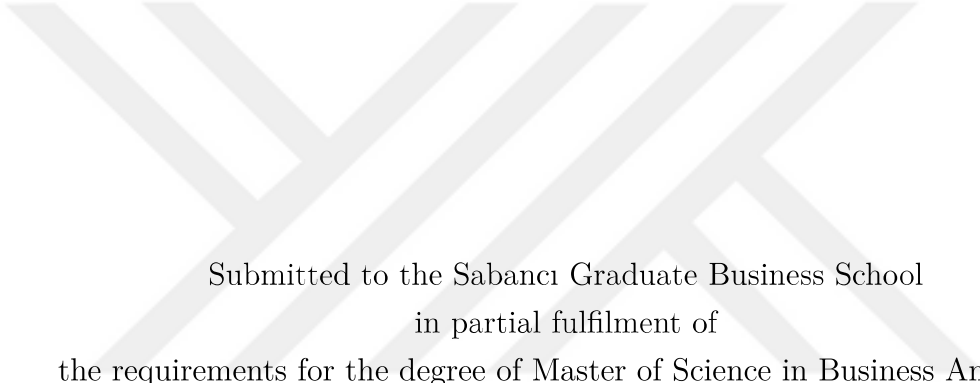


**DESIGNING A DIAGNOSTIC TEST ORDER RECOMMENDATION
SYSTEM: A DATA ANALYTICS APPROACH**

by
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in partial fulfilment of
the requirements for the degree of Master of Science in Business Analytics

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DESIGNING A DIAGNOSTIC TEST ORDER RECOMMENDATION
SYSTEM: A DATA ANALYTICS APPROACH

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ABSTRACT

DESIGNING A DIAGNOSTIC TEST ORDER RECOMMENDATION SYSTEM: A DATA ANALYTICS APPROACH

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Business Analytics M.Sc. Thesis, SEP 2020

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Keywords: Market basket analysis, diagnostic test order, apriori, frequent itemset detection, internal medicine, ICD code, medical examination, physician workload

In the thesis, we propose a frequent itemset detection based on a diagnostic test order set recommendation by ICD code for internal medicine physicians. In order to carry out this study, we used an examination data from the internal medicine department of a state hospital in Ankara, Turkey, which included 68,033 unique visits and 46,314 unique patients in the closed interval of 2015-2016. In the study, we calculated how using the test sets that we determined with the Apriori algorithm in the training set might affect the test selection effort in the ongoing period. As an evaluation criterion, we used the percentage change in the total number of clicks that the physician will use when choosing a test on HIMS if the test request group is used. In addition, we calculated the percentage of the visit that the recommendation set could be used by looking at the intersection of the examination request of the physician and the test set we recommended.

ÖZET

TEŞHİSE YÖNELİK TETKİK İSTEMİ ÖNERİ SİSTEMİ TASARLAMA: BİR VERİ ANALİTİĞİ YAKLAŞIMI

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İŞ ANALİTİĞİ YÜKSEK LİSANS TEZİ, EYLÜL 2020

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Anahtar Kelimeler: Market sepeti analizi, tetkik istemi, apriori, sık görülen ürün seti tespiti, iç hastalıkları, ICD kodu, tıbbi muayene, doktor iş yükü

Bu tezde, iç hastalıkları hekimlerinin kullanımı için, sık ürün kümeleri tespiti yöntemini kullanarak ICD grupları özelinde tıbbi tetkik istemi öneri seti tasarladık. Bu çalışmayı gerçekleştirmek için, 2015-2016 kapalı aralığında 68.033 tekil ziyaret ve 46.314 tekil hasta bilgisi içeren bir devlet hastanesinin iç hastalıkları bölümüne ait muayene verilerini kullandık. Çalışmada, eğitim setinde Apriori algoritması ile belirlediğimiz önerilen tetkik istem gruplarını kullanmanın devam eden süreçte doktorun tetkik istem eforunu nasıl etkileyebileceğini hesapladık. Değerlendirme kriteri olarak, tetkik istem grubunun kullanılması durumunda, doktorun HBYS üzerinden test seçimi yaparken kullanacağı toplam tık sayısının yüzde değişimini esas aldık.

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*Dedicated to
all healthcare professionals who work with great sacrifice under difficult conditions
during the COVID-19 pandemic*

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1. INTRODUCTION

Physicians have to manage many different tasks at the same time during the day. When we consider only an examination process, it is necessary to complete tasks such as listening to the medical history of the patient, physically examining the patient, making a preliminary diagnosis and determining the ICD code, and choosing the tests he orders. According to our data, physicians have to complete all these tasks in approximately 10 minutes. When we consider the other duties of the physician and his fatigue during the day, solutions that will facilitate the examination process of the physician become inevitable.

In our study, we focused on the diagnostic test order process, which is one of these tasks. When we examined the technology setup and operation of the hospital where we worked, we saw that the test request process was manually operated on HIMS (Chapter 3). The problem in our study was how we could make the diagnostic test selection process more efficient without affecting the physician's decision. While doing this, we have adopted a data analysis-oriented perspective. For this study, we chose internal medicine, which is one of the departments with the most disease diversity. We used the two-year ordered diagnostic tests of the internal medicine department as data (Chapter 4).

Although the data we used did not match as a field, it was largely similar to the market transaction data as its data structure. Therefore, we used the apriori algorithm, which is one of the most known algorithms of market basket analysis (Chapter 5). With the apriori algorithm, we determined the diagnostic test groups that were frequently ordered together. While determining these groups, we took into consideration the ICD codes assigned by the physician as a pre-diagnosis for the patient.

After determining the frequent test sets with 2015 diagnostic test order data, we calculated how the test selection effort of the physician would be affected if these sets were used in 2016. While doing these calculations, we accepted the test selection effort of the physician as the total number of clicks performed while selecting the test to order.

As a result of our analysis, we found that using the set we recommended could positively affect the doctor's test selection effort in 40.23% and 44.54% of the visits in 2015 and 2016, respectively. In the test selections made using our recommended set, we observed that the total number of clicks could decrease by 9.90% for 2015 and 6.80% for 2016 (Chapter 6). In short, with this method, the effort of physicians during test selection can be reduced and the physician can allocate more time to other tasks in the examination.

When we examined the literature (Chapter 2), we did not find any study using market basket analysis on test order data, although there are many articles on the physicians' test order behavior, and market basket analysis has been used in different medical problems. This study has shown that the market basket problem is applicable for the diagnostic test order data, and from now on, frequent itemset detections can be used for designing the HIMS test order panel to reduce the test order effort of the physicians.

2. LITERATURE REVIEW

In this section, we will examine previous studies in similar fields under two main headings. First of all, we will look at the articles written about physician's test order behavior. Then, we will examine the frequent itemset detection studies and its application in healthcare.

2.1 Physicians Test Order Behavior

Physician burnout is a problem that has been studied for a long time. Hospital structures, policies, and procedures are the main factors that lead that burnout (Deckard, Meterko & Field, 1994). With the development of technology, the transition to Hospital Information Management Systems (HIMS) has reduced the workload of the physicians to some extent. HIMS enabled the process of the document to be carried out through computers. Thanks to HIMS, paperwork in examination processes has decreased and it has become more automated through computers. In the study conducted by Chen & Hsiao in 2012, physicians were surveyed for investigating factors affecting physicians' acceptance of hospital information systems. A total of 202 questionnaires were sent out, with 124 completed copies returned, indicating a valid response rate of 61.4%. According to the results of the study, usefulness of HIS related with top management support and ease of use ($\beta = 0.952$, $p < 0.001$, $R^2 = 0.784$) of hospital information systems had a significant impact on the acceptance of the systems, accounting for 81.4% of total explained variance. This study proves that an easy-to-use HIMS is more readily accepted by physicians.

There are few studies conducted on physicians ordering various tests for patients with similar demographic characteristics (Daniels & Schroeder, 1977; Solomon, Hashimoto, Daltroy & Liang, 1998). According to Whiting et al. the factors that influence physician test order can be grouped under five categories: diagnostic factors,

therapeutic and prognostic factors, patient-related factors, doctor-related factors, and policy and organization-related factors. Also use of structured test ordering form mentioned in the policy and organization related factors (Whiting, Toerien, de Salis, Sterne, Dieppe, Egger & Fahey, 2007). Moreover, in the systematic review carried out by Roshanov et al., examples of how computerized clinical decision support systems improve practitioners' diagnostic test ordering behavior are presented (Roshanov, You, Dhaliwal, Koff, Mackay, Weise-Kelly, Navarro, Wilczynski & Haynes, 2011).

The relationship between the design of the test order system and total diagnostic test expenditures has also been the subject of a study carried out in the internal medicine department of Ankara Numune Hospital in Turkey (Yılmaz, Kahveci, Aksoy, Özer Kucuk, Akin, Mathew, Meads & Zengin, 2016). According to this study, they can save 371,183 US dollars in one year by reorganizing the HIMS test ordering page. In the study, unnecessary testing for chloride, folic acid, free prostate-specific antigen, hepatitis, and HIV testing were observed. Test panel use was pinpointed as the main cause of overuse of the laboratory and the Hospital Information System test ordering page was reorganized. It was seen that the main reason for unnecessary testing was that the tests were orders as a panel. Before the reorganization, the mean number of tests per patient was 15.8. A significant decrease (between 12.6–85.0%) was observed for the tests after the reorganization of the HIMS test ordering page.

2.2 Frequent Itemset Detection

Doddi et al., used association rule mining to find relationships between procedures performed on a patient and the reported diagnoses. According to the result of the study they found a relation between “Radiological examination of chest front and lateral view; Automated multi-channel test: one or two clinical chemistry tests; Glycated chemistry tests” and “Diabetes mellitus” with 320 support and 81.63% confidence. Also, “Radiological examination of chest front view; Generic doctor’s office visit; Initial in-patient hospital consultation” has a relation with “Symptoms involving respiratory system and chest” with 637 support and 68.86% confidence. These results show that it is possible to observe a relationship pattern between the ICD code and the ordered diagnostic tests (Doddi, Marathe & Ravi, 2001).

Although it is not a medical practice, it is argued that in the apriori application rel-

atively lower minimum support rates should be selected in sparse datasets according to the study on how to determine the minimum support rate for different types and sizes of data sets (Dahbi, Balouki & Gadi, 2018).

In another study, association rule mining was used to understand the relationship between ICD groups and diagnostic test groups. All diagnostic tests were considered in 4 main categories (LDT-type 1, LDT-type 2, LDT-type 3, and LDT-type 4) and in the analysis, each category was accepted as an item in basket. As a result of the analysis, they observe that LDT-type 1 and LDT-type 2, were frequently requested together (Sarıyer & Öcal Taşar, 2019).

According to a study conducted in the hospital in Taiwan, association rule mining was used for extracting the relation between abnormal health examination results and outpatient illnesses. Instead of apriori, they developed new data cutting and sorting algorithm for decreasing the working time of algorithm (Huang, 2013).

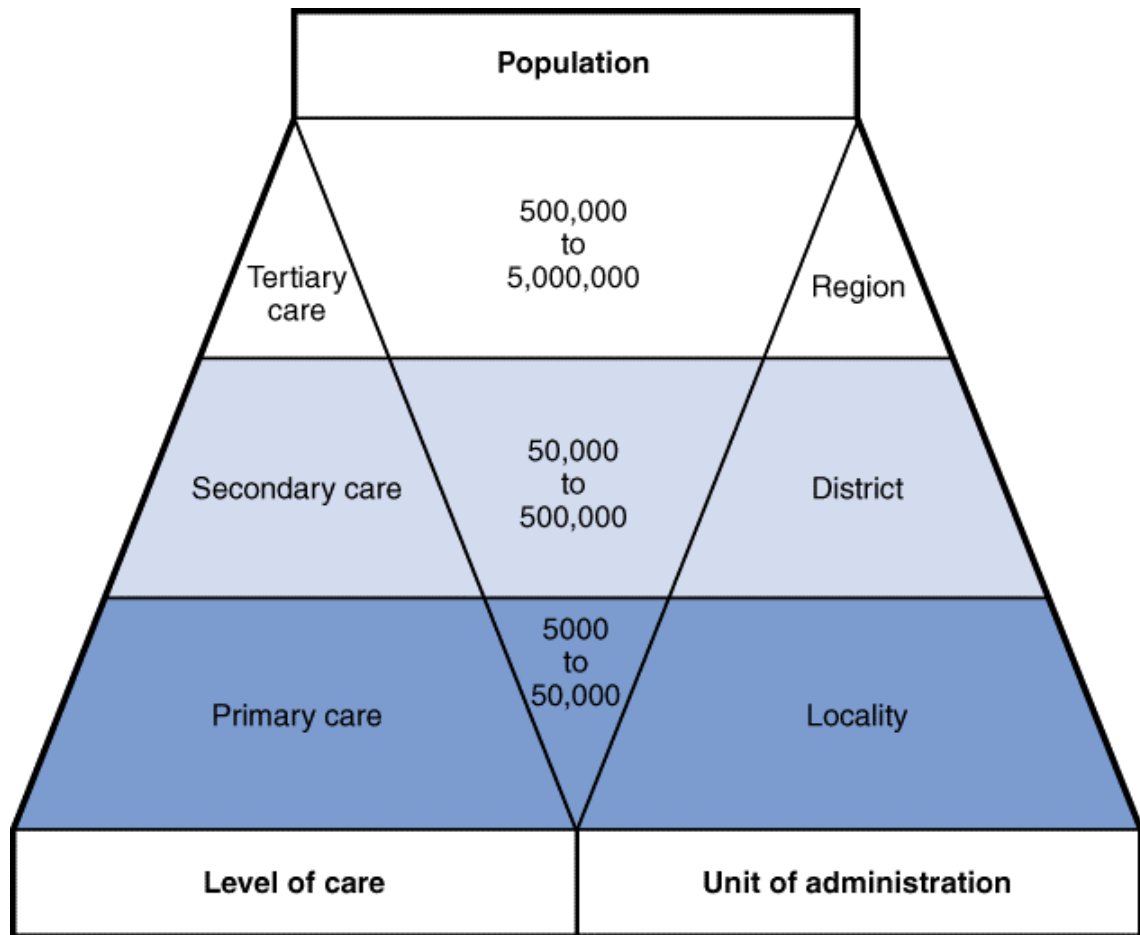
In addition to the apriori algorithm, PNFP-Growth also used in medical database analysis (Wang, Chen, Shi, Zhang, Duan, Chen & Hu, 2017). According to the analysis held on thousands of patient's health examination information, medical database analysis results were found to be quite compatible with clinical information and informative for physicians.

3. EMPIRICAL SETTING

In this section, we briefly review the functioning of the health system in Turkey, the physical and technological conditions of the hospital and the department where our study takes place, and the details of the information system used in the hospital.

3.1 The Turkish Healthcare System

The data used in this study is from an outpatient clinic of high volume research and teaching hospital. In Turkey, although primary care clinics exist and hospitals are labeled as secondary and tertiary healthcare providers, people can easily access to secondary and tertiary health care without applying for primary care. However, people cannot receive secondary or tertiary health care without applying for primary care in GP centered Healthcare systems such as the Netherlands, the UK, and Germany (Loenen, van den Berg, Heinemann, Baker, Faber & Westert, 2016). The Turkish government, in recent years, has tried to transform this flat healthcare system to a pyramid system (see Figure 3.1) (Bodenheimer, Grumbach, Lo, Kierszenbaum, Tres, Ferrier, Lieberman, Marks & Peet, 1995) but has not been able to totally implement this system yet (Akman, Sakarya, Sargin, Ünlüoğlu, Eğici, Boerma & Schäfer, 2017). Hence, patients generally apply directly to hospitals to receive health care, thus causing an increase in the number of patients applying for secondary and tertiary healthcare.



Source: Bodenheimer T, Grumbach K: *Understanding Health Policy: A Clinical Approach*, 6th Edition: www.accessmedicine.com

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Figure 3.1 Healthcare system pyramid

3.1.1 Turkish Health Insurance System

In Turkey, there are two types of health insurance systems that cover healthcare services: (1) public health insurance and (2) private health insurance. Public health insurance is provided by the state, and governed by the Republic of Turkey Social Security Institution (SGK), whereas private health insurance is provided by various private institutions.

Citizens with public health insurance can be examined at the public hospital by paying only a fixed fee for the examination. They do not pay extra fees for the requested tests. They can also be examined in contracted private hospitals via paying extra fees in the rates determined according to the agreement.

Citizens who have private health insurance can be examined in public hospitals, private hospitals, and private clinics according to the agreements of the company they are insured. Whether they pay for the inspection or the amount they will pay varies depending on the scope of their insurance and the insurance company.

3.1.2 Types of Hospitals in Turkey

In the Turkish healthcare system, hospitals can be grouped into three categories: (1) public hospitals, (2) private hospitals, and (3) university hospitals.

Public hospitals are governed by the state and report to the Ministry of Health. Their employees (both physicians and administrators) are appointed by the Ministry of Health. There are currently 884 public hospitals in Turkey; these vary from all-purpose hospitals to specialized institutions for gynecology, dental care, etc. The patients covered by public health insurance are cared for free or pay very nominal amounts in public hospitals; this includes not only the cost of examination, but also of tests and surgical operations. Private health insurance cannot be used in public hospitals.

Private hospitals do not report to the Ministry of Health, and are owned and managed by private enterprises. Public health insurance can be used only limitedly in private hospitals; in cases where there is an agreement between the state and the hospital, the public health insurance may cover certain treatments and surgeries performed in private hospitals. Hence, patients admitted to these hospitals either pay for their care themselves, or are covered to various degrees by private health insurance, if they have any. There are currently 560 private hospitals in Turkey.

University hospitals are affiliated with medical schools, and hence are fewer in number (there are currently 70 university hospitals in Turkey). They are funded by revolving funds, and the staff of university hospitals constitute of the faculty members and the students of the medical faculty they are affiliated with.

2015 YILI GENEL HİZMET BİLGİLERİ

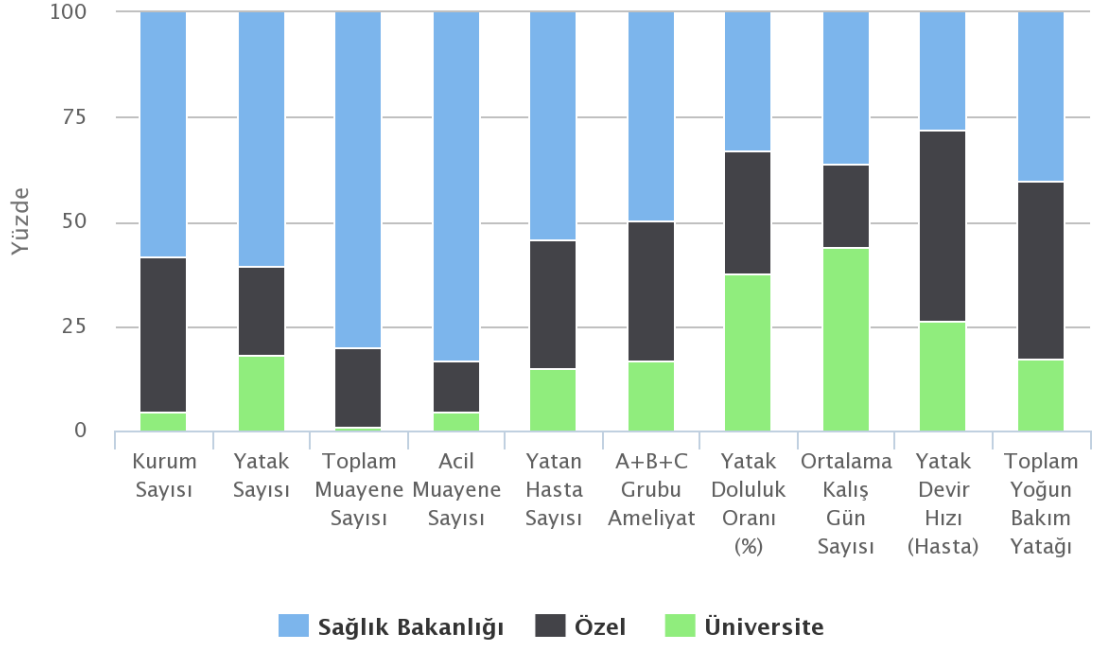


Figure 3.2 General health service information for 2015

In the Turkish healthcare system, most patients receive healthcare through public hospitals, Figure 3.2 (Republic of Turkey Ministry of Health, 2016) shows the general information about health services in Turkey in 2015. In this stacked column graph, blue color depicts public hospitals, black color depicts private hospitals, green color depicts university hospitals. First Column shows the distribution of the total number of hospitals in Turkey in terms of hospital type. The third column shows the distribution of the total number of examinations by hospital types. As seen in the Figure 3.2, although the number of public hospitals in Turkey is only 1,6 times more than the number of private hospitals, 4,25 times more examinations occurred in public hospitals in comparison to private hospitals in 2015 (which is the period of focus in this study) because on average, the capacity of public hospitals (both the physical size and the number of working physicians) exceeds that of private hospitals, and hence, they can serve more patients than private hospitals per unit time.

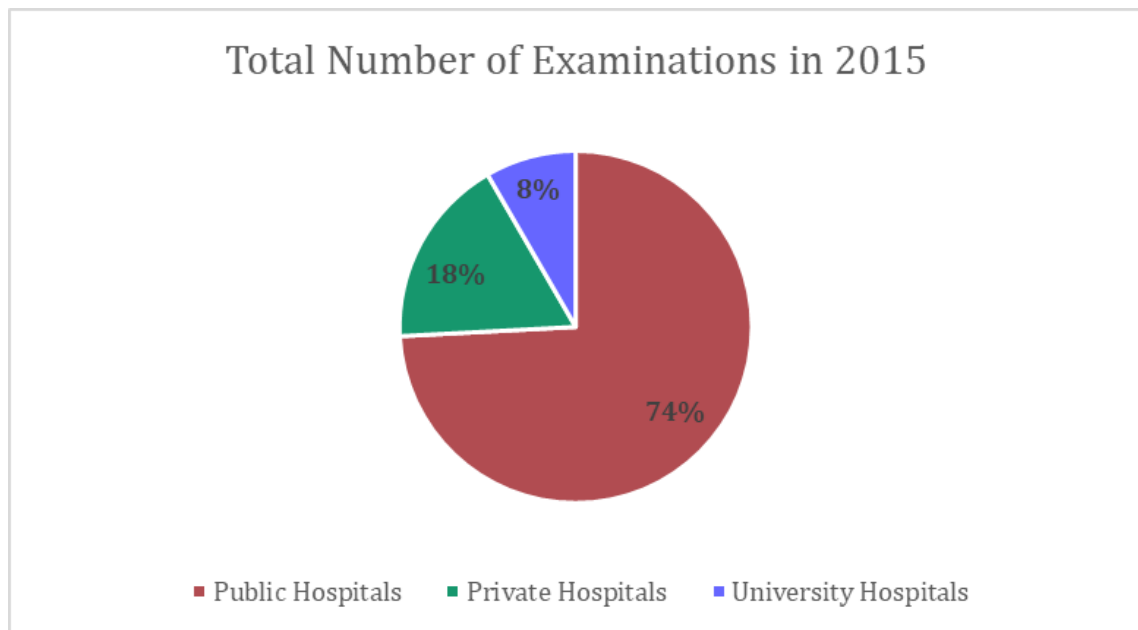


Figure 3.3 Total number of examinations in 2015

In fact, as seen in Figure 3.3 (Republic of Turkey Ministry of Health, 2016), 74% of all total patient examinations in 2015 occurred in public hospitals. This is why public hospitals in Turkey is an essential resource for health care management and research. The place of state hospitals in the total number of examinations is not limited to 2015. Since 2002, the number of examinations in total public hospitals has been increasing in parallel with the total number of examinations as seen in Figure 3.4 (In this figure, the blue columns show state hospitals, red columns show private hospitals, yellow columns show university hospitals. Y axis contains the total number of examinations.).

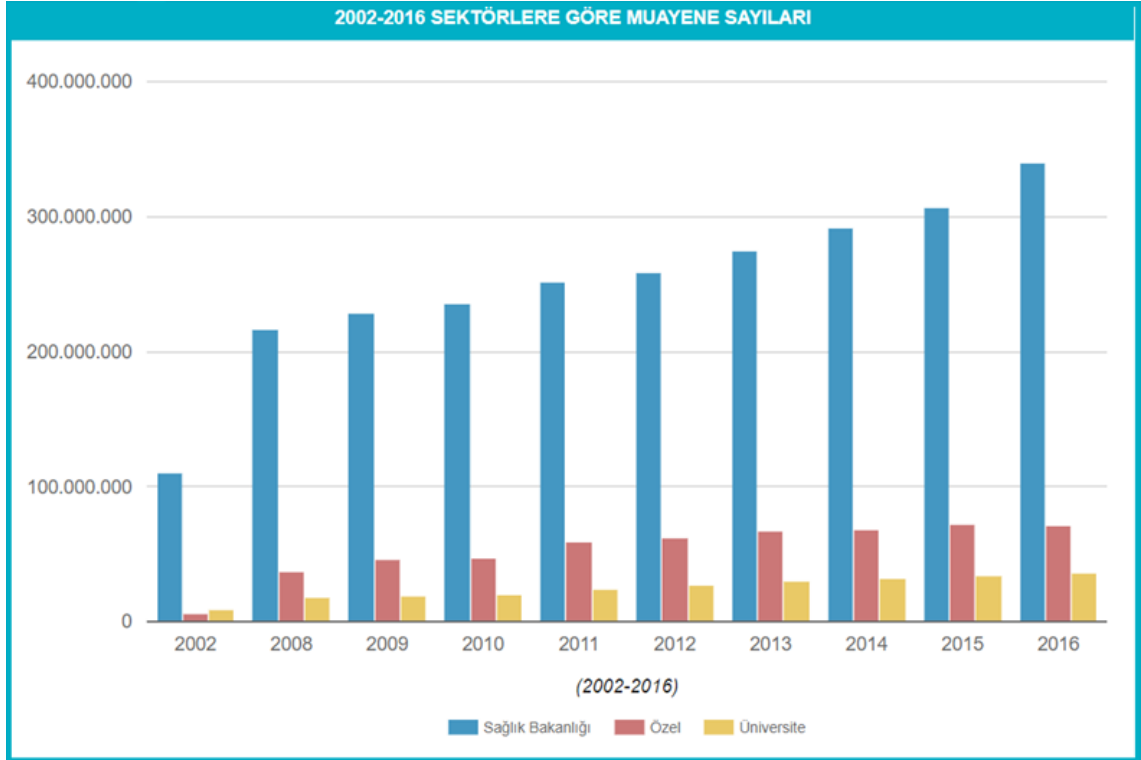


Figure 3.4 Total number of examinations by hospital types (2002-2020)

3.2 Atatürk Public Training and Research Hospital

As mentioned above, this study was conducted in a public training and research hospital in Ankara (the capital city of Turkey). Atatürk Public Training and Research Hospital was established in 2001, and is located in the southwest of the city, where the majority of the population is comprised of middle and upper-middle-income families. The hospital provides service through six main units: internal units, surgical units, consultant outpatient clinics, laboratories, radiological imaging, and nuclear medicine. For this study, we focused only on the internal medicine outpatient unit.

In the outpatient unit, the working hours begin at 08:30; however, patients usually start arriving before 08:30, because in order to be examined, they have to get a sequence number. Patients can get their sequence numbers by entering their national ID number on the ticket dispenser in the waiting area, and are ordered on a first-come-first-served basis (except for those who are over 65 years old, disabled and have appointments). While taking the sequence number, the patients can view the names of the physicians who are assigned to the outpatient unit on that day and

the number of patients waiting for each physician; the patients are able to choose among the physicians available.

In front of each physician's room in the clinic, there is a screen showing the sequence number of the patient who is currently being examined by the physician. When a patient's sequence number comes up, they proceed to the examination room. Here, the physician opens up the patient's screen on their computer, and proceeds with the examination. Depending on the patient's condition, at the end of the examination, the physician may (1) make a diagnosis and/or write a prescription, (2) order diagnostic tests from the laboratory or the radiology department, (3) refer the patient to another department of the hospital, and (4) refer the patient to the internal medicine inpatient clinic.

In the case of a test order, the patient applies to the relevant units for diagnostic tests. The time between tests and getting the results of the tests varies from test to test. Once the test results are ready, the patient comes for a post-test consultation, in which case, the process starts again (i.e., the patient gets a sequence number from the machine, etc.). It should also be noted that if a patient visits the outpatient unit within 10 days after the first examination, they are defined by the system as having a follow-up examination, whether it is to show the test results or not.

3.3 Hospital Information Management System (HIMS)

As stated in the previous section, the examination may end with the physician ordering diagnostic tests. Physicians order diagnostic tests via the hospital information management system (HIMS). At the beginning of the workday, all physicians log in to HIMS with their credentials. Then, when a patient enters the examination room, the physician opens up their screen on the computer. After the physician listens to the patient's medical history and physically examines them, they decide ICD code for the patient and whether to order a test. At each patient visit, the physician has to choose an ICD code based on the patient's complaints via HIMS. If they decide to order tests, they again use HIMS, which has a special test order panel. In the panel, physicians have to find tests via scrolling or the search tool and click the checkboxes next to the tests in order to add it to the ordered test list. In this system, diagnostic tests (Appendix A) are classified according to their type and laboratories, such as hemograms, hormone tests, USG and radiological tests.

All patient and prescription information entered through HIMS is kept in the central health database called MEDULA. MEDULA is a word formed by the combination of MEDikal (medical) and ULAk (messenger) words. MEDULA speaks to HIMS via web services.



4. DATA AND DESCRIPTIVE ANALYSIS

All processes from collecting the data to processing the model will be detailed in this section. How the data is collected, whether the data quality is sufficient, how the data is prepared for the model will be explained under sub-headings. Besides, the results of the descriptive statistics studies, which are an important part of the study will be included in this section.

4.1 Data Exploration

The data used in this study is from the outpatient unit of the hospital described in Section 3.2, and comprises data from January 1st of 2015 to December 31st of 2016. Data includes 80,394 unique visits of 51,536 unique patients. The metadata contained twenty fields, including the registration date and time, department, patient id, protocol no, arrival no, gender, age, queue no, status, physician ID, note, prescription date, test ID, name of test, test request date and time, test result date and time, examination time, ICD, quantity of test, cost of test. An overview of these fields, their type, and further information are provided in Table 4.1

#	Field Name	Data Type	Detail
1	Registration Date & Time	Date and Time	Represents the day and time of the patient's registration
2	Department	Text (Categorical)	Includes the department information the patient wants to be examined (Internal Medicine)
3	Patient ID	ID	Encrypted patient ID

#	Field Name	Data Type	Detail
4	Protocol No	Integer (Nominal)	Information about the patient's health insurance. Indicates whether health costs are paid by the government or patient
5	Arrival No	Integer (Ordinal)	Shows the order of arrival of the patient to register at the hospital
6	Gender	Text (Categorical)	Indicates the patient's gender (Male or Female)
7	Age	Integer (Interval)	Shows the age of the registered patient (0-110)
8	Queue No	Integer (Ordinal)	Shows the order of the person is to be examined. It is different from arrival no.
9	Status	Text (Categorical)	Shows the purpose of the patient's arrival. (examination or control)
10	Physician ID	Integer (Nominal)	Encrypted physician ID
11	Note	Free text	A note has taken by the physician during examination
12	Prescription Date	Date and Time	It shows the date of the prescription usually the same as the examination date. If the drug is not prescribed, it is empty.
13	Test ID	Integer (Nominal)	The identity number of the tests determined by the Health Ministry of Turkey. The same test ID represents the same test in all hospitals of Turkey.
14	Name of Test	Text	Describes the name of the diagnostic tests. For example calcium, T3, lower abdominal ultrasound
15	Test Request Date and Time	Date and Time	Indicates when the diagnostic test was ordered
16	Test Result Date and Time	Date and Time	The evaluation time for each test is different. Test result time shows the exact date and time which test result will be available for physicians.
17	Examination Time	Date and Time	Shows the time the physician's log in the HIMS for that patient. Since we do not know the exact time of the patient's entry into the examination room, we may consider the time of entry to the HIMS at the beginning of the examination.

#	Field Name	Data Type	Detail
18	ICD	Categorical	ICD (International Statistical Classification of Diseases and Related Health Problems) is an international classification system of diseases and health problems. The format of ICD can be X00.0 or X00 (X: letter, 0: number). Some special tests can be ordered for only selected ICD codes. ICD codes can be selected and changed by physicians.
19	Quantity of Test	Integer (Interval)	Shows how many of a unique test is ordered. It is not common behavior to order a unique test two times or more at the same time. So the quantity of tests is one for 99% of the examinations.
20	Cost of Test	Integer (Interval)	Health Implementation Communiqué (SUT) is the communiqué that provides guidance, pricing, regulation and all other details of the implementation of the social policies of the Turkey government regarding health. The cost of the test shows the corresponding cost for each test in the SUT. This value is generally much lower than the average market price.

Table 4.1 List of data fields

We used the data from 2015 as training and test data, and 2016 hospital diagnostic test order data as the validation data. As can be seen in the Table 4.2, preprocessed 2015 test order data consists of 571.303 rows, while the corresponding number is 546.039 for 2016. 26.322 unique patients visited the outpatient unit 39.777 times in 2015 (which corresponds to a rate of 1,51 visits per patient), while 25.036 unique patients visited the outpatient unit 40.617 times in 2016 (i.e., there were 1,62 visits per patient). It is interesting to note that the number of unique patients was more in 2015 compared to 2016. Usually, the number of patients is expected to increase over the years. This decrease may be due to new hospitals being opened in the city, or temporary reductions in hospital capacities may have been effective in reducing the number. Unlike the number of patients, a significant increase in repetitive visits was observed in 2016.

	2015	2016	Total
Row	571.303	546.039	1.117.342
Unique Patient	26.322	25.036	46.314
Unique Visit (Examination + Follow up)	39.777	40.617	80.394
Unique Visit (Examination)	34.581	33.452	68.033
% Unique Visit (Examination)	86,94%	82,36%	84,62%
Unique Visit (Follow up)	5.196	7.165	12.361
%Unique Visit (Follow up)	13,06%	17,64%	15,38%
Examination Visits with test order	23.595	23.938	47.533
%Examination Visits with test order	68,23%	71,56%	69,87%
Examination Visits without test order	10.986	9.514	20.500
% Examination Visits without test order	31,77%	28,44%	43,13%
Number of Unique Test	453	452	686
Average # of test order (for all examinations)	13,48	13,42	13,45
Average # of test order (for examinations with order)	19,75	18,74	19,24
Number of physicians	19	26	42
Number of physicians (>100 patient examination)	8	11	14
Patient age (mean)	44,64	44,35	44,50

Table 4.2 Data with numbers

When we look at the numbers from a test order behavior perspective, 86.94% of the individual visits in 2015 were examination visits and the remainder was follow-up visits. 68.23% of these examination visits resulted in a test order. The numbers for 2016 are not very different. 82.36% of the individual visits in 2016 were examination visits and the remainder was follow-up visits. 71.56% of these examination visits resulted in a test order. In 2016, we see a significant increase in the proportion of patients coming for a follow-up visit (35% more than the previous year). Finally, 453 unique tests were ordered in 2015 and 452 unique tests were ordered in 2016. The average number of test order per patient was 13,48 for 2015 and it decreased to 13,42 in 2016. In another study conducted in the internal medicine department of a different hospital in the same city, the mean number of tests per patient was 15,8 (Yılmaz et al., 2016).

In the internal medicine department, 42 physicians were examining patient but 14 of them dominates test order data. Because only some of these physicians were regularly examining patients, the remaining physicians have come for a temporary assignment or were examining patients instead of other physicians. Since our analysis is not physician based, we included all physicians' examinations in the analysis.

4.2 Data Quality

As in all data-oriented studies, data quality was checked before we conducted the analyses reported in this thesis.

One of the most common reasons for low data quality is manual data entry (Staes, Bennett, Evans, Narus, Huff & Sorensen, 2006). In our study, manual data entry is limited. A significant part of the data fields (“Age”, “Patient ID”, “Cost of Test” etc. are drawn directly from the records in MEDULA. Other fields, such as “Examination Time”, “Prescription Date” are automatically assigned by HIMS. The only areas of concern are those that constitute data entered by the physicians. For example “Name of Test” is selected from the menu manually by the physician and it is within possibility that the physician may order a test they did not intend to; however, the existing data does not allow us to ascertain whether the ordered test is incorrect or correct. In addition, the "Number of Tests" field is open to errors, we have seen that some tests are ordered more than once in our data. In fact, the number of order in a single visit can be up to 12 for a single test. However, in this study, we focused not on how many times the tests were ordered, but on whether they were ordered. Therefore, we converted the test request variable to dummy variables. Lastly “Notes” is the field with the greatest amount of null values (80,30%), and the possibility of errors due to manual data entry is highest, but we excluded this field from our analyses, hence its quality does not affect the results and insights from this study.

Although the study included data for two consecutive years, data quality differences was checked within two years. A mismatch was detected between test names and test IDs. To solve this problem, test ID and test names were standardized for two years. While performing the standardization, a study based on test names was carried out.

Also, rows without patient information were excluded from the study before starting the analysis.

4.3 Data Pre-processing

In order to apply the a-priori algorithm, we transformed the data. In the metadata, every test order was listed in a separate row with the fields summarized in Table 4.1. For our analysis, a unique visit-based data frame was needed, instead of the test order-based data frame of the original data. First, we created a unique visit ID by using a patient ID and the registration date and time. All the fields such as Unique ID, Patient ID, Gender, Age were added to this data, except test request date and time, test result date and time, and cost of the test. In addition to the mentioned fields, approximately 400 columns were also added for every test ID. Test ID columns were added as a binary field, with 1 indicating that particular test was ordered, and 0 indicating no order. While the number of columns increased to 462 via this change, the number of rows decreased from 571,303 to 39,777 for 2015 metadata, and from 546,039 to 40,617 for 2016 metadata (see Table 4.2). We noticed that some of the tests were ordered more than once for some patients. There can be two reasons for duplicate test orders; either the physician may have ordered the test more than once by mistake due to being tired, or it may have been repeated more than once due to the nature of the test. In this study, we considered this variable as binary because we are concerned with whether a test is ordered, rather than how many times it was ordered. For example, if for unique visit number 600389, the unique test number 909540 is equal to zero, this means the test with ID 99540 was not ordered for the unique visit number 600389.

4.4 Descriptive Analysis

In this section, we provide descriptive statistics for the main fields in our data set, including age, gender, and ICD codes. While examining the descriptive statistics, only examination patients were taken into account for the year the statistics were given. Control patients were excluded from the analysis.

Age and gender analysis were made on the basis of unique patients, each patient was included in the analysis only once, the number of visits is not considered. While conducting ICD code and test order analysis, a unique visit is taken as a basis. All visits are included in the analysis because the same patient may be labeled with

different ICD codes each time and a different number of tests may be ordered in case of multiple examination visits.

4.4.1 Gender

Contrary to expectations, the distribution of male and female patients in the data was unbalanced. In 2015, 37,8% of the patients who applied to the outpatient unit for examination were male and 62,2% were female; these percentages were similar in 2016. Figures 4.1 and 4.2 provide a visual summary. In order to understand the reasons behind this imbalance in gender distributions, similar statistics for other hospitals in the area might be studied, or comparisons with nationwide statistics might be required; these analyses are beyond the scope of this thesis and left to further studies.

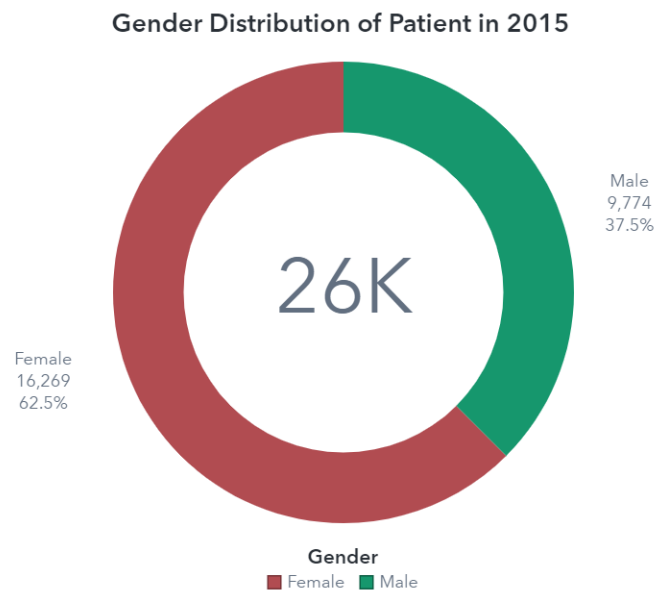


Figure 4.1 Gender distribution of patient in 2015

Gender Distribution of Patient in 2016

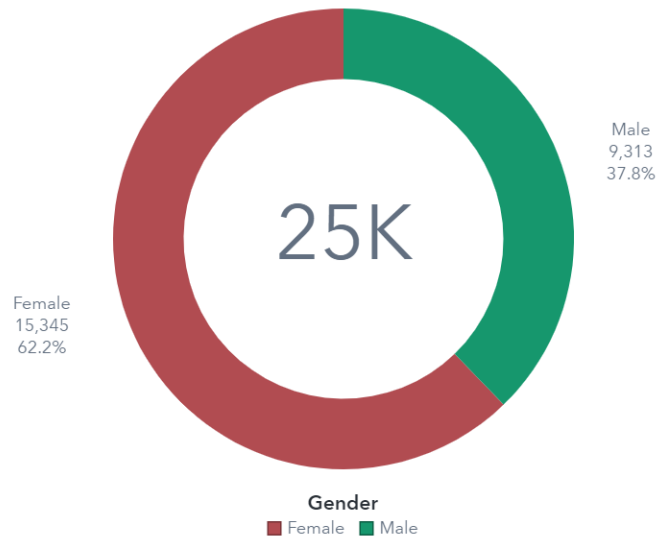


Figure 4.2 Gender distribution of patient in 2016

4.4.2 Age

As we mentioned at the beginning of the descriptive statistics section, age distribution calculated based on unique patients who applied to the internal medicine department for examination. Since we consider the data on a yearly basis while developing our models, we have calculated the statistics on a yearly basis.

	2015	2016
Mean	44,27	43,89
Median	45	44
Mode	50	51
Standard Deviation	15,90	15,66
Sample Variance	252,94	245,24
Kurtosis	-0,66	-0,65
Skewness	0,16	0,15
Minimum	0	1
Maximum	99	103

Table 4.3 Descriptive statistics according to age of patients

While the ages of the patients who applied to the internal medicine department in 2015 ranged from 0 to 99, in 2016 it ranged from 1 to 103. Mean and Median values

are very close to each other and around 44 for two years. While the most frequent patients who applied to the Internal Medicine department in 2015 were 50 years old, those who applied in 2016 were 51 years old.

In the age distribution of patients, patients who were less than 15 years old were almost negligible. This was expected because internal medicine is a department that treats only adult patients. Most patients were older than 15 years of age and younger than 70 years of age (Figure 4.3 and Figure 4.4)

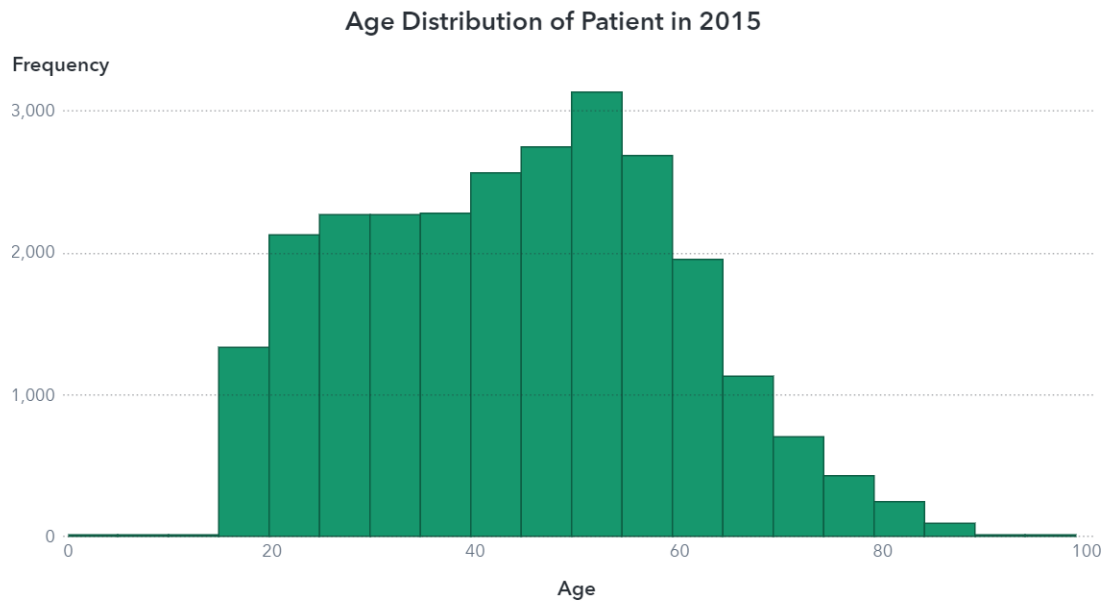


Figure 4.3 Age distribution of patient in 2015

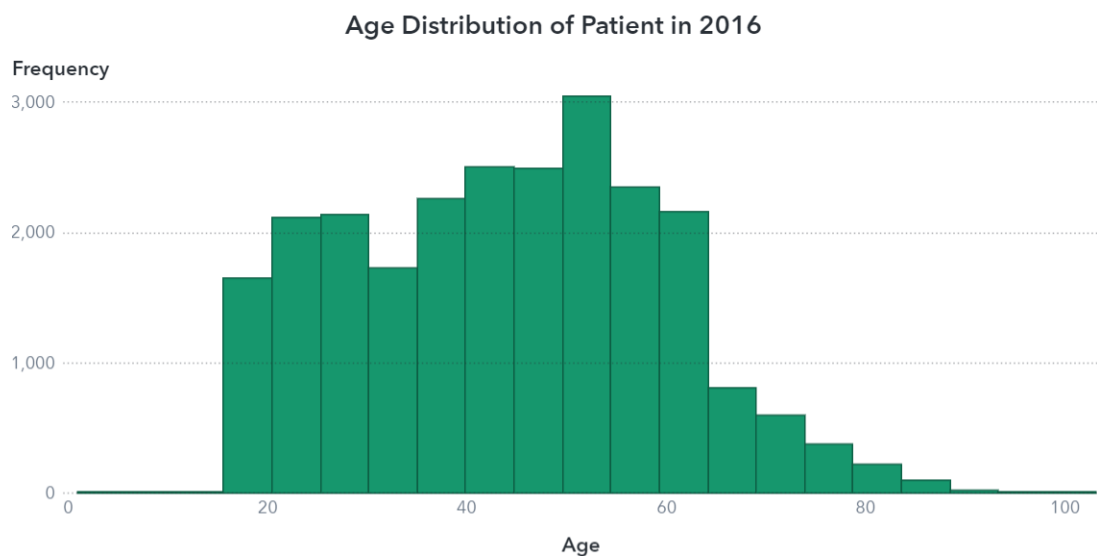


Figure 4.4 Age distribution of patient in 2016

When we analyzed age and gender jointly, we did not observe a gender-specific pattern in age distributions. The distribution of male and female for every age range is compatible with the age section. (Figure 4.5 and Figure 4.6)

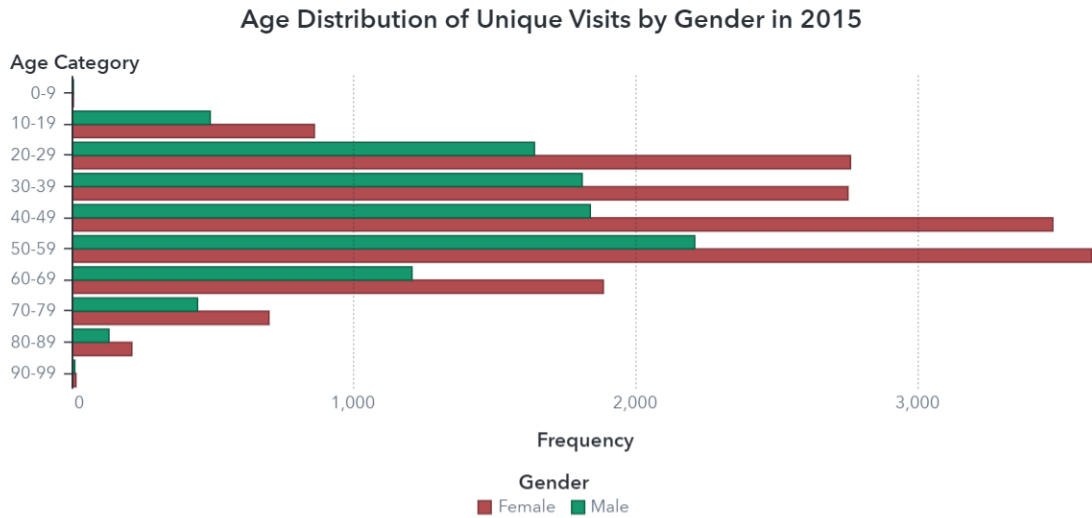


Figure 4.5 Age distribution of patients by gender in 2015

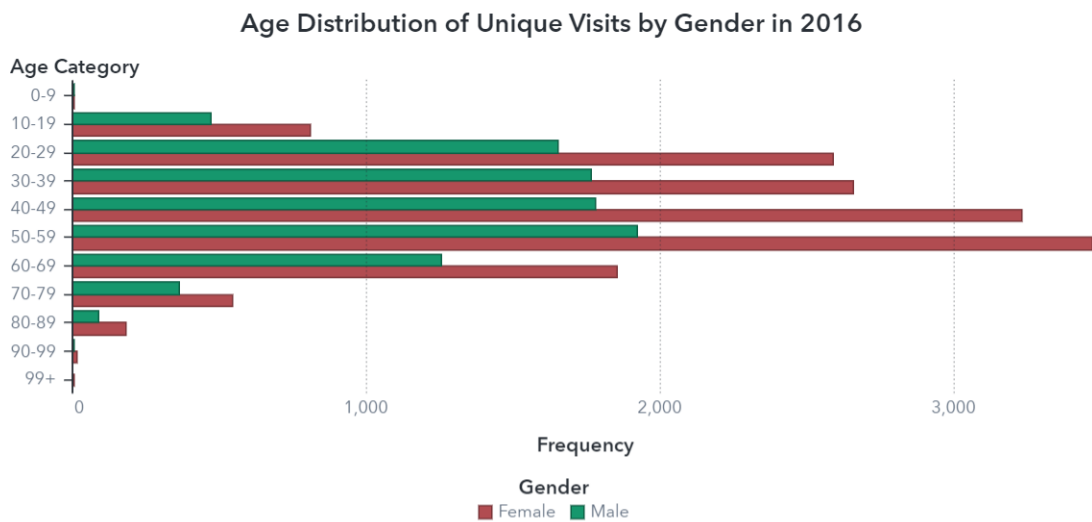


Figure 4.6 Age distribution of patients by gender in 2016

4.4.3 Test Orders

In this section, we will examine the results of descriptive statistics regarding the total number of tests ordered per visit (Table 4.4). The average number of tests

ordered for both years is around 13-14 per visit. While the maximum number of tests ordered was 85 in 2015, this number was 69 in 2016. The most common type of visit in both years is visits without test order. Approximately one out of every 3 patients examined in 2015 left the hospital without any testing (Figure 4.7). In 2016, we observe a decrease in the rate of visits without test order (Figure 4.8).

	2015	2016
Mean	13,48	13,42
Standard Error	0,07	0,07
Median	10	12
Mode	0	0
Standard Deviation	13,01	12,44
Sample Variance	169,17	154,86
Kurtosis	-1,22	-0,95
Skewness	0,36	0,43
Minimum	0	0
Maximum	85	69
Count	34581	33452

Table 4.4 Descriptive statistics according to total number of ordered test

In 2015, while the number of visits that end with 10-20 tests order was relatively low, we observed a high density in the visits which end with 25-35 tests. On the contrary, we observe a uniform distribution between 10-35 in 2016 compared to 2015.

If we examine the examination requests specific to the test, we see that bilirubin is the most requested test in both years. Cholesterol was the second most ordered (4,70%) test in 2015, and the ninth most ordered (3,32%) test in 2016. Although there are proportional differences in the examinations that are ordered from year to year, the most frequently ordered examination list for both years is similar (Table 4.5, Table 4.6)

Test Name	Test ID	Frequency	% Frequency
BILIRUBIN (DIRECT)	900690	26894	4,89%
CHOLESTEROL	902110	25830	4,70%
IRON (SERUM)	901020	24578	4,47%
TRIGLYCERID	903990	20655	3,76%
CREATINE	902210	20166	3,67%
HDL CHOLESTEROL	901580	20144	3,66%
FULL BLOOD (HEMOGRAM)	901620	19738	3,59%
GLUCOSE	901500	19518	3,55%
FIELD AMINOTRANSFERASE (SUB)	900200	19272	3,51%
ASPARTATE TRANSAMINASE (AST)	900580	19162	3,49%
UREA	901940	18787	3,42%
TSH	904030	18727	3,41%
FERRITINE	901220	17244	3,14%
VITAMIN B12	904150	17188	3,13%
POTASSIUM	903130	17096	3,11%
SODIUM (NA)	903670	17082	3,11%
FOOL	901240	16162	2,94%
LDL CHOLESTEROL	902290	15724	2,86%
GAMMA GLUTAMIL TRANSFERASE (GGT)	901390	15510	2,82%
IRON BINDING CAPACITY	901040	14528	2,64%
CALCIUM (CA)	901910	11707	2,13%
FREE T4	903480	9967	1,81%
PHOSPHORUS (P)	901260	9355	1,70%
GLYCOLYZED HEMOGLOBIN (HB A1C)	901450	8568	1,56%
ALKALINE PHOSPHATASE	900340	8436	1,53%
FREE T3	903470	8287	1,51%
URINE TESTING	901780	7980	1,45%
URIC ACID	904120	7777	1,41%
CRP	900901	7755	1,41%

Table 4.5 Most ordered tests in 2015

Test Name	Test ID	Frequency	% Frequency
BILIRUBIN (DIRECT)	900690	22788	4,43%
CREATINE	902210	21261	4,13%
FIELD AMINOTRANSFERASE (SUB)	900200	20731	4,03%
GLUCOSE	901500	20652	4,01%
FULL BLOOD (HEMOGRAM)	901620	19853	3,86%
UREA	901940	19300	3,75%
ASPARTATE TRANSAMINASE (AST)	900580	17733	3,45%
TSH	904030	17325	3,37%
CHOLESTEROL	902110	17056	3,32%
TRIGLYCERID	903990	16514	3,21%
HDL CHOLESTEROL	901580	16444	3,20%
POTASSIUM	903130	16238	3,16%
SODIUM (NA)	903670	16226	3,15%
VITAMIN B12	904150	15598	3,03%
LDL CHOLESTEROL	902290	15111	2,94%
FERRITINE	901220	14586	2,84%
FOOL	901240	13246	2,58%
GAMMA GLUTAMIL TRANSFERASE (GGT)	901390	12852	2,50%
CRP	900901	12126	2,36%
URINE TESTING	901780	11308	2,20%
ALKALINE PHOSPHATASE	900340	10732	2,09%
CALCIUM (CA)	901910	10299	2,00%
SEDIMENTATION	903400	10079	1,96%
GLYCOLYZED HEMOGLOBIN (HB A1C)	901450	8693	1,69%
PHOSPHORUS (P)	901260	8662	1,68%
FREE T4	903480	8626	1,68%
IRON (SERUM)	901020	8434	1,64%
ALBUMIN	900210	7651	1,49%
IRON BINDING CAPACITY	901040	5720	1,11%
POST PRANDIAL BLOOD SUGAR	903120	5146	1,00%

Table 4.6 Most ordered tests in 2016

Distribution of Total Number of Ordered Test in 2015

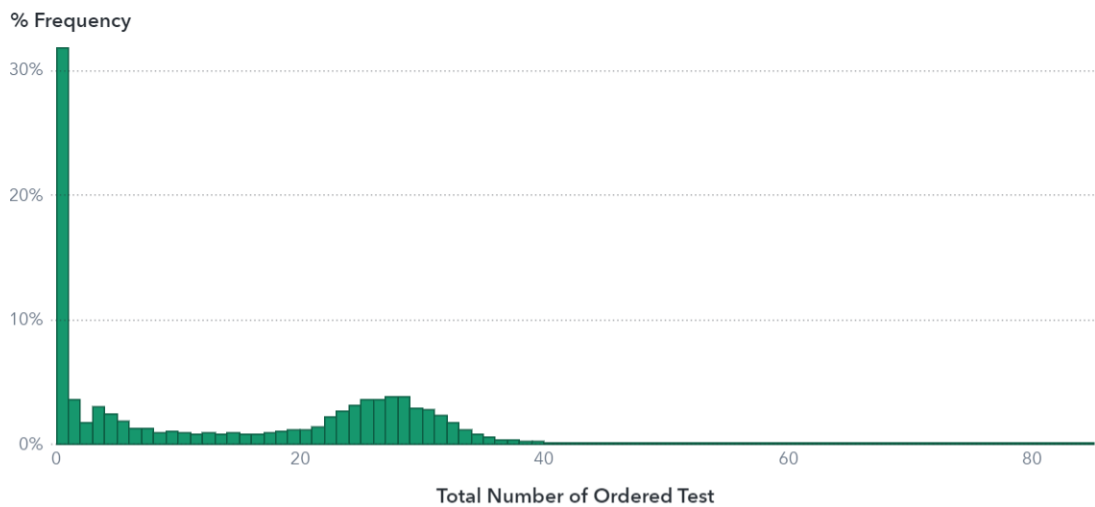


Figure 4.7 Distribution of total number of ordered test per visits in 2015

Distribution of Total Number of Ordered Test in 2016

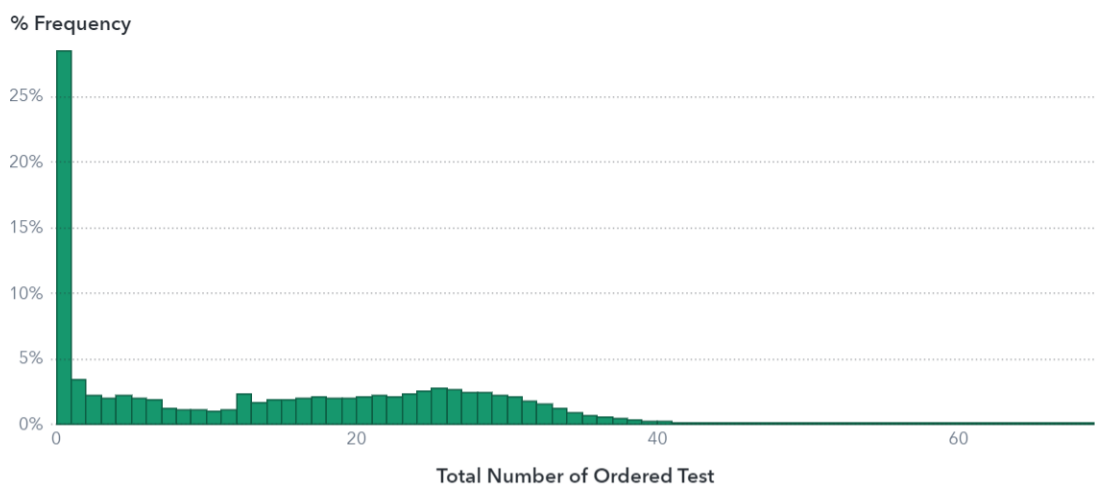


Figure 4.8 Distribution of total number of ordered test per visits in 2016

4.4.4 ICD Codes

As we mentioned in previous chapters, the ICD code is the code indicating the suspected disease that the physician makes a decision based on the findings of the patient's examination. As we will detailed mention in the method section, the ICD code of the visit was used as a distinctive variable in our analysis. Z04.8-Other

Identified Reasons for Inspection and Observation is the most used ICD code by physicians in both years. This code is generally used for patients who do not have a specialized complaint. Although the rate of this code seems to have decreased in 2016, the rate of Z00.8, which is also used for general examination, has increased (see Table 4.7 and 4.8). E13.8-Diabetes Mellitus with Other Specified, Unspecified Complications, I10-Essential (Primary) Hypertension, E03.9-Hypothyroidism, Unspecified, the three most common pre-diagnoses other than general examination in both years.

When the remaining of the list is examined, it can be said that the most common ICD codes in both years are similar.

ICD Code	Frequency	%Frequency
Z04.8-OTHER DESCRIBED CAUSES FOR INSPECTION AND OBSERVATION	26847	77,64%
E13.8-DIABETES MELLITUS WITH OTHER DEFINED, NON-DEFINED COMPLICATIONS	1517	4,39%
I10-ESSENTIAL (PRIMARY) HYPERTENSION	886	2,56%
Z00.8-GENERAL INSPECTIONS, OTHER	552	1,60%
E03.9-HYPOTROIDISM, UNSPECIFIED	544	1,57%
K30-DISPEPSY	534	1,54%
K21.9-GASTRO-ESOPHAGEAL REFLUX DISEASE WITHOUT ESOPHAGITIS	406	1,17%
D64.9-ANEMIA, UNSPECIFIED	194	0,56%
M79.1-MYALGIA	188	0,54%
M25.5-JOINT PAIN	170	0,49%
K27-PEPTIC ULCER, LOCATION NOT DEFINED	163	0,47%
J39.9-DISEASE OF THE UPPER RESPIRATORY TRACT	161	0,47%
D50.9-IRON DEFICIENCY ANEMIA, UNSPECIFIED	152	0,44%
E55.9-VITAMIN D DEFICIENCY, NOT SPECIFIED	130	0,38%
R10.4-Abdominal PAIN OTHER AND UNSPECIFIED	130	0,38%
J06.9-ACUTE UPPER RESPIRATORY TRACT INFECTION	115	0,33%
D51.8-VITAMIN B12 DEFICIENCY ANEMIA, OTHER	102	0,29%
R54-AGE	102	0,29%
E78.4-HYPERLIPIDEMIA, OTHER	90	0,26%
N39.0-URINARY SYSTEM INFECTION, LOCATION NOT DEFINED	76	0,22%
K52.9-GASTROENTERITE AND COLLITE, NON-INFECTIVE	75	0,22%
R05-COUGH	70	0,20%
K59.0-CONSUMPTION	69	0,20%
J01.9-ACUTE SINUSITIS, UNSPECIFIED	66	0,19%
J02.9-ACUTE PHARENGIDE, UNSPECIFIED	55	0,16%

Table 4.7 Frequency of visits by ICD code in 2015

ICD Code	Frequency	%Frequency
Z04.8-OTHER DESCRIBED CAUSES FOR INSPECTION AND OBSERVATION	23155	69,22%
Z00.8-GENERAL INSPECTIONS, OTHER	1815	5,43%
E13.8-DIABETES MELLITUS WITH OTHER DEFINED, NON-DEFINED COMPLICATIONS	1574	4,71%
I10-ESSENTIAL (PRIMARY) HYPERTENSION	888	2,65%
E03.9-HYPOTROIDISM, UNSPECIFIED	593	1,77%
K29.7-GASTRITE, NOT DEFINED	502	1,50%
R10.4-Abdominal PAIN OTHER AND UNSPECIFIED	392	1,17%
M25.5-JOINT PAIN	346	1,03%
R53-FLEXIBILITY AND FATIGUE	337	1,01%
M12.8-ARTHROPATHIES OTHER DEFINED, NOT CLASSED ELSEWHERE	285	0,85%
D50.9-IRON DEFICIENCY ANEMIA, UNSPECIFIED	282	0,84%
D64.9-ANEMIA, UNSPECIFIED	257	0,77%
E55.9-VITAMIN D DEFICIENCY, NOT SPECIFIED	220	0,66%
M79.1-MYALGIA	180	0,54%
K21.9-GASTRO-ESOPHAGEAL REFLUX DISEASE WITHOUT ESOPHAGITIS	179	0,54%
K30-DISPEPSY	171	0,51%
D51.8-VITAMIN B12 DEFICIENCY ANEMIA, OTHER	140	0,42%
E78.5-HYPERLIPIDEMIA, UNSPECIFIED	121	0,36%
J06.9-ACUTE UPPER RESPIRATORY TRACT INFECTION	121	0,36%
R54-AGE	87	0,26%
R05-COUGH	85	0,25%
R94.5-ABNORMAL RESULTS OF LIVER FUNCTION TESTS	83	0,25%
N39.0-URINARY SYSTEM INFECTION	79	0,24%
J39.9-DISEASE OF THE UPPER RESPIRATORY TRACT	77	0,23%
M06-ROMATOID ARTHRITIS, OTHER	72	0,22%

Table 4.8 Frequency of visits by ICD code in 2016

4.4.5 Visit Time

In the last part of descriptive statistics, we examined the time of examination in the internal medicine department of the patients. We made our first analysis on which hours of the day patients come more frequently.

In this analysis, (see Figure 4.9 and 4.10) we observed serious similarities across the years. In both years, the examination starts at 8:00. Most patients are examined between 9:00 am and 10:00 am. As the hour progresses towards noon, the number of patients examined per hour decreases. The number of patients is decreasing because of the lunch break between 12:00 and 13:00. Most patients that examined in the afternoon, are examined between 14:00 and 15:00. The number of patients examined after 16:00 is very low.

When we look at the total number of examinations by months, most patients were examined in 2015: March, January, and April. In 2016, this ranking changes as

of November, March, and December. In 2015, the least patients were examined in September, October, and July, while in 2016, July, June, and September. (See Figure 4.11 and 4.12)

Time of Examination Visits in 2015

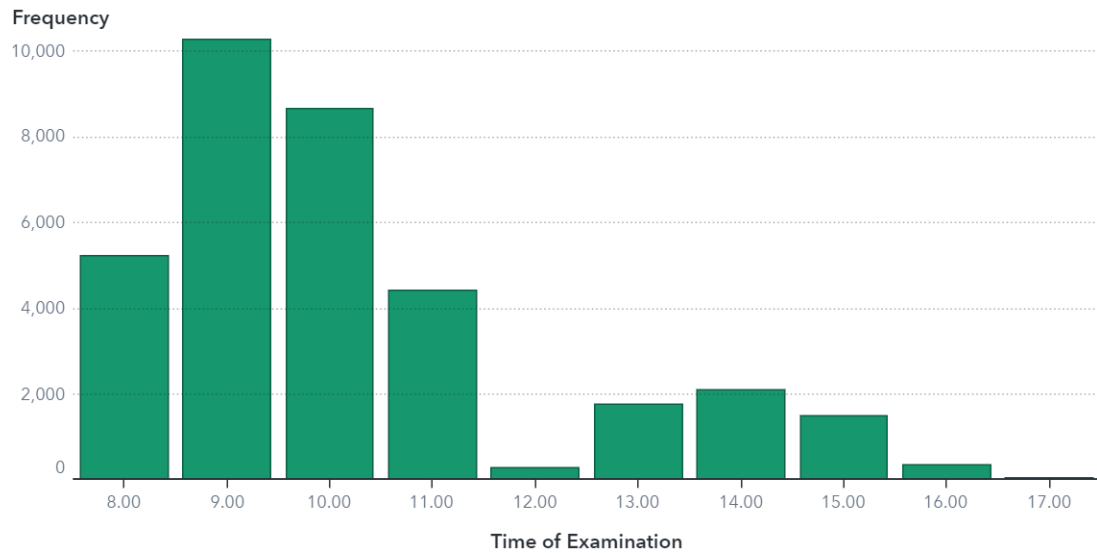


Figure 4.9 Time of visits in 2015

Time of Examination Visits in 2016

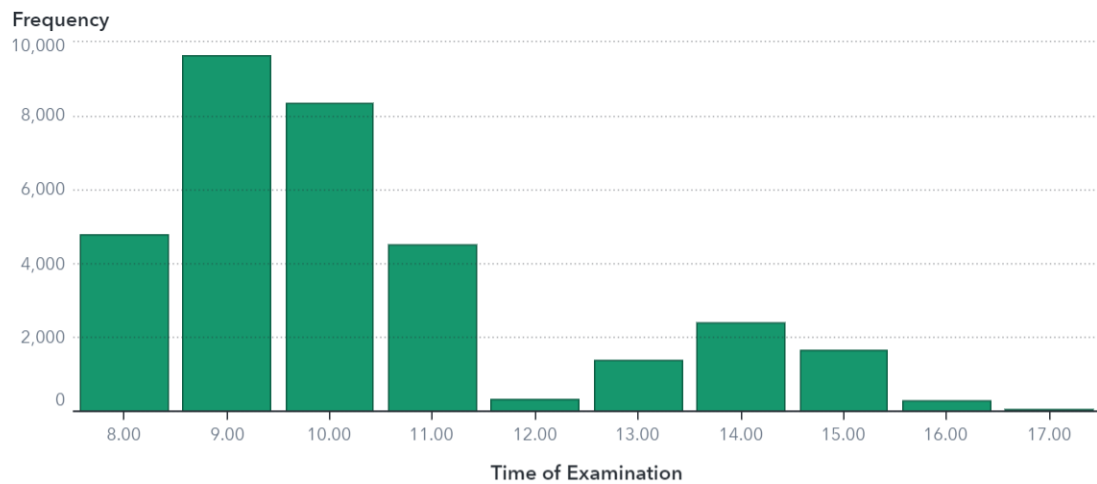


Figure 4.10 Time of visits in 2016

Examination Visits by Month in 2015

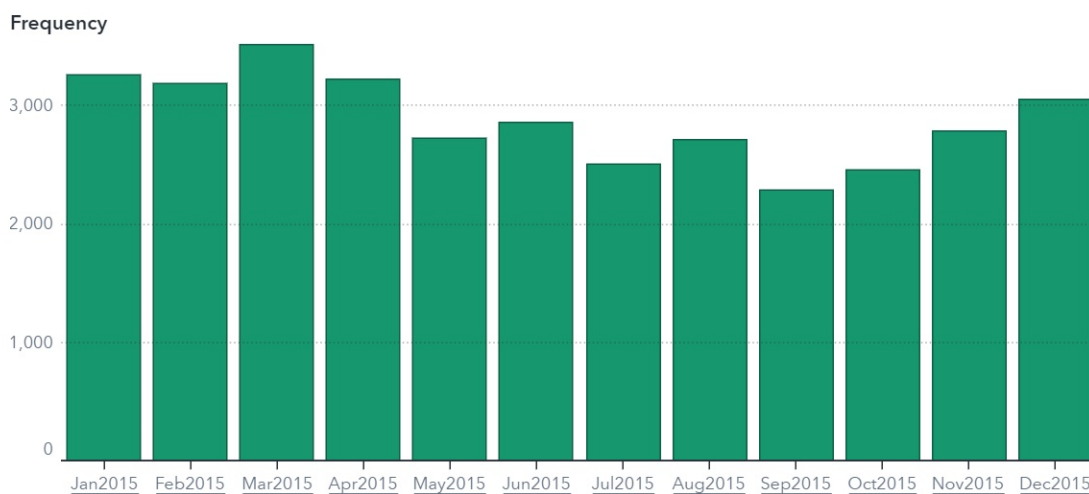


Figure 4.11 Distribution of visits by months in 2015

Examination Visits by Month in 2016

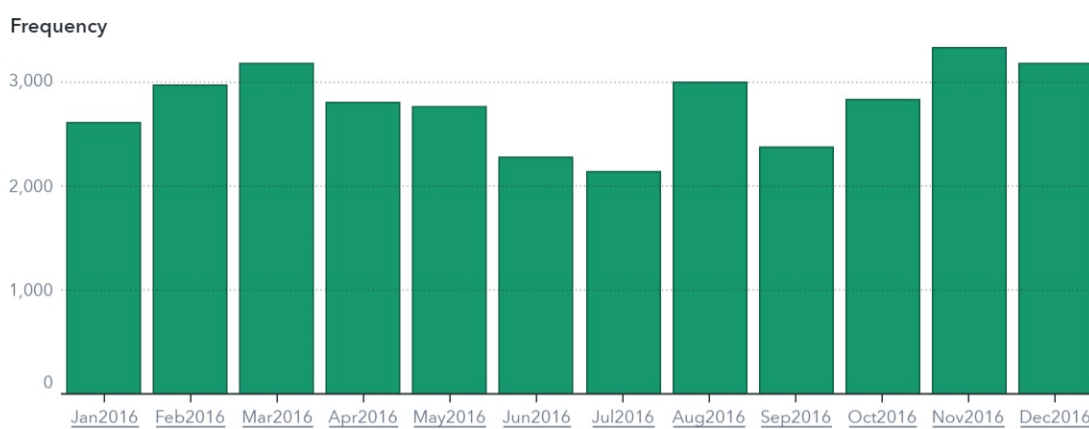


Figure 4.12 Distribution of visits by months in 2016

5. METHODS

This section will be examined under three main parts. In the first part, available methods which could be used to find the best diagnostic test order set, and which method was eventually used in this study will be discussed. In the second part, we will explain how the physician deciding whether to use the recommended diagnostic test order set in the examination. In the last part, we will explain how we calculate the total clicks of the test selection.

5.1 Diagnostic Test Order Recommendation Set Based on ICD Code

To facilitate the test selection process for physicians, we wanted to implement a test order recommendation system suitable for the selected ICD code. There are two common approaches to determining which tests should be recommended for each ICD code. In the first one, a medical committee determines test sets for each ICD code. There are dozens of studies on this method, especially for specific cases and ICD codes (Biljak, Honović, Matica, Krešić & Vojak, 2017; Sacks, Arnold, Bakris, Bruns, Horvath, Kirkman, Lernmark, Metzger & Nathan, 2011). Since this method is outside the scope of this research and the aim of this thesis is to design an unsupervised recommendation method, we will not go into the details of this methodology here.

This study proposes an unsupervised method to determine the diagnostic tests to be recommended for a particular ICD code. In this method, frequent patterns are determined by analyzing the physicians' past test ordering behavior. Before we describe the details of the methodology, we note that the tests ordered for a particular ICD code may vary due to hospital or country specific application differences. Factors such as test completion times, health regulations, insurance terms, payment coverage differences, quota systems applied to physicians, may all affect the test

ordering behavior of physicians. Hence, we note that the results of the analysis presented in this study would be affected by the conditions of the experiment setup. However, given the added value created by our proposed methodology, similar methods can be used in other hospitals and similar health care settings, using data from the corresponding settings.

5.2 Frequent Itemset Discovery

Frequent pattern discovery is a common method used in business applications of data science, and aims to detect a similar and repeating pattern in datasets. The method used for frequent pattern discovery mostly depends on the data type and data structure.

Market Basket Analysis is the most known type of Frequent Pattern Discovery (Leskovec, Rajaraman & Ullman, 2020). The nature of market basket analysis is focused on the association between two main elements of the shopping: basket and item. Namely, market basket analysis aims to find frequent item sets in consumers' baskets. Although the retail industry and the healthcare industry are conceptually different, the market basket analysis algorithm can be used in our problem.

The first element in market basket analysis, the basket, corresponds to the test sets physicians have ordered in the past in our data. The second element of market basket analysis, items, corresponds to a diagnostic test in our data. The patient can be considered as a customer. A customer can visit the market more than once in a given time frame; similarly, the patient can visit the internal medicine department more than once in a given time frame. The size of the basket may vary, just like the number of ordered tests, from visit to visit, or customer to customer.

Usually, the number of products that can be bought in the market is very high compared to the size of the basket. In our data, the average number of items in the ordered set is 13,44, and the number of available tests is 686; the corresponding ratio is 0,02, which is suitable for the analysis. Because of all these similarities, we conclude that the market basket analysis algorithm is a suitable tool for our analysis.

Although our market basket problem and our frequently ordered test set problem show many similarities, there are also points where they diverge. The first and

biggest difference is, in the market basket problem, the selection of the products to be included in the basket is made by the end-user. This means that the number of the decision makers is equal to the number of unique users. Even the same user can often act with different decision mechanisms in different visits. Their needs, their reason for visiting the market, and the season can affect the decision-making process. However, in our problem, physicians decide which tests to be ordered. While the average number of decision-makers in the market basket problem is thousands, in our problem it is limited to the number of physicians (14).

The low number of decision-makers naturally increases the similarity between the order set in visits. But unlike the market basket problem, the decision-maker in our problem has a much more complex decision-making mechanism. The patient's age, gender, past disease history, complaints, and findings play an important role in determining the tests that the physician will order.

To summarize, although the two problems are not similar in terms of the number of decision-makers, we can say that they are quite similar considering the item sets and items. Some tests are rarely requested, frequent itemset support rates are very low, and the ICD code is more effective than the decision-maker (physician) in the similarity of item sets.

All these findings show that the low number of decision-makers does not prevent the use of market basket analysis algorithms in the frequent order set detection problem. In fact, in the long term, the test order suggestion system that we designed can be customized according to the physician's choices and may lead to the possibility of the development of a physician-specific test order suggestion system.

5.2.1 Apriori Algorithm

Apriori is a classical algorithm which frequently used in market basket analysis and frequent itemset detection (Rathod, Dhabariya & Thacker, 2014). The dictionary meaning of "apriori" is "in reference to reasoning from antecedent to consequent, based on causes and first principles"; it is the ablative of "priori", which means "first", hence, "apriori" can literally be translated as "from what comes first" (Online Ethimology Dictionary). Parallel to its dictionary meaning, the apriori algorithm is designed to solve the relationships (between items in basket) that lead to the final frequent item sets. Apriori is basically based on three concepts: support, confidence, and lift. Next, we consider these three concepts one by one.

Support can be described as the frequency of the item, and is given by,

$$Support \frac{freq(A)}{N}.$$

For example, let's assume we have data for 100 unique examination visits and TSH (Test ID: 904030) ordered in 10 of them. Support (TSH) can be calculated as,

$$Support (TSH) = [Visit involving TSH order] / [Total visit] = 10 / 100 = 0,1.$$

Confidence, in our context, is the likelihood that two or more tests are ordered at the same time:

$$Confidence(A \rightarrow B) = \frac{freq(A,B)}{freq(A)}.$$

In our example, if we want to calculate confidence for ordering FSH for visit with TSH order, confidence is calculated by dividing the number of transactions that include both TSH and FSH (Test ID: 901280) by the total number of transactions that include TSH. Let's assume TSH and FSH ordered together in 6 unique examination visits. Confidence of (TSH -> FSH) can be calculated by Confidence (TSH -> FSH) = [Visit involving TSH and FSH] / [Visit involving TSH] = 6 / 10 = 0,6.

Lift value is the increase in the ratio of the order of FSH when the physician order TSH.

$$Lift = \frac{Confidence (A \rightarrow B)}{Support (A)}.$$

In the same example, Lift = [Confidence(TSH -> FSH)] / [Support(TSH)] = 0,6 / 0,1 = 6

It means that the likelihood of a physician order both TSH and FSH together is 6 times more than the chance of ordering TSH alone. If the Lift value is less than 1, it indicates that the physicians are unlikely to order both items together. In other words, the greater the Lift value, the better the combination is.

Apriori algorithm assumes that each item in a frequent itemset should be also frequent. Every apriori algorithm needs a minimum support threshold for working properly. Apriori begins with one item and finds the frequency of each item in all transactions. It prunes items which have a support rate less than the threshold value. In the second step, the same process is repeated for a combination of two

items (found via step-1). The algorithm continues working until the support value of item sets is lower than the threshold value (see Figure 5.1).

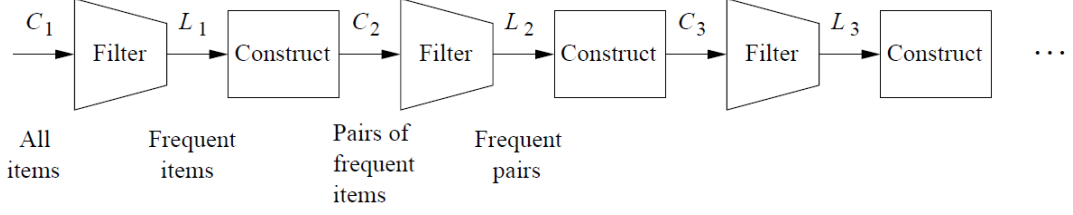


Figure 5.1 The Apriori algorithm pattern (Leskovec, 2020)

Although the apriori algorithm is easy to understand and its operating principle is clear, and hence it is an interpretable method, it is also a computationally expensive algorithm. Hence, there exist many variations of apriori (Eclat, FP-Growth, FP-Max) which were developed to improve its memory usage and speed (Heaton, 2016). In this study, although we did not experience any memory or speed problems while using the apriori algorithm due to the size of our data, nevertheless, we tried the FP-Max algorithm as well, and decided to use the apriori algorithm as we did not observe any difference in the results.

5.2.2 ICD Selection for Designing Recommendation Set

As mentioned in Section 3, physicians have to choose an ICD code through the HIMS according to each patient's disease or complaints. We accept these ICD codes as classification labels; both the ordered tests and the ICD code are determined according to the complaints of the patient and the physical examination during the visit (Muslim, Mutiara, Suhendra & Oswari, 2018).

In the market basket analysis problem, better results are obtained when customers who are similar to each other are divided into segments and the analysis is performed on the basis of these segments (Boztuğ & Reutterer, 2008). In our study, we also carried out a segment-oriented approach instead of analyzing all visits, and used ICD codes while segmenting the visits. Hence, we applied the frequent itemset detection algorithm to the segments labeled by the ICD codes.

Before starting the analysis, we filtered the examination patients from the preprocessed data (follow-up visits are excluded); visits with no test order were excluded

(in line with market basket analysis, where customers with no purchase are not included in the analysis).

In our analysis, we focused on the 15 most frequent ICD codes (see Table 5.1) in the system (during 2015 and 2016). We applied the apriori algorithm for each selected ICD code segment in the 2015 unique internal medicine department visit data, and detected the frequent item sets and support rates of item-sets for each ICD. The results of this analysis are provided in Section 6.1.

Z04.8-Other Identified Reasons for Inspection and Observation
E13.8-Diabetes Mellitus with Other Specified, Unspecified Complications
I10-Essential (Primary) Hypertension
Z00.8-General Inspections, Other
E03.9-Hypothyroidism, Unspecified
K30 Dyspepsia
K21.9-Gastro-Esophageal Reflux Disease without Esophagitis
D64.9-Anemia, Unspecified
M79.1-Myalgia
M25.5-Joint Pain
D50.9-Iron Deficiency Anemia, Unspecified
E55.9-Vitamin D Deficiency, Unspecified
R10.4-Abdominal Pain Other And Unspecified
J06.9-Acute Upper Respiratory Tract Infection, Unspecified
D51.8-Vitamin B12 Deficiency Anemia, Other

Table 5.1 Most frequent ICD codes

Before we conclude this section, we note the following: while doing our analysis, we kept the minimum support rate as low as possible (0.01) in order to find the largest frequent item-sets. We found multiple frequent item-sets for each ICD segment. Furthermore, in our analysis, one of the following three approaches could be used: (1) keeping the recommended diagnostic test order set small and suggesting more than one recommended diagnostic test order set for each ICD, (2) keeping the recommended diagnostic test order sets optimal and not allowing changes by the physician, or (3) keeping only one large recommended diagnostic test order set for each ICD and allowing the physician to remove items that they do not want to order. We used the third method and designated the largest frequent itemset we could find for min support (0.01) as the recommended diagnostic test order set for each selected ICD (Table 5.1)

5.3 Evaluation Criteria

We conducted two different evaluations to measure the performance of the test sets we determined in the previous section. First, we measured whether the recommended test set was applicable for each visit by looking at the intersection of the test set with the actual order (see Section 5.2.1). Then we calculated how the total number of clicks performed by the physician would change if this recommended set was used (see Section 5.2.2).

5.3.1 Usage Rate of Recommended Set

In the first stage of our study, described in Section 5.1.3, we determined the most frequently requested itemset for each ICD code using the 2015 data. In the second stage of our study, we will analyze whether the recommended diagnostic test order set will actually be used by the physician. In the application currently available in the hospital, physicians select the tests they want to order one by one among more than 600 tests in the HIMS interface. With our suggestion system, we assume that the physician will add all the tests in the recommended set with one click, and, at the same time, if they do not want to order any test from the recommended set, they can unselect them with a click. Based on this information, we assumed that the recommended test set would be selected in cases when it did not increase the total number of clicks performed by physician, but would not be selected when it did.

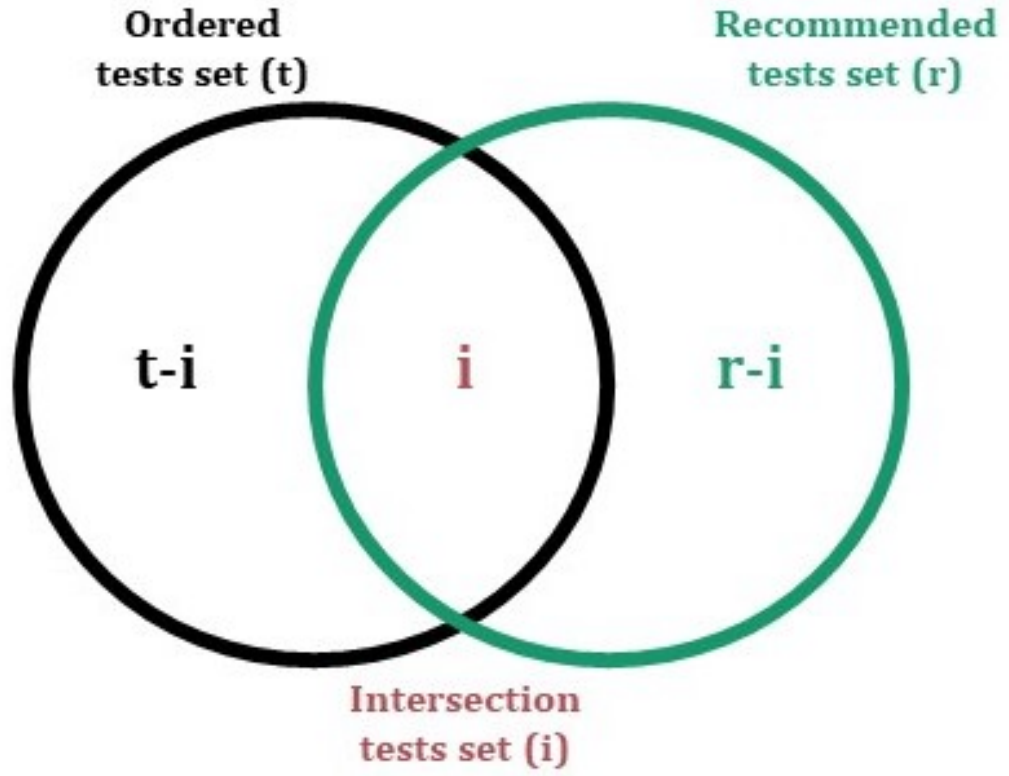


Figure 5.2 Ordered and recommended set illustration

Figure 5.2 provides a visual overview of this analysis; if $i \geq r-i$, the physician will use the recommended set. In a different notation, $i \geq r/2$ so we assume that, if the physician is considering ordering at least half of the tests in the recommended set, it makes sense to choose this set. Otherwise, they will select the tests one by one.

5.3.2 Total Click Calculations

The main purpose of this study is to reduce the test selection effort of physicians, and we focused on the number of clicks, which is one of the numerical metrics we can use here.

While doing the study, we excluded the clicks performed to open the system and confirm the examinations, we only dealt with the clicks during the test selection. In case of not using the suggested sets, we considered the total number of clicks as the total number of tests, since one click is required to select each test.

We assumed that if the recommended set was chosen, more than one scenario could

occur. First, if the physician wants to order all the tests in the set, he can add the set to the request with one click. If he does not want to add the whole set, he can select the set with a click and unselect each examination he does not order in the set with one click.

As a result, the process can result in 4 ways in its simplest form. (Figure 5.3)

1.1 No test order (number of click = 0)

1.2 Order without a recommended set (number of click = t)

1.3 Order containing the entire recommended set (number of click = $t-i+1$)

1.4 Order containing part of the recommended set (number of click = $t-i+r-i+1$)

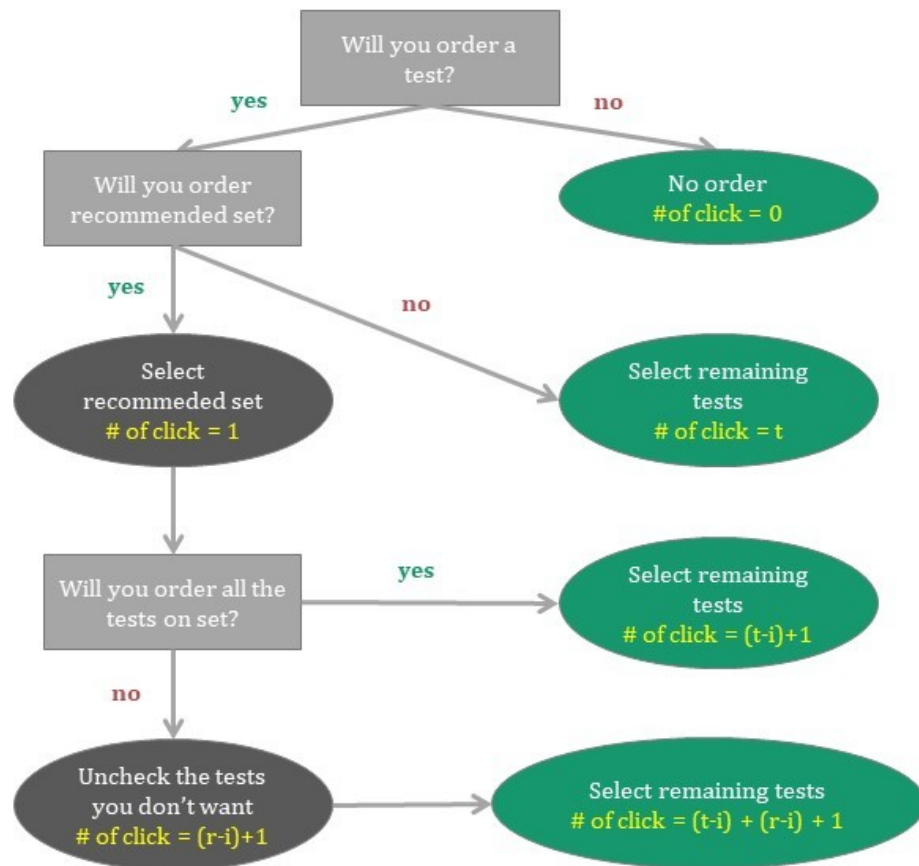


Figure 5.3 Decision tree for physician test order process

6. RESULTS

6.1 Diagnostic Test Order Recommendation Set Based on ICD Code

As mentioned in the previous section, the Apriori algorithm was applied to each selected ICD segment. We detected multiple frequent item sets when min support 0,01 is used; among the available sets, the largest one (due to the nature of the problem, the support rate decreases as the itemset expands) was selected. The recommended diagnostic test order sets for the ICD codes considered in this study are provided in Table 6.1, alongside the corresponding support rates.

As can be seen from Table 6.1, although we did the analysis for each segment separately, most of the recommended diagnostic test order sets include the same test set. In particular, the tests 901020 (Iron Serum), 902110 (Cholesterol), 903990 (Triglyceride), and 901580 (HDL Cholesterol), were recommended for all 15 ICD codes considered, except for D51.8 (Vitamin B12 Deficiency Anemia, Other), M25.5 (Joint Pain) and I10 (Essential –Primary- Hypertension). This is not very surprising since these tests are fairly general tests that can be requested in different diseases, and such similar sets can be found in market basket analysis.

For the (901020, 902110, 903990, 901580) set, we observed the highest support rate (0,62) for the ICD code E13.8-Diabetes Mellitus with Other Specified, Unspecified Complications. This shows that for 62 out of every 100 visits, the (901020, 902110, 903990, 901580) set was ordered by the physician. On the other hand, the lowest support rate (0.04) was observed for the ICD code D50.9-Iron Deficiency Anemia, Unspecified, indicating this particular set was ordered in only 4 out of 100 visits. We expect the support rate to be the same or higher for subsets of this set. For example, the support rate of (901020,902110) for the ICD code D50.9-Iron Deficiency Anemia is 0,11.

ICD Code	Recommended Diagnostic Test Order Set	Support Rate
Z04.8-Other Identified Reasons for Inspection and Observation	(901020, 902110, 903990, 901580)	0,12
E13.8-Diabetes Mellitus with Other Specified, Unspecified Complications	(901020, 902110, 903990, 901580)	0,62
I10-Essential (Primary) Hypertension	(902211, 901941, 902110, 903990, 901580)	0,01
Z00.8-General Inspections, Other	(901020, 902110, 903990, 901580)	0,27
E03.9-Hypothyroidism, Unspecified	(901020, 902110, 903990, 901580)	0,32
K30 Dyspepsia	(901020, 902110, 903990, 901580)	0,31
K21.9-Gastro-Esophageal Reflux Disease without Esophagitis	(901020, 902110, 903990, 901580)	0,13
D64.9-Anemia, Unspecified	(901020, 902110, 903990, 901580)	0,29
M79.1-Myalgia	(901020, 902110, 903990, 901580)	0,27
M25.5-Joint Pain	(901020, 906780, 903381, 901501, 903400, 900901, 901580, 901780, 903990)	0,01
D50.9-Iron Deficiency Anemia, Unspecified	(901020, 902110, 903990, 901580)	0,04
E55.9-Vitamin D Deficiency, Unspecified	(901020, 902110, 903990, 901580)	0,13
R10.4-Abdominal Pain Other and Unspecified	(901020, 902110, 903990, 901580)	0,19
J06.9-Acute Upper Respiratory Tract Infection	(901020, 902110, 903990, 901580)	0,12
D51.8-Vitamin B12 Deficiency Anemia, Other	(907030, 907010, 906980, 906990, 907020, 100007, 907000)	0,03

Table 6.1 Recommended diagnostic test order sets

The recommended diagnostic test order set for I10-Essential (Primary) Hypertension consists of five tests: 902211 (Creatinine), 901941 (Urea), 902110 (Cholesterol), 903990 (Triglyceride), and 901580 (HDL Cholesterol). The support rate for this set is 0,01; this is expected for large item sets (for example, for a subset of this itemset, (903990, 901020, 901580, 902110) the support rate is 0,59). As we mentioned earlier, we referenced larger item sets to capture more tests, but optimizing these sets may be the subject of further study.

The ICD code M25.5 - Joint Pain has the largest recommended diagnostic test order set we observed in this study, and includes 9 items: 901020 (Iron Serum), 906780 (Anti Nuclear Antibody Master), 903381 (Rheumatoid Factor (Rf) Nephelometric), 901501 (Glucose), 903400 (Sedimentation), 900901 (CRP), 901580 (HDL Cholesterol), 901780 (Urine Analysis Fully Automatic Urine Biochemistry), 903990 (Triglyceride). The support rate for this set is also 0,01, due to the reasons discussed above.

D51.8-Vitamin B12 Deficiency Anemia, Other is the last ICD code analyzed in this study. The recommended diagnostic test order set for D51.8-Vitamin B12 Deficiency Anemia, Other has 7 tests with a support rate 0,03, meaning this set was ordered in 3 visits out of 100: 907030 (Anti-Ssb Immunoblotting), 907010 (Anti-

Sm / Rnp Immunoblotting), 906980 (Anti-Jo1 Immunoblotting), 906990 (Anti-Scl 70 Immunoblotting), 907020 (Anti-Ssa Immunoblotting), 100007 (Ena Jo-1, Scl-70, Sm, Sm / Rnp, Ssa, Ssb), 907000 (Anti-Sm Immunoblotting).

Before we conclude this section, we note that, we could not run similar analyses for the other ICD codes that were assigned in the data, since we did not have enough observations. However, with data that covers more years, or includes more visits, or in another medical branch whose ICD distribution is not very dispersed, similar analyses can be conducted.

6.2 Evaluation Results

6.2.1 Usage Rate of Recommended Set

As described in Section 5.2, we next calculated the percentage of unique visits where the physicians ordered at least half of the items in the recommended test order set. The results are provided in Table 6.2 (further details are provided in Appendix A-2 and A-3).

From Table 6.2, we observe that the percentage of unique visits where at least half of the tests in the recommended set were ordered varies for each ICD code. For example, for the ICD code Z04.8-Other Identified Reasons for Inspection and Observation, the tests in the recommended set were ordered in 59.67% of the visits in 2015 and 56.27% in 2016. We conclude that the recommended set is suitable for this ICD, since the rates are high, and it does not differ much between the two years.

As described in Section 6.1, the recommended set for the ICD code E13.8-Diabetes Mellitus with Other Specified, Unspecified Complications has the highest support rate in our study; consistent with this result, it has one of the highest recommended set usage rates.

Although I10-Essential (Primary) Hypertension has a low support rate (0.01), we observe 79.87% recommended set usage in 2015 and 83.74% recommended set usage in 2016. The reason of the high usage rate is that the item set contains 5 items and this set is used in the visits where at least three of them are ordered.

ICD Code	Recommended set usage in examination visit with order	
	2015	2016
Z04.8-Other Identified Reasons for Inspection and Observation	59,67%	56,22%
E13.8-Diabetes Mellitus with Other Specified, Unspecified Complications	82,90%	79,37%
I10-Essential (Primary) Hypertension	79,87%	83,74%
Z00.8-General Inspections, Other	62,80%	43,41%
E03.9-Hypothyroidism, Unspecified	45,01%	38,00%
K30 Dyspepsia	42,81%	45,97%
K21.9-Gastro-Esophageal Reflux Disease without Esophagitis	42,55%	31,58%
D64.9-Anemia, Unspecified	37,01%	44,16%
M79.1-Myalgia	40,69%	54,35%
M25.5-Joint Pain	68,15%	54,20%
D50.9-Iron Deficiency Anemia, Unspecified	28,07%	30,91%
E55.9-Vitamin D Deficiency, Unspecified	30,43%	29,31%
R10.4-Abdominal Pain Other and Unspecified	37,11%	23,90%
J06.9-Acute Upper Respiratory Tract Infection, Unspecified	26,53%	47,06%
D51.8-Vitamin B12 Deficiency Anemia, Other	2,63%	0,00%
Total	40,23%	44,54%

Table 6.2 Recommended set usage results

E03.9-Hypothyroidism, Unspecified, K30 Dyspepsia, K21.9-Gastro-Esophageal Reflux Disease without Esophagitis, D64.9-Anemia, Unspecified, M79.1-Myalgia, D50.9-Iron Deficiency Anemia, Unspecified, E55.9-Vitamin D Deficiency, Unspecified, R10.4-Abdominal Pain Other And Unspecified and J06.9-Acute Upper Respiratory Tract Infection, Unspecified have the same recommended itemset and its usage rate varies between 26,53% and 45,01% in 2015 and 23,90% and 54,35% in 2016.

M25.5-Joint Pain has the largest recommended itemset with 9 items and it has a high usage rate as expected.

Finally, the ICD code D51.8-Vitamin B12 Deficiency Anemia, Other has the lowest usage rate; this can be attributed to the fact that the data for this particular ICD code is limited (38 observations) for detecting frequent sets.

To summarize, we have seen that the frequent sets determined are also acceptable for validation (2016) data and can be used frequently during the test order through examination visit. We also note that the possibility of using the recommended set increases as the number of unique visits with test order in the train set, the recommended set support rate and the number of tests in the recommended set increases.

6.2.2 Total Click Calculations

Firstly, when we calculate the total number of clicks, we focused only on visits which tests are ordered by using the recommended set (see Table 6.3). Using the recommended set decreases the number of clicks by 9,90% on average in 2015 and 6,80% in 2016 (further details are provided in Appendix A-4 and A-5).

Considering that the average number of ordered tests for visits with orders is 19.24 and that most of our test sets contain 4 items, these rates are compatible.

The highest decrease was seen in I10-Essential (Primary) Hypertension, it is the only segment that includes 5 items in the recommended set. Mathematically, it is natural that we see an increase in the decrease as the size of the set increases up to a point. Because as the set size increases, the number of examinations the physician adds with one click increases. When the set gets too big, the number of clicks starts to increase again, as the number of unnecessary examinations in the set also increases.

ICD Code	% decrease in number of clicks	
	2015	2016
Z04.8-Other Identified Reasons for Inspection and Observation	9,80%	6,39%
E13.8-Diabetes Mellitus with Other Specified, Unspecified Complications	9,97%	7,11%
I10-Essential (Primary) Hypertension	14,47%	17,58%
Z00.8-General Inspections, Other	9,07%	6,29%
E03.9-Hypothyroidism, Unspecified	10,06%	7,34%
K30 Dyspepsia	9,78%	8,20%
K21.9-Gastro-Esophageal Reflux Disease without Esophagitis	10,42%	6,60%
D64.9-Anemia, Unspecified	10,46%	9,01%
M79.1-Myalgia	9,38%	5,56%
M25.5-Joint Pain	11,89%	11,70%
D50.9-Iron Deficiency Anemia, Unspecified	10,68%	7,80%
E55.9-Vitamin D Deficiency, Unspecified	9,84%	9,48%
R10.4-Abdominal Pain Other And Unspecified	8,60%	5,97%
J06.9-Acute Upper Respiratory Tract Infection, Unspecified	8,38%	7,16%
D51.8-Vitamin B12 Deficiency Anemia, Other	N/A	N/A
Total	9,90%	6,80%

Table 6.3 Decrease in number of total clicks (orders that recommended set is used)

M25.5-Joint Pain has the second-best results and its recommended set contains 9 items. This result also supports the inverse correlation between the size of the itemset and the number of clicks.

D51.8-Vitamin B12 Deficiency Anemia, Other was excluded from the analysis be-

cause it does not contain enough data for observing a decrease in the number of clicks.

The success rates are similar in 2015 for the remaining ICD codes with the same recommendation set. As in most of the analysis, we observe that the success of the test set is higher than the validation set. We can explain the decrease in success in 2016 with it. If we do the same calculation with the recommended set which detected from unique visit data collected in 2016, we can observe higher success rates for 2016.

Secondly, we calculate the total number of clicks for all orders (both orders recommended set used and unused) (see Table 6.4). Using the recommended set decreases the number of clicks for all orders by 8,00% on average in 2015 and 4,97% in 2016 (further details are provided in Appendix A-6 and A-7).

ICD Code	% decrease in number of clicks	
	2015	2016
Z04.8-Other Identified Reasons for Inspection and Observation	7,87%	4,72%
E13.8-Diabetes Mellitus with Other Specified, Unspecified Complications	9,44%	6,44%
I10-Essential (Primary) Hypertension	13,67%	16,15%
Z00.8-General Inspections, Other	7,50%	3,59%
E03.9-Hypothyroidism, Unspecified	7,77%	5,17%
K30 Dyspepsia	6,50%	5,97%
K21.9-Gastro-Esophageal Reflux Disease without Esophagitis	8,01%	3,87%
D64.9-Anemia, Unspecified	6,19%	5,98%
M79.1-Myalgia	6,46%	3,90%
M25.5-Joint Pain	10,50%	8,77%
D50.9-Iron Deficiency Anemia, Unspecified	5,91%	4,27%
E55.9-Vitamin D Deficiency, Unspecified	6,88%	5,49%
R10.4-Abdominal Pain Other And Unspecified	5,02%	2,05%
J06.9-Acute Upper Respiratory Tract Infection, Unspecified	4,88%	5,10%
D51.8-Vitamin B12 Deficiency Anemia, Other	N/A	N/A
Total	8,00%	4,97%

Table 6.4 Decrease in number of total clicks (all orders)

As expected, rates decrease when the same analysis was repeated for all visits. In terms of ICD codes, the ordering is similar to the Table 6.4 I10-Essential (Primary) Hypertension has the highest rate, followed by M25.5-Joint Pain.

D51.8-Vitamin B12 Deficiency Anemia, Other was again excluded from the analysis because it does not contain enough data for observing a decrease in the number of clicks.

7. CONCLUSION

As a result, frequent test sets for the 15 most common ICD codes were determined. Among these sets, the best-recommended test set was selected one for each ICD code. The suitability of the recommended set for the order during the visit was tested. It was observed that the recommended sets could be used in 40.23% and 44.54% of the visits for the years 2015 and 2016, respectively. For the visits using this set, it was observed that the total number of clicks decreased by 9.90% for 2015 and 6.80% for 2016.

There was some limitation we encountered while conducting this study. As we conducted a data-focused study, we could not analyze for ICD codes that did not contain enough visits. If our data were to cover a wider time span, we could have done a study with more data and more ICD codes. Again, if our data were sufficient, we could repeat this study for patient groups segmented by age and gender.

In addition, during our study, we assumed that a patient had only one illness since only one ICD code for each patient was defined on the data. Due to restrictions in the data, we could not take co-morbidities into account while performing our study. The fact that most of the data was labeled as ICD code as the general examination was another detail that limited our analysis. Finally, in the study, we made the calculations assuming that the proposed system would not affect the doctor's decision. We assumed that the recommended sets do not alter the doctor's likelihood of choosing the recommended tests.

For further studies, the chosen ICD group can be expanded via grouping them into wider categories. Moreover, as a method, the subsets of the recommended sets can be defined according to their frequency for each ICD code. After the analyzes are repeated for each subset, the size of the subset that achieves the best success can be calculated and the optimal support rate can be determined. More than one suggested set can be specified for each ICD code and the possibility to add more than one test in each request can be offered.

While completing the study, we think that it will be beneficial to integrate such

suggestion systems in hospitals, especially HIMS, in order to reduce the effort of physicians. We hope that hospital administrations will improve more usable and less tiring systems for physicians by taking such studies into account.



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APPENDIX A

Test Name	Test ID
17-HİDROKSİPROGESTERON	900120
24 saat EKG kaydı (Holter)	700540
24 SAAT İDRAR MİKRO TOTAL PROTEİN	902552
24 SAATLİK İDRARDA FOSFOR	100012
24 SAATLİK İDRARDA GLUKOZ	100015
24 SAATLİK İDRARDA KALSİYUM	100013
24 SAATLİK İDRARDA KAPPA HAFİF ZİNCİR	100009
24 SAATLİK İDRARDA KLOR	100016
24 SAATLİK İDRARDA KREATİNİN	902213
24 SAATLİK İDRARDA LAMPDA HAFİF ZİNCİR	100010
24 SAATLİK İDRARDA MAGNEZYUM	100014
24 SAATLİK İDRARDA MİKROALBÜMİN	100004
24 SAATLİK İDRARDA MİKROALBÜMİN(BALGAT)	100018
24 SAATLİK İDRARDA POTASYUM	100017
24 SAATLİK İDRARDA SODYUM	100006
24 SAATLİK İDRARDA ÜRE	100005
24 SAATLİK İDRARDA ÜRİK ASİT	904122
25-HİDROKSİ VİTAMİN D	900130
5 HİDROKSİ İNDOL ASETİK ASİT	900135
5 HİDROKSİTRİPTAMİN (SERATONİN) (PLAZMA)	901630
5' NÜKLEOTİDAZ	900070
ABDOMEN US, TÜM	803570
ABDOMEN US, ÜST	803590
ABO+RH TAYİNİ (FORWARD GRUPLAMA)+ABO REVERSE GRU	705130
ACTH 0.DK	900181
ADACIK HÜCRE ANTİKORU (İSLET CELL ANTİKORU-İCA)	906320
ADENOZİN DEAMİNAZ AKTİVİTESİ (ADA) (MAYİ)	900160
ADRENAL VENÖZ ÖRNEKLEME	802701
ADRENOKORTİKOTROPİK HORMON (ACTH)	900182
AKCİĞER GRAFİSİ DEKUBİTİS POZ	801724
AKCİĞER GRAFİSİ P.A. (TEK YÖN)	801721
AKCİĞER GRAFİSİ YAN (SAĞ)	801722

Table A.1 continued from previous page

Test Name	Test ID
AKCİĞER GRAFİSİ YAN (SOL)	801725
AKCİĞER PERFÜZYON SİNTİGRAFİSİ	800620
AKCİĞER PERFÜZYON SPECT	800640
AKTİVASYONLU EEG	703000
AKTİVE PROTEİN C REZİSTANSİ	904280
ALANİN AMİNOTRANSFERAZ (ALT)	900200
ALBÜMİN	900210
ALDOSTERON 0'	900230
ALDOSTERON AYAKTAN	900231
ALFA- FETO PROTEİN (AFP)	900250
ALKALEN FOSFATAZ	900340
ALKALEN FOSFATAZ İZOENZİMLERİ	900360
ALT EKSTREMİTE ARTERİEL SİSTEM RDUS, TEK TARAFLI	803780
ALT EKSTREMİTE PERFORAN VEN RENKLİ DOPPLER US, TEK	803640
ALT EKSTREMİTE VENÖZ SİSTEM RDUS, TEK TARAFLI	803790
Ambulatuvar kan basıncı ölçümü (24 saat)	700470
AMİLAZ	900370
AMİP ANTİJEN (GAİTA)	907350
AMPHETAMİNES (AMP)	901794
ANATOMİK KORELASYON İSKELET SİSTEMİ UYGULAMALARI I	800902
ANKİLOZAN SPONDİLİT YATKINLIK ALLELLER (HLA B27)	908735
ANTI NÖT. SİTOPLAZMIK ANTİKOR (P-ANCA VE C-ANCA)	906770
ANTİ ASETİLKOLİN RESEPTÖR ANTİKORU	906340
ANTİ BETA-2 GLİKOPROTEİN 1 İGA	900420
ANTİ BETA-2 GLİKOPROTEİN 1 İGG	900430
ANTİ BETA-2 GLİKOPROTEİN 1 İGM	900440
ANTİ CMV İGG (MİKROPARTİKÜL İMMÜN ASSAY-MEİA VEYA	906360
ANTİ CMV İGM (MİKROPARTİKÜL İMMÜN ASSAY-MEİA VEYA	906370
ANTİ DİURETİK HORMON (ADH)	900450
ANTİ DNASE B	906400
ANTİ DS DNA	906410
ANTİ DÜZ KAS ANTİKORU (ASMA)	906420
ANTİ ENDOMİSYUM ANTİKOR	906430
ANTİ FOSFOLİPİD İGG	906470
ANTİ FOSFOLİPİD İGM	906480
ANTİ GLİADİN LGA	906490
ANTİ GLİADİN LGG	906500

Table A.1 continued from previous page

Test Name	Test ID
ANTİ HAV İGG (MİKROPARTİKÜL İMMÜN ASSAY-MEİA VEYA	906510
ANTİ HAV İGM (ELİSA)	906540
ANTİ HAV İGM (MİKROPARTİKÜL İMMÜN ASSAY-MEİA VEYA	906530
ANTİ HBC İGG (MİKROPARTİKÜL İMMÜN ASSAY-MEİA VEYA	906560
ANTİ HBC İGM (MİKROPARTİKÜL İMMÜN ASSAY-MEİA VEYA	906580
ANTİ HBC İGM (ELİSA)	906570
ANTİ HBE (MİKROPARTİKÜL İMMÜN ASSAY-MEİA VEYA BEN	906600
ANTİ HBS (MİKROPARTİKÜL İMMÜN ASSAY-MEİA VEYA BEN	906620
ANTİ HCV (MİKROPARTİKÜL İMMÜN ASSAY-MEİA VEYA BENZ	906640
ANTİ HEPATİT E (HEV)	906650
ANTİ HİSTON ANTİKOR	906700
ANTİ HİV (KEMİLUMİNESANS VEYA BENZERİ)	906670
ANTİ İNSÜLİN ANTİKOR	906710
ANTİ KARDİYOLİPİN LGG	906730
ANTİ KARDİYOLİPİN LGM	906740
ANTİ MİTOKONDRIYAL ANTİKOR (AMA)	906760
ANTİ NÜKLEER ANTİKOR (ANA)	906780
ANTİ PARİYETAL ANTİKOR (APA)	906790
ANTİ RUBELLA İGG (KEMİLUMİNESANS VEYA BENZERİ)	906820
ANTİ RUBELLA İGM (KEMİLUMİNESANS VEYA BENZERİ)	906840
ANTİ THROMBİN 3 AKTİVİTESİ	904350
ANTİ TİROGLOBULİN ANTİKOR	906880
ANTİ TOXOPLAZMA İGG (KEMİLUMİNESANS VEYA BENZERİ)	906910
ANTİ TOXOPLAZMA İGM (KEMİLUMİNESANS VEYA BENZERİ)	906930
ANTİ TPO	900480
ANTİBİYOTİK DUYARLILIK TESTİ	905610
ANTİ-GAD ANTİKORU	906960
ANTİ-JO1 (İMMUNOBLOTTİNG)	906980
ANTİMÜLLERİEN HORMON	900475
ANTİ-SCL 70 (İMMUNOBLOTTİNG)	906990
ANTİ-SM (İMMUNOBLOTTİNG)	907000
ANTİ-SM/RNP (İMMUNOBLOTTİNG)	907010
ANTİ-SSA (İMMUNOBLOTTİNG)	907020
ANTİ-SSB (İMMUNOBLOTTİNG)	907030
APOLİPOPROTEİN A ALT GRUPLARI (HER BİRİ)	900490
APOLİPOPROTEİN B ALT GRUPLARI (HER BİRİ)	900500
APSE-DRENAJ KÜLTÜRÜ	905661

Table A.1 continued from previous page

Test Name	Test ID
APTT	904290
ARB BOYAMA	905764
ASO (NEFELOMETRİK)	900571
ASPARTAT TRANSAMİNAZ (AST)	900580
AYAK BİLEĞİ ÇİFT GR(SAĞ)	801783
AYAK BİLEĞİ ÇİFT GR(SOL)	801784
AYAK ÇİFT YN.GRF.(SAĞ)	801781
AYAK ÇİFT YN.GRF.(SOL)	801782
AYAKTA DİREKT BATİN GRF.	801741
BAKIR (24 SAATLİK İDRAR)	900592
BAKIR (SPOT İDRAR)	900593
BAKİR	900591
BAKTERİ TANIMLANMASI (MANUEL)	905680
BAKTERİ TANIMLANMASI (YARI OTOMATİK)	905700
BALGAM KÜLTÜRÜ	905675
BARBİTURATES (BAR)	901795
BCR / ABL, T(9;22) FISH	908708
BEHÇET HASTALIĞI (HLA-B5)	998732
BENCE-JONES PROTEİNİ	900610
BENZODİAZEPİNES (BZO)	901796
BETA-2 MİKROGLOBULİN	900620
BETA-HCG (TOTAL HCG)	900650
BEYİN OMURİLİK SIVISI (BOS) KÜLTÜRÜ (ÖZEL ZENGİNLE	905730
BİKARBONAT	900681
BİLİRUBİN (DİREKT)	900691
BİLİRUBİN (İNDİREKT)	900693
BİLİRUBİN (TOTAL)	900692
BIOTİNİDAZ AKTİVİTESİ	900700
BOĞAZ KÜLTÜRÜ	905670
BORRELİA BURGDORFERİ İGG	907050
BORRELİA BURGDORFERİ İGM	907060
BOYALI MİKROSKOPİK İNCELEME	905761
BOYALI MİKROSKOPİK İNCELEME (GRAM, M.MAVİSİ, WRİGH	905762
BOYASIZ DİREKT MİKROSKOBİK İNCELEME	905771
BOYUN US	803320
BRONKOALVEOLER LAVAJ SIVISI (BAL) KÜLTÜRÜ	906250
BRONKUS, BİYOPSİ	909500

Table A.1 continued from previous page

Test Name	Test ID
BRUCELLA AGLÜTİNASYON TESTİ (ROSE BENGAL)	907070
BRUCELLA AGLÜTİNASYONU (COOMBS ANTİSERUMU İLE)	907080
BRUCELLA İG G (ELİSA)	907091
BRUCELLA İG M (ELİSA)	907092
BRUCELLA TÜP AGLÜTİNASYONU	907090
BT, 3 BOYUTLU GÖRÜNTÜLEME	803870
BT, ABDOMEN, ALT	803890
BT, ANGIOGRAFI, TEK ANATOMİK BÖLGE İÇİN	803880
BT, BEYİN	803910
BT, BOYUN	803920
BT, DİNAMİK, TRİFAZİK, BİFAZİK İNCELEME	804140
BT, EXTREMİTE (20-50CM BÖLGE)	803940
BT, MAKSİLLOFASİYAL TOMOGRAFİ, AKSİYEL	803990
BT, ORBİTA	804020
BT, PARANAZAL SİNÜS	804030
BT, TOMOGRAFİ, DİĞER	804080
BT, TORAKS	804070
BT, ÜST ABDOMEN	804090
BT, VERTEBRA SERVİKAL	804100
BT, VERTEBRA LUMBAL	804102
BT, VERTEBRA TORAKAL	804101
BT, YÜKSEK REZOLUSYONLU AKCİĞER	804150
BUFFY COAT DEPLESYONU	705190
BURUN KÜLTÜRÜ	905677
BÜYÜME HORMONU	900740
C PEPTİT	900751
C.PEPTİT 120'	900752
C.PEPTİT 180'	900753
C.PEPTİT 30'	900754
C.PEPTİT 300'	900755
C.PEPTİT 60'	900756
C.PEPTİT 90'	900757
C1 ESTERAZ İNHİBİTÖRÜ	900760
C4	900790
CA 72-4	900840
CA-125	900810
CA-15-3	900820

Table A.1 continued from previous page

Test Name	Test ID
CA-19-9	900830
CCP	907101
CEA (KARSİNOEMBRYONİK ANTİJEN)	902030
CENP-B (İMMUNOBLOTTİNG)	906860
CEP 7 FISH	908701
CEP 8 FISH	908702
CHLAMYDİA PNEUMONİA İGA	907120
CHLAMYDİA PNEUMONİAE İGG	907130
CİVA (ATOMİK ABSORBSİYON)	900871
CK (KREATİN KİNAZ)	902190
CLOSTRİDİUM DİFFİCİLE TOXİN-A VE B	907190
CMV İGG AVİDİTE	907220
CMV PCR	908140
COCAİNE (COC)	901797
CROSS MATCH	705200
CRP	900901
ÇİNKO	900950
ÇİNKO ERİTROSİT İÇİ	900951
D13S319/13Q34 FISH	908703
D20S108 (20Q12) FISH	908704
D7S486 (7Q31) / CEP 7 FISH	908705
D-DİMER (KANTİTATİF)	904400
DEHİDROEPIANDROSTERON	900990
DEHİDROEPIANDROSTERON SULFAT	901000
DELTA ANTİKORU	907240
DEMİR (SERUM)	901020
DEMİR BAĞLAMA KAPASİTESİ	901040
DERİ, EKSİZYONEL BİYOPSİ 1-2 LEZYON	910270
DERİ, KİST/ UZANTI (TAG) /DEBRİD. /PLASTİK ONARIM	909540
DİGOXİN	901792
DİREK ÜRİNER SİST.GRF.	801742
DİREKT COOMBS (KOMPLEMAN)	705230
DİREKT COOMBS TESTİ (İG G)	705220
DİREKT PARAZİT İNCELENMESİ (MANUEL)	905774
DİRSEK ÇİFT YN.GRF. (SOL)	801788
DİRSEK ÇİFT YN.GRF.(SAĞ)	801792
DİZ ÇİFT YN.GRF. (SOL)	801786

Table A.1 continued from previous page

Test Name	Test ID
DİZ ÇİFT YN.GRF.(SAĞ)	801787
DİZ TANJ.PAT.TEK.GR(SOL)	801777
DİZ TANJ.PAT.TEK.GR.(SAĞ)	801774
DİZ TÜNEL TEK GR(SOL)	801775
DİZ TÜNEL TEK.GR(SAĞ)	801776
D-METHAMPHETAMİNE (MET)	901798
DOKU TRANSGLUTAMİNAZ İG A	901100
DOKU TRANSGLUTAMİNAZ İG G	901110
DOPPLER US, DİĞER	803861
DUODENUM, BİYOPSİ	909560
EBV EA	907280
EBV EBNA LGG	907290
EBV VCA LGG	907310
EBV VCA LGM	907320
EGFR	100019
EGR-1 (5Q31) FISH	908706
EKLEM GRAFİSİ (İKİ YÖN) MUKAYESELİ	801750
EKLEM GRAFİSİ (TEK YÖN) MUKAYESELİ	801760
EKLEM GRAFİSİ (TEK YÖN) TEK EKLEM	801771
EKLEM GRAFİSİ(İKİ YÖN)TEK EKLEM	801790
EKLEM SIVISI KÜLTÜRÜ	905881
EKLEM US (TEK TARAF)	803340
EKTOPIK PARATİROİD GÖRÜNTÜLEME	800982
EL BİLEK GR 2 YÖNLÜ	801785
EL BİLEK TEK YÖNLÜ GRF.	801560
ELEKTROKARDİYOGRAM	530100
EMG, GENEL TARAMA (ÜÇ EKSTREMİTE)	703130
EMG, MYOPATİ PROTOKOLÜ	703180
EMG, POLİNÖROPATİ PROTOKOLÜ	703200
EMG, RADİKÜLOPATİ VE PLEKSUS PROTOKOLÜ	703210
EMG, TUZAK NÖROPATİ PROTOKOLÜ	703220
ENA (JO-1,SCL-70, SM, SM/RNP, SSA, SSB)	100007
ENDOMETRİUM, KÜRETAJ/BİYOPSİ	909590
ENG	703990
EREL TEST PROFİLİ	100002
ERİTROPOETİN	904470
Eritrosit Süspansiyonu	705370

Table A.1 continued from previous page

Test Name	Test ID
ESTRADIÖL	901160
FAKTÖR II	904537
FAKTÖR IX	904532
FAKTÖR V	904536
FAKTÖR VIII İNHİBİTÖR TAYİNİ	904550
FAKTÖR VII	904538
FAKTÖR X	904539
FAKTÖR XI	904534
FAKTÖR XII	904533
FAKTÖR XIII	904535
FAKTÖR VIIİ	904531
FEMUR ÇİFT YN.GRF.(SAĞ)	801674
FEMUR ÇİFT YN.GRF.(SOL)	801675
FEMUR TEK YN.GRF.(SAĞ)	801677
FEMUR TEK YN.GRF.(SOL)	801678
FENİTOİN	901790
FERRİTİN	901220
FİBRİNOJEN	904610
FLT3 MUTASYON SAPTAMA	908734
FMF MUTASYON ANALİZİ 1. BASAMAK (EKZON2,10)	998710
FMF MUTASYON ANALİZİ 2. BASAMAK (EKZON3,5)	998711
FMF MUTASYON ANALİZİ 3. BASAMAK (TÜM GEN)	998713
FMF-AİLESEL AKDENİZ ATEŞİ	998712
FOLAT	901240
FOSFOR (P)	901261
FOSFOR (P) (24 SAATLİK)	901262
FSH	901280
GAİTA KÜLTÜRÜ	905672
GAİTA MİKROSKOPİSİ VE PARAZİT İNCELEME	100001
GAİTADA GİZLİ KAN ARANMASI (MANUEL)	905930
GALAKTOMANNAN ANTİJENİ	907390
GAMMA GLUTAMİL TRANSFERAZ (GGT)	901390
GASTRİN	901400
GASTROÖZAFAGİAL REFLÜ ÇALIŞMASI	801010
GEÇ POTANSİYEL (LP) VE/VEYA KALP HİZİ DEĞİŞKENLİĞİ	700560
GENİŞLETİLMİŞ SPEKTRUMLU BETA LAKTAMAZ (ESBL)	905950
GİEMZA BOYAMA	905765

Table A.1 continued from previous page

Test Name	Test ID
Glikolize hemoglobin (Hb A1C), HPLC yöntemi ile	901450
GLOMERUL BAZAL MEMBRAN ANTİKORU	900460
GLUKOZ	901501
GLUKOZ (24 SAATLİK)	901502
GLUKOZ 6-FOSFAT DEHİDROGENEZ	901510
GÖRÜNTÜLEME EŞLİĞİNDE BİOPSİ (KALİN YA DA İNCE İĞN	802930
GRAM BOYAMA	905763
HAPTOGLOBİN	901550
HBEAG (KEMOLUMİNESANS VEYA BENZERİ)	907420
HBSAG (KEMOLUMİNESANS VEYA BENZERİ)	907450
HBV-DNA (KANTİTATİF)	908150
HCV GENOTİPLENDİRME	908160
HCV-RNA (KANTİTATİF)	908170
HDL KOLESTEROL	901580
HDV-RNA	908171
HELİCOBACTER PYLORİ DİREK ANTİJEN	907490
HELİCOBACTER PYLORİ İGA (ELİSA)	907500
HELİCOBACTER PYLORİ İGG (ELİSA)	907510
HEMOGLOBİN ELEKTROFOREZİ AQAR JEL İLE	904700
HEMOGLOBİN ELEKTROFOREZİ HPLC İLE	904690
HEMOGLOBİN ZİNCİR ANALİZİ (HPLC)	904710
HEPATOBLİTER US	803390
HERPES SİMPEKS TİP 1 İGG	907520
HERPES SİMPEKS TİP 1 İGM	907530
HERPES SİMPEKS TİP 2 İGG	907560
HERPES SİMPEKS TİP 2 İGM	907570
HİSTOKİMYASAL BOYAMALAR	911160
HLA-B5	904810
HOMOSİSTEİN	901680
HUMERUS GRAFİSİ(SAĞ)	801672
HUMERUS GRAFİSİ(SOL)	801671
HÜCRE BLOĞU HAZIRLANMASI	909260
IGF-1 (SOMATOMEDİN-C)	903680
IGG SUBCLASS 4	907790
IGH / FGFR3 T(4;14) FISH	908709
IGH/CCND1 { T(11;14)(Q13;Q32)} (FISH)	908710
INV (16) (P13Q22) FISH	908711

Table A.1 continued from previous page

Test Name	Test ID
İ.V.P.	802140
İ.V.P.(DAKİKALIK)	802150
İDRAR KÜLTÜRÜ	905671
İDRAR MİKROSKOBİSİ	901730
İDRAR TETKİKİ (STRİP İLE)	901750
İDRAR TETKİKİ (TAM OTOMATİK İDRAR BİYOKİMYASI VE M	901780
İGA (İMMUN ELEKTROFOREZ)	907622
İGA (NEFELOMETRİK)	907621
İGG (İMMUN ELEKTROFOREZ)	907632
İGG (NEFELOMETRİK)	907631
İGM (İMMUNELEKTROFOROZİ)	907633
İGM (NEFELOMETRİK)	907640
İMMÜNFLORESAN MİKROSKOPİ	911170
İMMÜNHİSTOKİMYASAL İNCELEME	911180
İMMÜNOFİKSASYON ELEKTROFOREZİ (24H İDRAR)	901822
İMMÜNOFİKSASYON ELEKTROFOREZİ (KAN)	901821
İNCE İĞNE ASPIRASYONU, GÖNDERİLEN YAYMA PREPERATLA	909300
İNDİREKT COOMBS TESTİ	705290
İNSÜLİN	901841
İNSÜLİN 120'	901843
İNSÜLİN 180'	901844
İNSÜLİN 240'	901845
İNSÜLİN 30'	901846
İNSÜLİN 300'	901847
İNSÜLİN 60'	901842
İNSÜLİN 90'	901848
İNSÜLİN LİKE GROWTH FAKTÖR BAĞLAYAN PROTEİN-3	901850
İNTERLÖKİN 28B MOLEKÜLER ANALİZİ	998734
İYOT (İDRARDA)	901890
JAK-2 (MYELOPROLİFERATİF HASTALIKLAR)	908712
JAK-2 MUTASYON ANALİZİ V617F KANTİTASYON	908728
KABAKULAK İGG (ELİSA)	907690
KABAKULAK İGM (ELİSA)	907700
KAFA GRAFİSİ (DÖRT YÖN)	801800
KAFA GRAFİSİ (İKİ YÖN)	801810
KAFA GRAFİSİ (TEK YÖN)	801820
KALÇA EKLEMİ US (TEK TARAF)	803420

Table A.1 continued from previous page

Test Name	Test ID
KALÇA GR AP	801873
KALÇA GR YAN	801874
KALSİTONİN	901900
KALSİYUM (CA)	901911
KALSİYUM (CA) (24 SAATLİK)	901912
KAMPDA/LAMPDA ORANI	100011
KAMPDA/LAMPDA ORANI 24H	100008
KAN GAZLARI	901920
KAN KÜLTÜRÜ ŞİŞESİNDE BOS KÜLTÜRÜ	906023
KANAMA ZAMANİ	904850
KANTİTATİF BCR ABL (P190)	998735
KANTİTATİF BCR ABL (P210)	998733
KANTİTATİF T(8;21)	908727
KAPPA HAFİF ZİNFİR (İMMUNELEKTROFOREZ)	901972
KAPPA HAFİF ZİNFİR 24H İDRAR	901971
KARACİĞER, BİYOPSİ İĞNE / WEDGE (KAMA)	910360
KARBON MONOKSİT DİFFÜZYON TESTİ	701161
KARDİYOVASKÜLER STRESS TEST	700530
KARNİTİN	902010
KAROTİS RENKLİ DOPPLER US	803680
KATALAZ TESTİ	906040
KATEKOLAMİNLER VE METABOLİTLERİ 24H İDRAR	902042
KATEKOLAMİNLER VE METABOLİTLERİ	902041
KEMİK DENSİTOMETRESİ (LOKAL)	802900
KEMİK DENSİTOMETRESİ, TÜM VUCUT	802910
KEMİK İLİĞİ ASİRASYON DEĞERLENDİRMESİ	704720
KEMİK İLİĞİ ASİRASYONU	704730
KEMİK İLİĞİ BİYOPSİSİ, PATOLOJİ	909720
KEMİK İLİĞİNDEN KROMOZOM ANALİZİ	908471
KEMİK SPECT	800900
KİST HİDATİK (İNDİREKT HEMAGLÜTİNASYON)	907730
KİTLE LEZYONU RENKLİ DOPPLER US	803690
KİZAMİK LGG	907710
KİZAMİK LGM	907720
KLAVİKULA GR (AKROMİYOKLAVİKÜLER)	801679
KLOR (CL)	902091
KLOR (CL) (24 SAATLİK)	902092

Table A.1 continued from previous page

Test Name	Test ID
KOKSİKS GR 2 YÖNLÜ	801791
KOLESTEROL	902110
KOLLOGEN TIP I - CTX (BETA CROSS)	902120
KOLON, BİYOPSİ TEK LOKALİZASYON	909760
KOLONOSKOPİ, TOTAL	701450
KOLONOSKOPİK POLİPEKTOMİ	701460
KOMPLE VESTİBÜLER İNCELEME	704050
KOMPLEMAN 3 (C3) DÜZEYİ	900780
KONJUNKTİVA KÜLTÜRÜ	905679
KONTRAST EKOKARDİYOĞRAFI	700590
KORTİZOL	902171
KORTİZOL (SAAT 06:00)	902172
KREATİN	902180
KREATİNİN	902211
KREATİNİN (24 SAATLİK)	902214
KREATİNİN (İDRARDA)	902212
KREATİNİN KLERENS TESTİ	902220
KRİYOglobULİN	904910
KRONİK MYELOİD LÖSEMİ (KML) PANELİ FISH	908722
KURŞUN	902231
KÜTLE CK-MB	902240
LAKTAT	902250
LAKTİK DEHİDROGENAZ (LDH)	902260
LAMPDA HAFİF ZİNCİR (İMMUNELEKTROFOREZ)	902272
LAMPDA HAFİF ZİNCİR 24H İDRAR	902271
LDL KOLESTEROL	902290
LEGİONELLA ANTİJENİ (İDRAR)	907750
LENF DÜĞÜMÜ, BİYOPSİ	910390
LEVETRACETAM	901791
LH (20')	902412
LİPAZ	902320
LİPOPROTEİN A	902340
LİPOPROTEİN ELEKTROFOREZİ	902330
LİTYUM	902350
LİVER KİDNEY MİKROZOMAL ANTİKOR (İFA)	907810
LOMBER VERT. İKİ YN.GRF	801951
LOMBER VERT.TEK YN.GRF.	801962

Table A.1 continued from previous page

Test Name	Test ID
LUPUS ANTİKOAGÜLAN (DOĞRULAMA TESTİ İLE)	905000
LUPUS ANTİKOAGÜLAN TARAMASI	905010
LÜTEİNLEŞTİREN HORMON (LH)	902411
MAGNEZYUM	902421
MAGNEZYUM (24 SAATLİK)	902422
MAMMOGRAFI (SAĞ)	801591
MAMMOGRAFI (SOL)	801592
MEME RENKLİ DOPPLER US	803700
MEME US (BİLATERAL)	803430
MEME US (UNİLATERAL)	803440
MEME, BİYOPSİ	910400
METANEFİRİN	902043
METHADONE (MDN)	901802
METİL MALONİK ASİT (İDRAR)	902492
METİL MALONİK ASİT (SERUM)	902491
MİDE BOŞALMA ZAMANI ÇALIŞMASI	801050
MİDE, BİYOPSİ TEK LOKALİZASYON	909820
MİKROBAKTERİ (PCR)	908290
MİKROBAKTERİ KÜLTÜRÜ	906160
MİKROBAKTERİ KÜLTÜRÜ (ÜREME KONTROLLÜ OTOMATİK SİST	906170
MİKROALBUMİN	902541
MİKROALBUMİN (24 SAATLİK)	902542
MİKROPROTEİN	902551
MİKROPROTEİN (24 SAATLİK)	902553
MİYOGLOBİN	902570
MİYOKARD ATTENÜASYON DÜZELTME	800863
MİYOKARD PERFÜZYON GATED SPECT TC-99M KOMPLEKSLERİ	800800
MİYOKARD PERFÜZYON SİNTİGRAFİSİ (SPECT) TC-99M KOM	800830
MLL (11Q23) YENİDEN DÜZENLENMELERİ FISH	908714
MONO TEST (TAM HETEROFİL ANTİKORLAR)	907830
MP1 KÜF PANELİ 1 MP1L4	903720
MR ANJİYOGRAFI	804340
MR ENTEROKLİZİS	804412
MR KOLANJİYOGRAFI	804350
MR SPEKTROSKOPİ (MULTİVOKSEL TEK EKO)	804380
MR T2 * KARACİĞER	804411
MR T2 * KARDİYAK	804281

Table A.1 continued from previous page

Test Name	Test ID
MR ÜROGRAFI	804390
MR, ABDOMEN, ALT	804180
MR, ABDOMEN, ÜST	804480
MR, BEYİN	804190
MR, BOS AKİM	804200
MR, BOYUN	804210
MR, DİFFUZYON	804220
MR, DİĞER	804410
MR, DİNAMİK	804230
MR, EKLEM TEK	804240
MR, EKSTREMİTE TEK TARAFLI	804250
MR, HİPOFİZ	804270
MR, KULAK	804310
MR, NAZOFARİNGS	804420
MR, PERFÜZYON	804440
MR, TEMPOROMANDİBULER EKLEM (TEK EKLEM)	804460
MR, VERTEBRA, LOMBER (BASKILI, BASKISIZ)	804320
MR, VERTEBRA, SERVİKAL	804450
MR, VERTEBRA, TORAKAL	804470
MYCOPLASMA PNEUMONİA İGG (ELİSA)	907860
MYCOPLASMA PNEUMONİAE İGM (ELİSA)	907870
NAZOFARİNGS/OROFARİNGS, BİYOPSİ	909840
NORMETANEFİRİN	902044
NÜKLEOSOM	907871
OBSTETRİK RENKLİ DOPPLER US	803710
OBSTETRİK US	803450
ODİOMETRİ + TİMPANOMETRİ	704110
OGTT 100 GR (0 - 60 - 120 - 180 DK.)	901522
OGTT 75 GR (0-30-60-90-120. DK)	901521
OGTT UZATILMIŞ (0-30-60-90 -120 -180 -240-300DK.)	901520
OGTT-GEBE 100 GR (0.DK- 60.DK-120.DK-180.DK)	901523
OGTT-GEBE 75 GR (0.DK- 60.DK-120.DK)	901524
OMUZ AKS.TEK GR(SAĞ)	801772
OMUZ AKS.TEK GR(SOL)	801773
OMUZ GR 2 YÖNLÜ	801789
Onkolojik PET (F-18FDG)	801440
OPIATES (OPİ)	901803

Table A.1 continued from previous page

Test Name	Test ID
ORGANİK ASİDEMİLERİN PRENATAL TANILARI (GC/MS)	902820
OZMOLARİTE	902901
OZMOLARİTE(İDRAR)	902902
OZMOTİK FRAJİLİTE TESTİ	905120
ÖN KOL GR AP	801670
ÖZOFAGOSKOPİ, GASTROSKOPİ, DUODENOSKOPİ (BİRİ VEYA	701540
ÖZOFAGOSKOPİ, GASTROSKOPİ, DUODENOSKOPİ + BİYOPSİ	701550
PANKREAS, BİYOPSİ	910460
PARATHORMON (PTH)	902980
PARATİROİD SİNTİGRAFİSİ	800940
PARATİROİD SPECT	800942
PAROTİS BEZİ US	803470
PARVOVİRUS B19 İGG	907900
PARVOVİRUS B19 İGM	907910
PELVİK RENKLİ DOPPLER US	803730
PELVİS GR.(TEK YÖN)	801872
PERİFERİK KANDAN KROMOZOM ANALIZI	908501
PERİFERİK KAN KÜLTÜRÜ (ANAEROB)	906022
PERİFERİK KAN KÜLTÜRÜ 1. İSTEM (AEROB)	906021
PERİFERİK KAN KÜLTÜRÜ 2. İSTEM (AEROB)	906024
PERİFERİK KAN KÜLTÜRÜ 3. İSTEM (AEROB)	906025
PERİFERİK KAN YAYMASI DEĞERLENDİRİLMESİ	704770
PERİTON SIVI KÜLTÜRÜ	906222
PERKÜTAN ASİT, PLEVRAL EFFÜZYON DRENAJİ	803030
PHEBCYCLİDİNE (PCP)	901799
PİRUVAT KİNAZ	905220
PLANER EK GÖRÜNTÜLEME	801559
PML / RARA, T(15;17) (Q22;21) FISH	908713
PORTAL VEN RENKLİ DOPPLER US	803750
POST PRANDİAL KAN ŞEKERİ (TOKLUK KAN ŞEKERİ)	903120
POTASYUM	903131
POTASYUM (24 SAATLİK)	903132
PROCALCİTONİN	903170
PROGESTERON	903180
PROLAKTİN	903211
PROLAKTİN 15' (MAKROPROLAKTİN)	903212
PROSTAT SPESİFİK ANTİJEN (PSA)	903220

Table A.1 continued from previous page

Test Name	Test ID
PROSTATİK ASİT FOSFATAZ (PAP)	903230
PROTEİN	903240
PROTEİN C	905260
PROTEİN C ANTİJENİ	905270
PROTEİN ELEKTROFOREZİ (24 H İDRAR)	903252
PROTEİN ELEKTROFOREZİ (SERUM VE VÜCUT SIVILARI)	903251
PROTEİN S	905280
PROTEİN S ANTİJENİ	905290
PROTROMBİN ZAMANI (KOAGÜLOMETRE)	905320
PSA (SERBEST)	903280
PSEUDOKOLİN ESTERAZ	903290
REKTOSKOPİ VE/VEYA SİGMOİDOSKOPİ	701390
RENAL KORTİKAL SİNTİGRAFI	801170
RENAL RENKLİ DOPPLER US (BİLATERAL)	803760
RENAL US	803480
RENİN DİREKT	903330
RENİN DİREKT AYAKTAN	903331
RETİKÜLOSİT SAYIMI	905360
REVERSE TRANSCRIPTASE PCR MULTIPLEX	908732
RİB-P0 (İMMUNOBLOTTİNG)	906800
ROMATOİD FAKTÖR (RF) (NEFELOMETRİK)	903381
ROTAVİRUS ANTİJENİ	907980
RUBELLA İGG AVIDİTE	908000
RUTİN EEG (ÇOCUK-BÜYÜK)	703020
SAFRA KESESİ	909960
SAKROİLİAK EKLEM GR	801871
SEDİMENTASYON	903400
SEDİMENTASYON (BEŞEVLER)	903401
SEKS HORMON BAĞLAYICI GLOBULİN (SHBG)	903410
SELENYUM	903420
SELLÜLER KAN ÜRÜNLERİNİN İŞİNLANMASI	705310
SELOBANT YÖNTEMİ İLE KİL KURDU ARAMA	905773
SENSİTİF CRP	903430
SERBEST KORTİZOL(İDRAR)	903460
SERBEST T3	903470
SERBEST T4	903480
SERBEST TESTOSTERON	903490

Table A.1 continued from previous page

Test Name	Test ID
SERULOPLAZMİN (NEFELOMETRİK)	903530
SERUM ACE DÜZEYİ	903540
SERUM AMİLOİD A	903550
SERVİKAL VEYA VAJİNAL SİTOLOJİ, SİVİ BAZLI İNCE TA	909330
SERVİKAL VEYA VAJİNAL SİTOLOJİ, YAYMA PREPERATLAR	909340
SİKLOSPORİN A - C0 (CYCLOSPORİN A)	900930
SİNÜS (WATERS) GRAFİSİ (TEK YÖN)	801630
SKOLYOZ TETKİKİ	801640
SKROTAL RENKLİ DOPPLER US	803770
SKROTAL US	803490
SODYUM (NA) (24 SAATLİK)	903672
SODYUM (NA) (SERUM VE VÜCUT SIVILARINDA, HERBİRİ)	903671
SOLUNUM FONKSİYON TESTLERİ	701220
SOLUNUM FONKSİYONLARI İLE REVERSİBİLİTE TESTİ	701230
SSA/RO52KD (İMMUNOBLOTTİNG)	907025
SUBMANDİBULER BEZ US	803500
SUPRAPUBİK PELVİK US	803560
TAKROLİMUS (FK 506)	903810
TAM KAN (HEMOGRAM)	901621
TAM KAN (HEMOGRAM) BEŞEVLER SEMT	901620
TAM KAN(HEMOGRAM)	901622
TBC DNA PCR	100020
TELEFONİK YA DA TELEMETRİK RİTM EKG (1 KEZ)	700500
TELEKARDİYOGRAM	801723
TETRAHYDROCANNABİNO (THC)	901800
TİBİA-FİBULA ÇİFT GR(SAĞ)	801673
TİBİA-FİBULA ÇİFT.GR(SOL)	801676
TİBİA-FİBULA TEK.GR(SAĞ)	801680
TİBİA-FİBULA TEK.GR(SOL)	801681
TİROGLOBULİN	903830
TİROİD BEZİ RENKLİ DOPPLER US	803820
TİROİD SİNTİGRAFİSİ	800950
TİROİD UPTAKE ÇALIŞMASI (İ-131 İLE)	800970
TİROİD US	803510
TORAKS US	803520
TOTAL İGE	903890
TOTAL TESTESTERON	903930

Table A.1 continued from previous page

Test Name	Test ID
TOXOPLASMA İGG AVIDİTE	908070
TP53 (17P13.1) DELESYONU FISH	908707
TRANSFERRİN	903952
TRANSFERRİN SATÜRASYONU	903951
TRANSKRANİAL VEYA TRANSFONTANEL RENKLİ DOPPLER	803830
TRANSÖZOFAGEAL EKOKARDİYOĞRAFI	700610
TRANSTORASİK EKOKARDİYOĞRAFI	700600
TRANSVAJİNAL US	803550
TREPONEMA PALLİDUM HEMAGLÜTİNASYON (TPHA)	908090
TRİCYCLİC ANTİDEPRESSANTS (TCA)	901801
TRİGLİSERİD	903990
TROMBİN ZAMANI	905440
TROMBOFİLİ PANELİ (FII, FV, FXIII, MTHFR, PAI)	998714
TROMBOZ FAKTOR II (G20210A)	998727
TROMBOZ FAKTÖR V LEİDEN	998728
TROMBOZ MTHFR 677 RİSK ANALİZİ	998729
TROMBOZ MTHFRA1298 RİSK ANALİZİ	998730
TROMBOZ PAI-1	998731
TROPONİN T	904020
TSH	904030
TSH RESEPTOR BLOKE EDİCİ ANTİKOR	904040
TÜKRÜK BEZİ, BİYOPSİ	910580
TÜM VÜCUT KEMİK SİNTİGRAFİSİ	800890
ULTRASON, DİĞER	803601
ULTRASON, GENEL	803602
ÜÇ FAZLI BÖLGESEL KEMİK SİNTİGRAFİSİ	800880
ÜRE	901941
ÜRE (24 SAATLİK)	901942
ÜRE NEFES TESTİ	900770
ÜRETRAL AKINTI KÜLTÜRÜ	905970
ÜRİK ASİT	904121
ÜRİK ASİT (24 SAATLİK)	904123
ÜRİNER SİSTEM US	803580
ÜRODİNAMİK ÇALIŞMA	704460
ÜROFLOWMETRİ	704470
ÜST EKSTREMİTE ARTERİEL SİSTEM RDUS, TEK TARAFLI	803800
ÜST EKSTREMİTE VENÖZ SİSTEM RDUS, TEK TARAFLI	803810

Table A.1 continued from previous page

Test Name	Test ID
VAJEN KÜLTÜRÜ	905676
VALPROİC ASİT	901793
VANİL MANDELİK ASİT (VMA)	904130
VARİCELLA ZOSTER VİRUS (VZV) İG G	908100
VARİCELLA ZOSTER VİRUS (VZV) İG M	908110
VDRL-RPR	906290
VERTEBRA GRAFİLERİ, DORSAL VEYA LOMBER (DÖRT YÖN)	801940
VERTEBRA GRAFİLERİ, DORSAL VEYA LOMBER (İKİ YÖN)	801952
VERTEBRA GRAFİLERİ, DORSAL VEYA LOMBER (TEK YÖN)	801961
VERTEBRA GRAFİLERİ, SERVİKAL (İKİ YÖN)	801910
VERTEBRA GRAFİLERİ, SERVİKAL (TEK YÖN)	801920
VERTEBRAL ARTER RENKLİ DOPPLER US	803850
VİTAMİN A (KAROTEN)	904140
VİTAMİN B12	904150
VİTAMİN C	904160
VİTAMİN E	904170
VİZÜEL UP (VEP)	703440
VOLUME	100003
VON WİLLEBRANT FAKTÖR ANTİJENİ	905570
VON WİLLEBRANT FAKTÖR, RİSTOSETİN KOFAKTÖR	905580
VÜCUT SIVILARI VE EKSFOLİYATİF SİTOLOJİ	909360
VÜCUT SIVILARINDA HÜCRE SAYIMI	905772
VÜCUT SIVILARININ PH ÖLÇÜMÜ	904200
YARA KAZINTI/ASPIRASYON KÜLTÜRÜ 1. İSTEM	905674
YÜZEYEL DOKU US	803600

Table A.1 Diagnostic test list

ICD Code	Total number of examination visit	Total number of examination visit with order	Total number of visit which suitable to use recommended test set	Recommended set usage in examination visit with order
Z04.8-Other Identified Reasons for Inspection and Observation	26.847	19.428	11.593	59,67%
E13.8-Diabetes Mellitus with Other Specified, Unspecified Complications	1.517	953	790	82,90%
I10-Essential (Primary) Hypertension	886	298	238	79,87%
Z00.8-General Inspections, Other	552	379	238	62,80%
E03.9-Hypothyroidism, Unspecified	544	411	185	45,01%
K30 Dyspepsia	534	334	143	42,81%
K21.9-Gastro-Esophageal Reflux Disease without Esophagitis	406	141	60	42,55%
D64.9-Anemia, Unspecified	194	127	47	37,01%
M79.1-Myalgia	188	145	59	40,69%
M25.5-Joint Pain	170	135	92	68,15%
D50.9-Iron Deficiency Anemia, Unspecified	152	57	16	28,07%
E55.9-Vitamin D Deficiency, Unspecified	130	23	7	30,43%
R10.4-Abdominal Pain Other and Unspecified	130	97	36	37,11%
J06.9-Acute Upper Respiratory Tract Infection	115	49	13	26,53%
D51.8-Vitamin B12 Deficiency Anemia, Other	102	38	1	2,63%
Total	32.467	22.615	13.518	40,23%

Table A.2 Recommended set usage in 2015

ICD Code	Total number of examination visit	Total number of examination visit with order	Total number of visit which suitable to use recommended test set	Recommended set usage in examination visit with order
Z04.8-Other Identified Reasons for Inspection and Observation	23.155	17.417	9.792	56,22%
E13.8-Diabetes Mellitus with Other Specified, Unspecified Complications	1.574	1.071	850	79,37%
I10-Essential (Primary) Hypertension	888	406	340	83,74%
Z00.8-General Inspections, Other	1.815	1.396	606	43,41%
E03.9-Hypothyroidism, Unspecified	593	479	182	38,00%
K30 Dyspepsia	171	124	57	45,97%
K21.9-Gastro-Esophageal Reflux Disease without Esophagitis	179	57	18	31,58%
D64.9-Anemia, Unspecified	257	197	87	44,16%
M79.1-Myalgia	180	138	75	54,35%
M25.5-Joint Pain	346	262	142	54,20%
D50.9-Iron Deficiency Anemia, Unspecified	282	165	51	30,91%
E55.9-Vitamin D Deficiency, Unspecified	220	58	17	29,31%
R10.4-Abdominal Pain Other and Unspecified	392	318	76	23,90%
J06.9-Acute Upper Respiratory Tract Infection	121	51	24	47,06%
D51.8-Vitamin B12 Deficiency Anemia, Other	140	71	0	0,00%
Total	30.313	22.210	12.317	44,54%

Table A.3 Recommended set usage in 2016

ICD Code	Total click without recommended set	Total click after recommended set	% decrease in number of click
Z04.8-Other Identified Reasons for Inspection and Observation	308.830	278.577	9,80%
E13.8-Diabetes Mellitus with Other Specified, Unspecified Complications	21.485	19.343	9,97%
I10-Essential (Primary) Hypertension	6.481	5.543	14,47%
Z00.8-General Inspections, Other	6.971	6.339	9,07%
E03.9-Hypothyroidism, Unspecified	5.117	4.602	10,06%
K30 Dyspepsia	3.976	3.587	9,78%
K21.9-Gastro-Esophageal Reflux Disease without Esophagitis	1.650	1.478	10,42%
D64.9-Anemia, Unspecified	1.271	1.138	10,46%
M79.1-Myalgia	1.674	1.517	9,38%
M25.5-Joint Pain	2.758	2.430	11,89%
D50.9-Iron Deficiency Anemia, Unspecified	412	368	10,68%
E55.9-Vitamin D Deficiency, Unspecified	193	174	9,84%
R10.4-Abdominal Pain Other and Unspecified	1.000	914	8,60%
J06.9-Acute Upper Respiratory Tract Infection	346	317	8,38%
D51.8-Vitamin B12 Deficiency Anemia, Other	N/A	N/A	N/A
Total	362.164	326.327	9,90%

Table A.4 Decrease in number of total clicks (orders that recommended set is used) in 2015

ICD Code	Total click without recommended set	Total click after recommended set	% decrease in number of click
Z04.8-Other Identified Reasons for Inspection and Observation	244.676	229.050	6,39%
E13.8-Diabetes Mellitus with Other Specified, Unspecified Complications	17.705	16.447	7,11%
I10-Essential (Primary) Hypertension	7.259	5.983	17,58%
Z00.8-General Inspections, Other	16.637	15.591	6,29%
E03.9-Hypothyroidism, Unspecified	4.633	4.293	7,34%
K30 Dyspepsia	1.817	1.668	8,20%
K21.9-Gastro-Esophageal Reflux Disease without Esophagitis	485	453	6,60%
D64.9-Anemia, Unspecified	2.496	2.271	9,01%
M79.1-Myalgia	2.212	2.089	5,56%
M25.5-Joint Pain	3.828	3.380	11,70%
D50.9-Iron Deficiency Anemia, Unspecified	1.167	1.076	7,80%
E55.9-Vitamin D Deficiency, Unspecified	327	296	9,48%
R10.4-Abdominal Pain Other and Unspecified	1.978	1.860	5,97%
J06.9-Acute Upper Respiratory Tract Infection	726	674	7,16%
D51.8-Vitamin B12 Deficiency Anemia, Other	N/A	N/A	N/A
Total	305.946	285.131	6,80%

Table A.5 Decrease in number of total clicks (orders that recommended set is used) in 2016

ICD Code	Total click without recommended set	Total click after recommended set	% decrease in number of click
Z04.8-Other Identified Reasons for Inspection and Observation	384.375	354.122	7,87%
E13.8-Diabetes Mellitus with Other Specified, Unspecified Complications	22.695	20.553	9,44%
I10-Essential (Primary) Hypertension	6.864	5.926	13,67%
Z00.8-General Inspections, Other	8.422	7.790	7,50%
E03.9-Hypothyroidism, Unspecified	6.625	6.110	7,77%
K30 Dyspepsia	5.985	5.596	6,50%
K21.9-Gastro-Esophageal Reflux Disease without Esophagitis	2.147	1.975	8,01%
D64.9-Anemia, Unspecified	2.149	2.016	6,19%
M79.1-Myalgia	2.432	2.275	6,46%
M25.5-Joint Pain	3.125	2.797	10,50%
D50.9-Iron Deficiency Anemia, Unspecified	744	700	5,91%
E55.9-Vitamin D Deficiency, Unspecified	276	257	6,88%
R10.4-Abdominal Pain Other and Unspecified	1.713	1.627	5,02%
J06.9-Acute Upper Respiratory Tract Infection	594	565	4,88%
D51.8-Vitamin B12 Deficiency Anemia, Other	N/A	N/A	N/A
Total	448.146	412.309	8,00%

Table A.6 Decrease in number of total clicks (all orders) in 2015

ICD Code	Total click without recommended set	Total click after recommended set	% decrease in number of click
Z04.8-Other Identified Reasons for Inspection and Observation	331.060	315.434	4,72%
E13.8-Diabetes Mellitus with Other Specified, Unspecified Complications	19.534	18.276	6,44%
I10-Essential (Primary) Hypertension	7.900	6.624	16,15%
Z00.8-General Inspections, Other	29.142	28.096	3,59%
E03.9-Hypothyroidism, Unspecified	6.573	6.233	5,17%
K30 Dyspepsia	2.494	2.345	5,97%
K21.9-Gastro-Esophageal Reflux Disease without Esophagitis	826	794	3,87%
D64.9-Anemia, Unspecified	3.760	3.535	5,98%
M79.1-Myalgia	3.152	3.029	3,90%
M25.5-Joint Pain	5.108	4.660	8,77%
D50.9-Iron Deficiency Anemia, Unspecified	2.129	2.038	4,27%
E55.9-Vitamin D Deficiency, Unspecified	565	534	5,49%
R10.4-Abdominal Pain Other and Unspecified	5.752	5.634	2,05%
J06.9-Acute Upper Respiratory Tract Infection	1.020	968	5,10%
D51.8-Vitamin B12 Deficiency Anemia, Other	N/A	N/A	N/A
Total	419.015	398.200	4,97%

Table A.7 Decrease in number of total clicks (all orders) in 2016