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

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

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## ABSTRACT

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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 ($\beta = 0.952$, $p < 0.001$, $R2 = 0.784$) 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, Akın, 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, Sargın, 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.

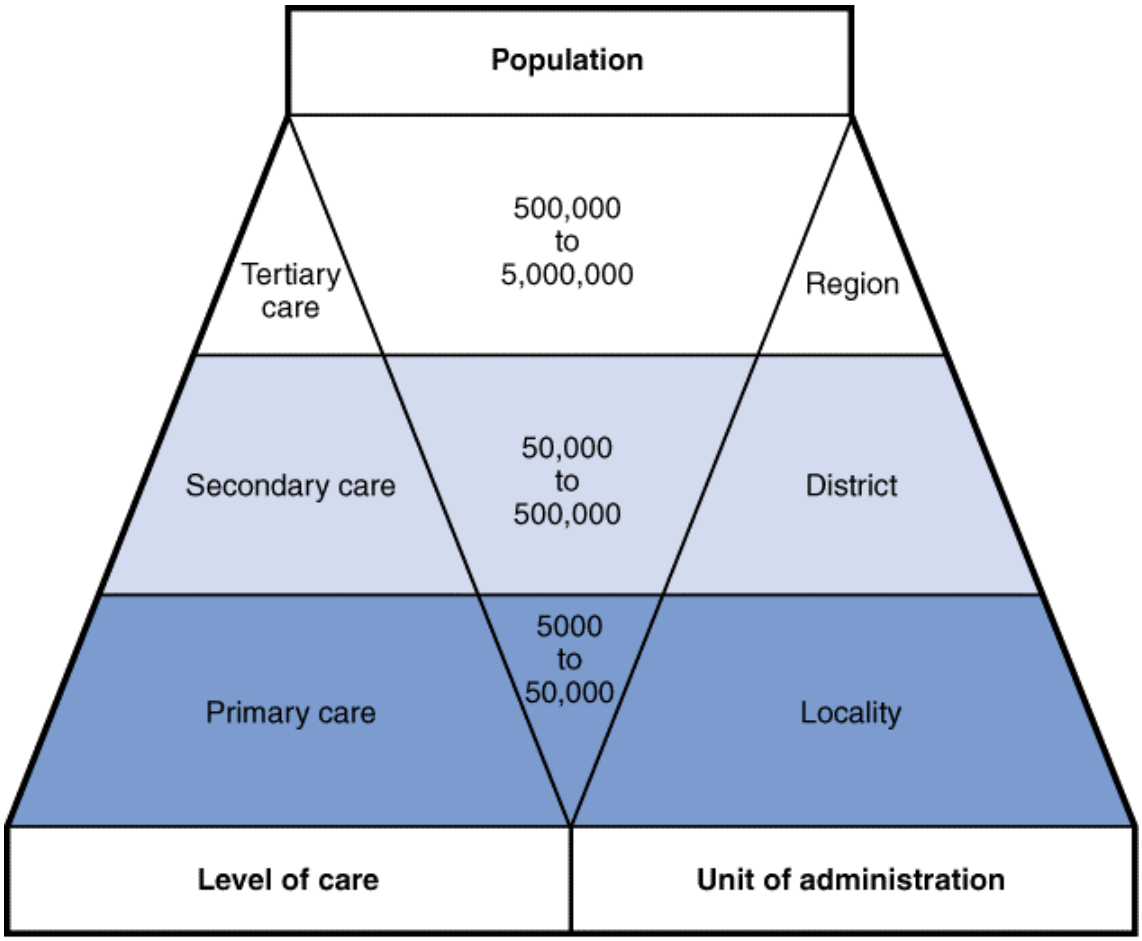




Figure 3.1 Healthcare system pyramid

### 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.

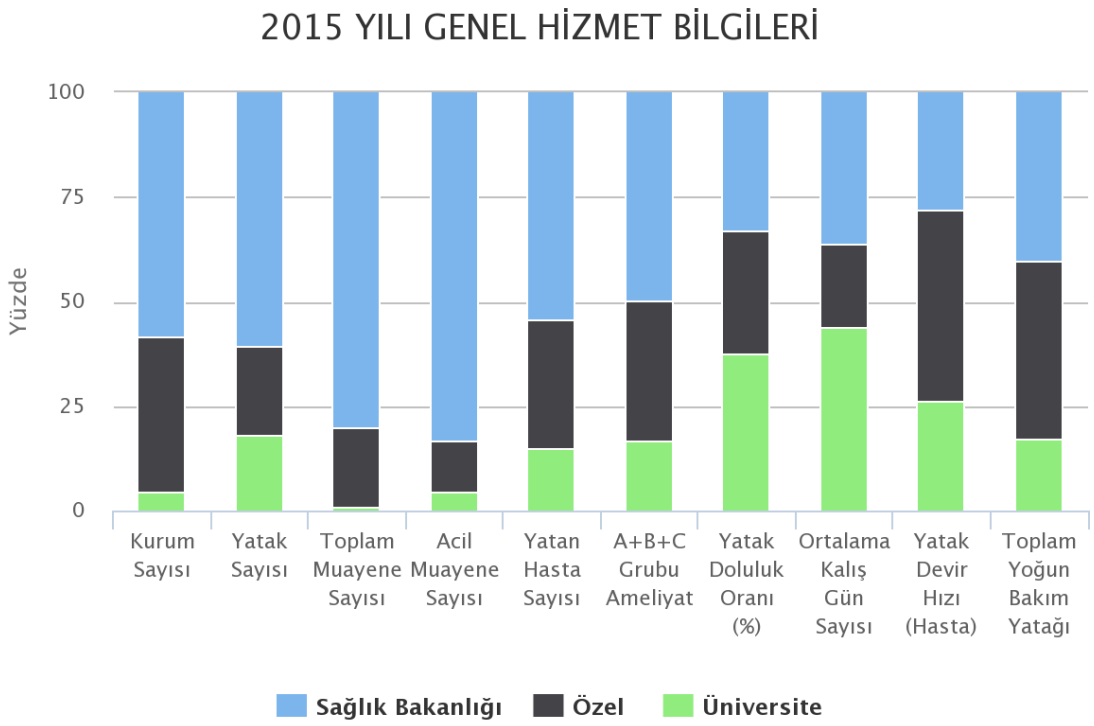


Figure 3.2 General health service information for 2015

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.

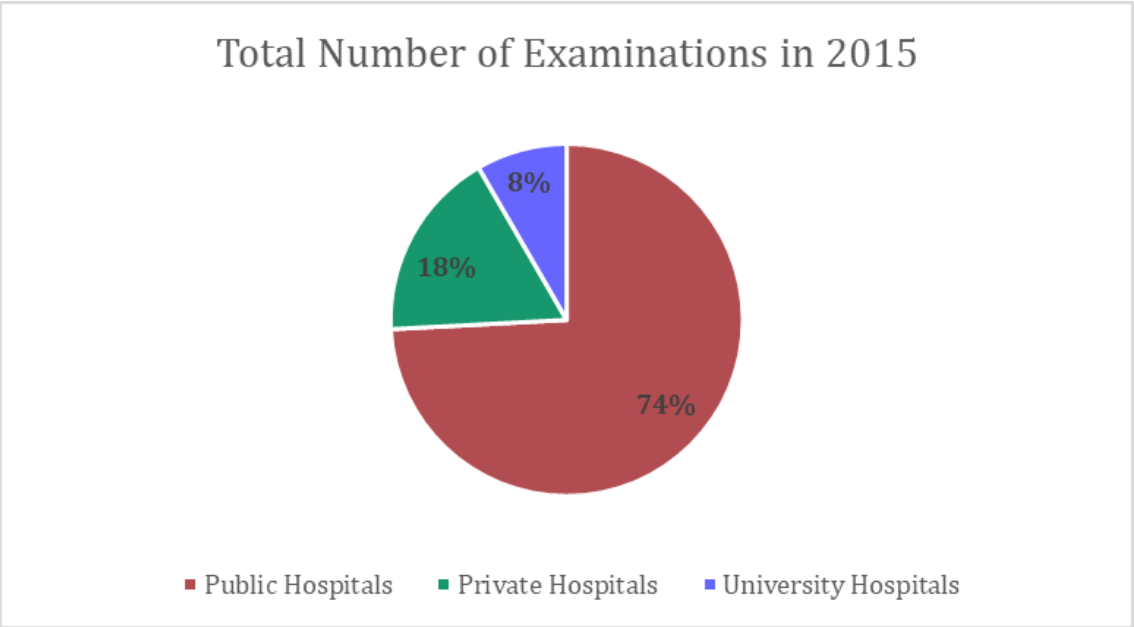


Figure 3.3 Total number of examinations in 2015

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.).

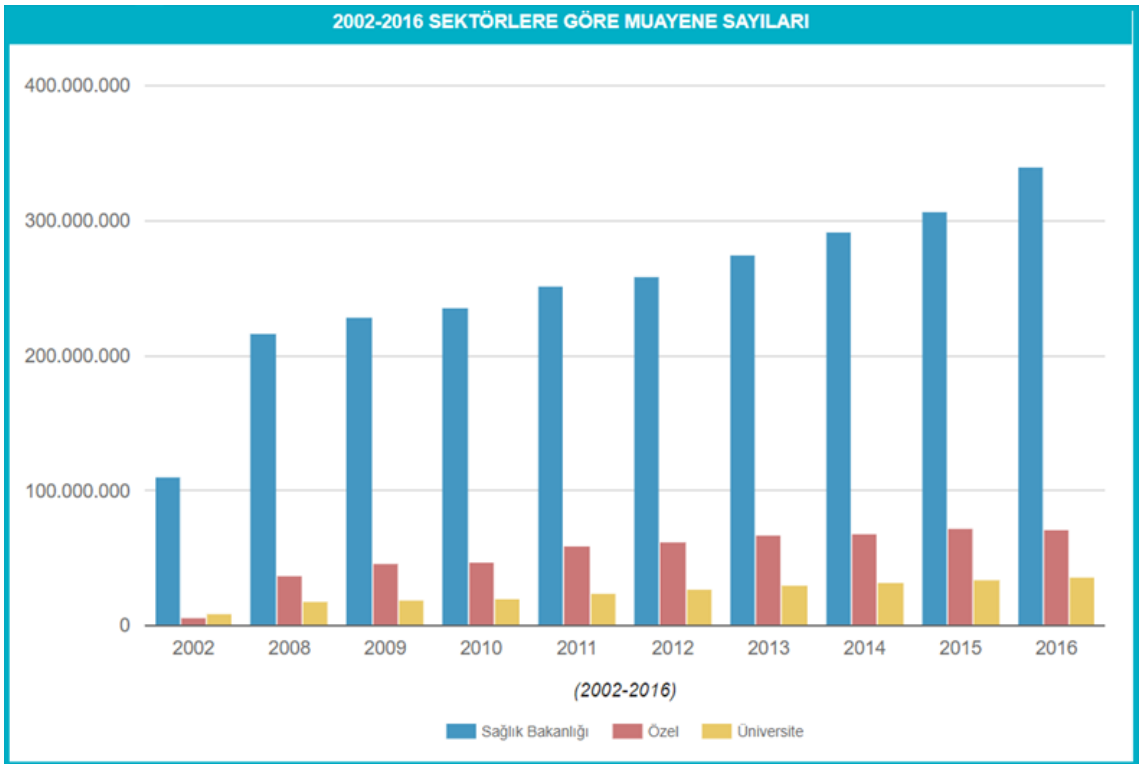


Figure 3.4 Total number of examinations by hospital types (2002-2020)

### 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 (Categorial) | 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 analyze 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.

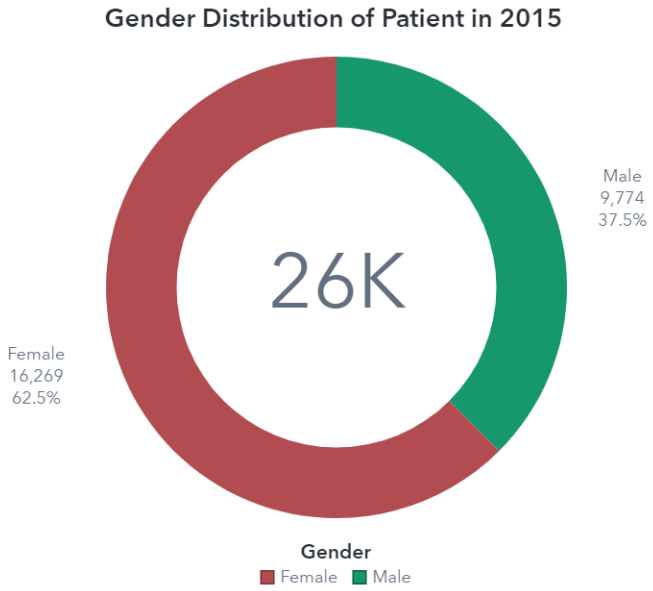


Figure 4.1 Gender distribution of patient in 2015

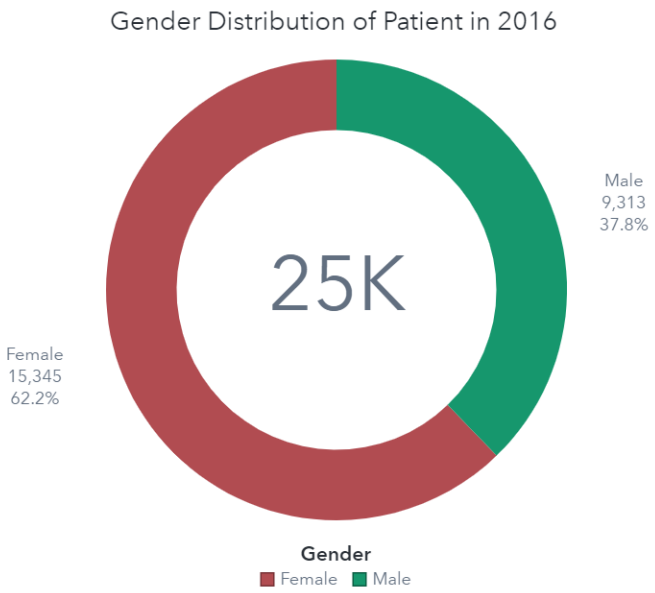


Figure 4.2 Gender distribution of patient in 2016

### 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)

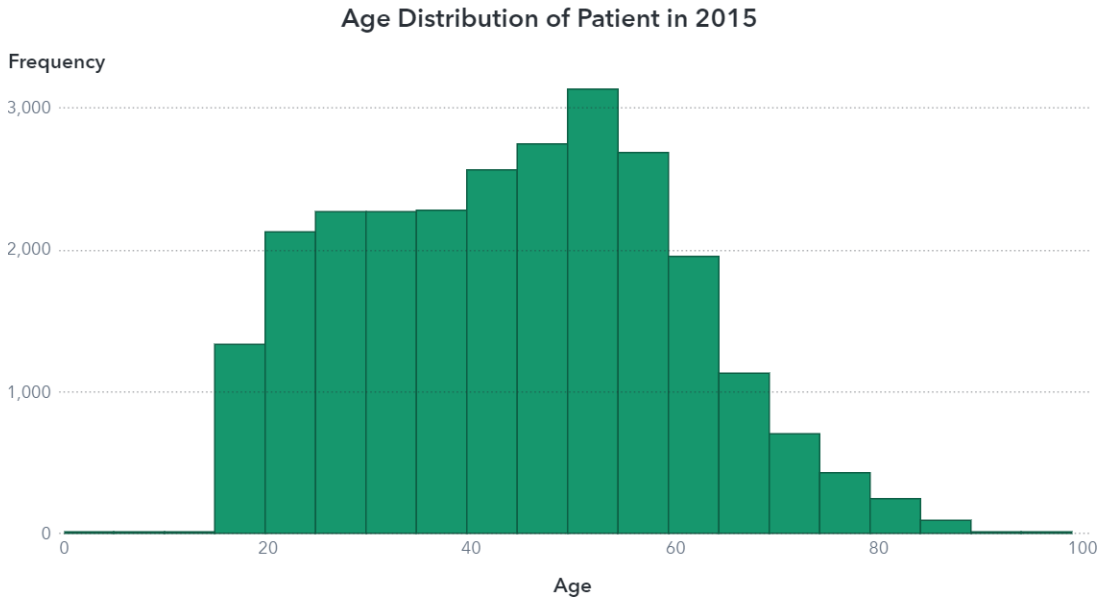


Figure 4.3 Age distribution of patient in 2015

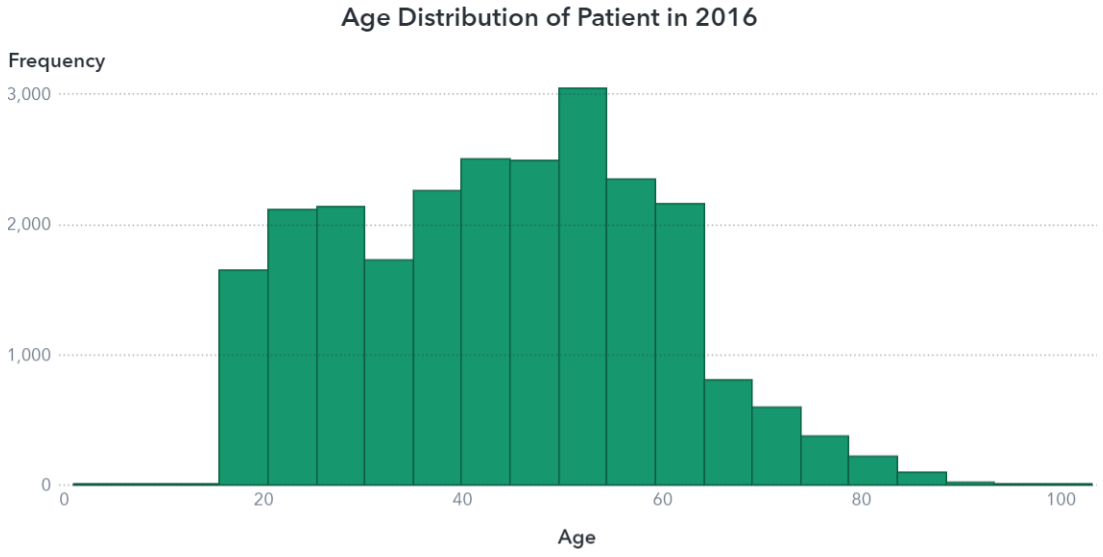


Figure 4.4 Age distribution of patient in 2016

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)

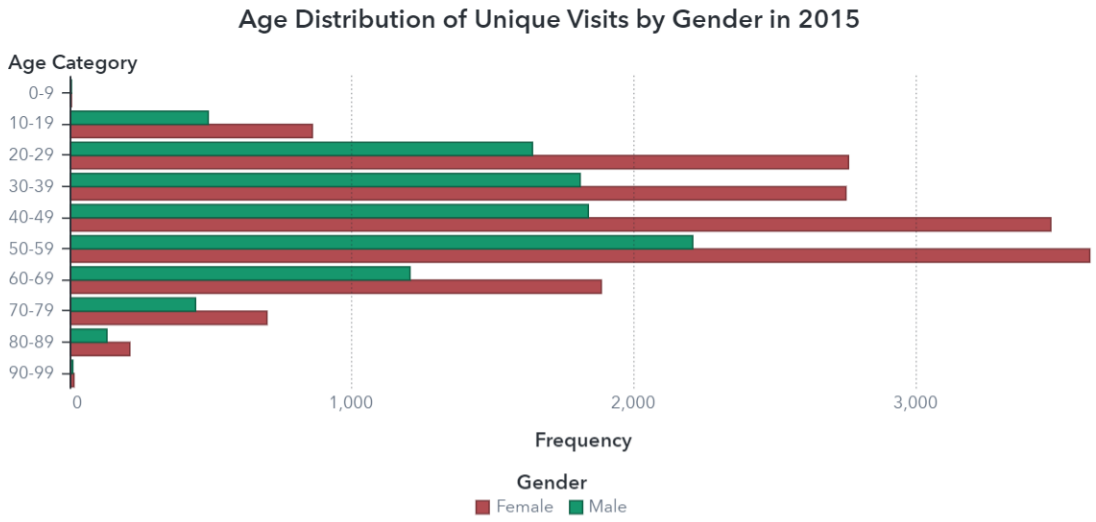


Figure 4.5 Age distribution of patients by gender in 2015

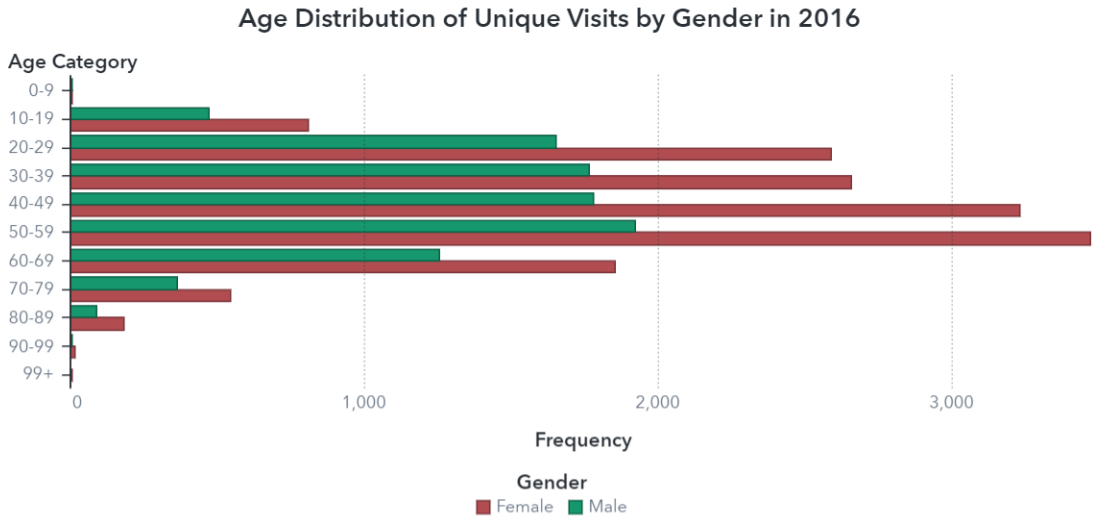


Figure 4.6 Age distribution of patients by gender in 2016

### 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 AMINOTRANSPHERASE (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 HEMOGLOBİN (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 AMINOTRANSPHERASE (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 HEMOGLOBİN (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

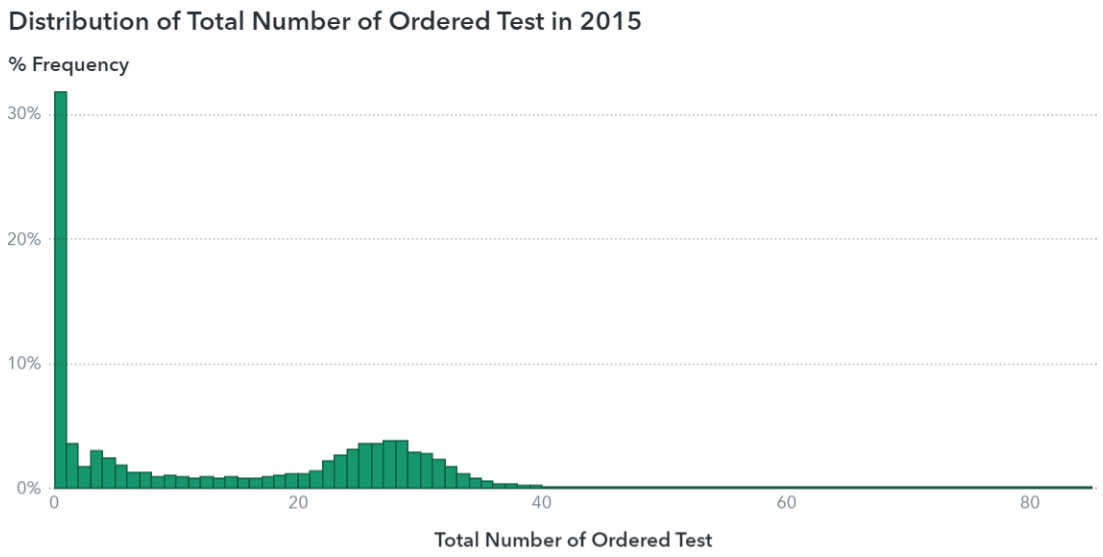


Figure 4.7 Distribution of total number of ordered test per visits in 2015

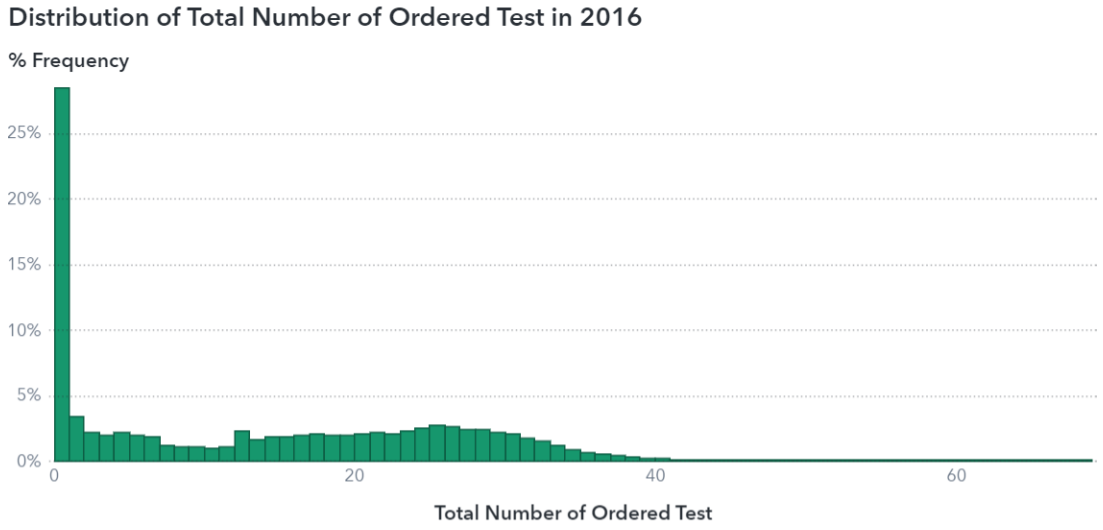


Figure 4.8 Distribution of total number of ordered test per visits in 2016

### 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)

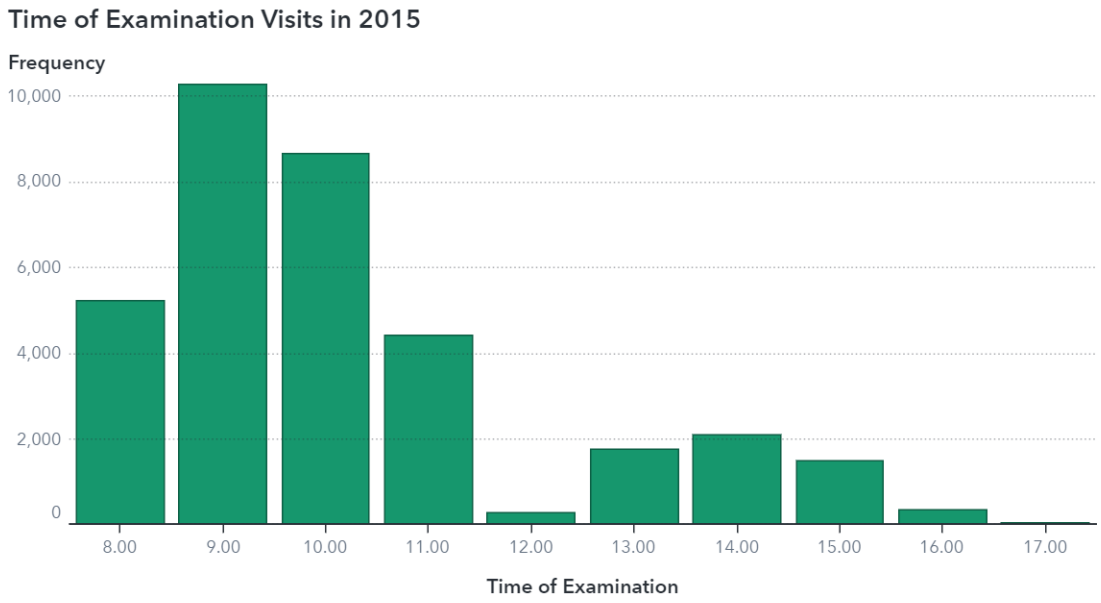


Figure 4.9 Time of visits in 2015

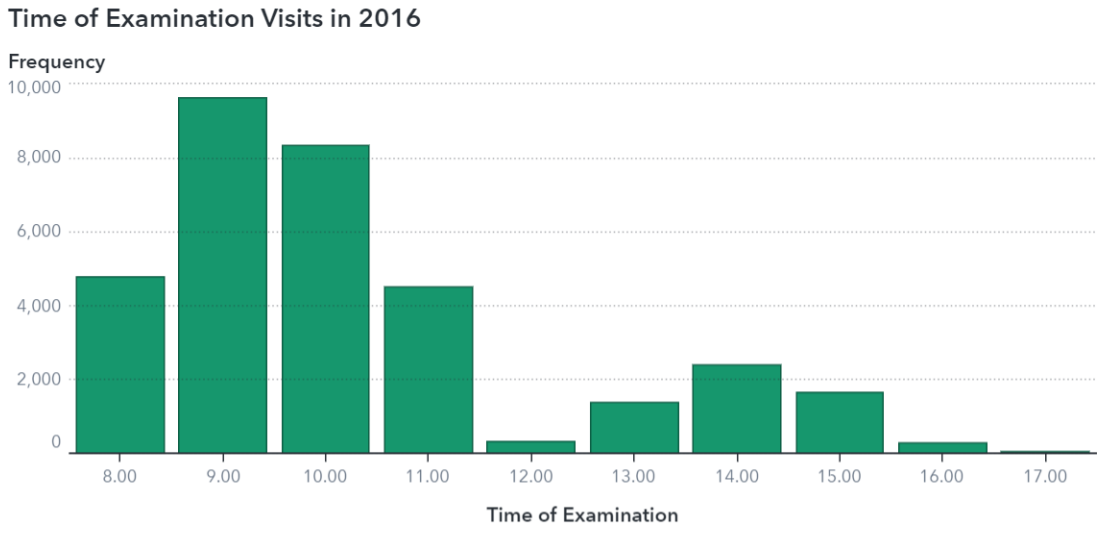


Figure 4.10 Time of visits in 2016

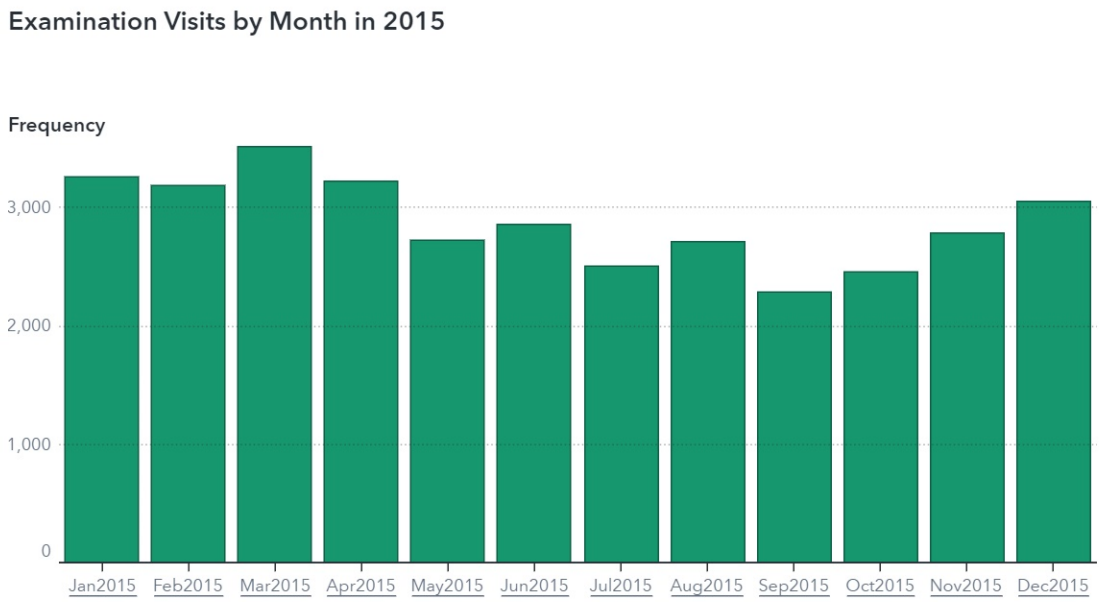


Figure 4.11 Distribution of visits by months in 2015

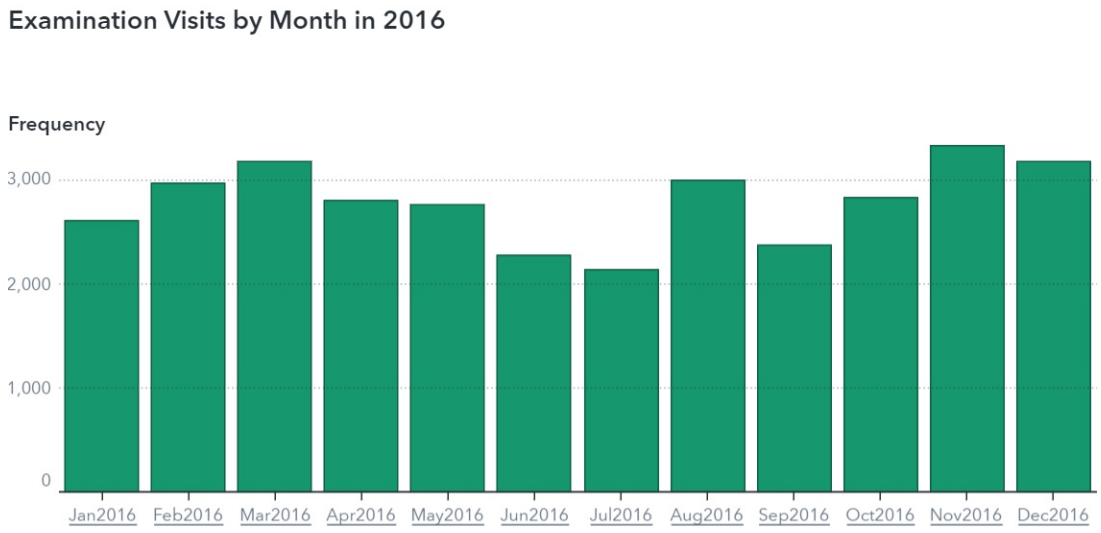


Figure 4.12 Distribution of visits by months in 2016

# 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).

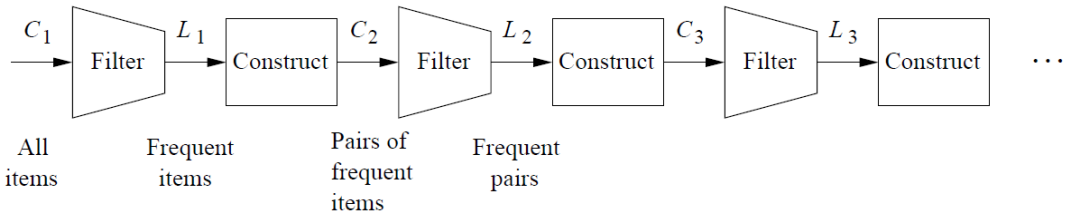


Figure 5.1 The Apriori algorithm pattern (Leskovec, 2020)

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.

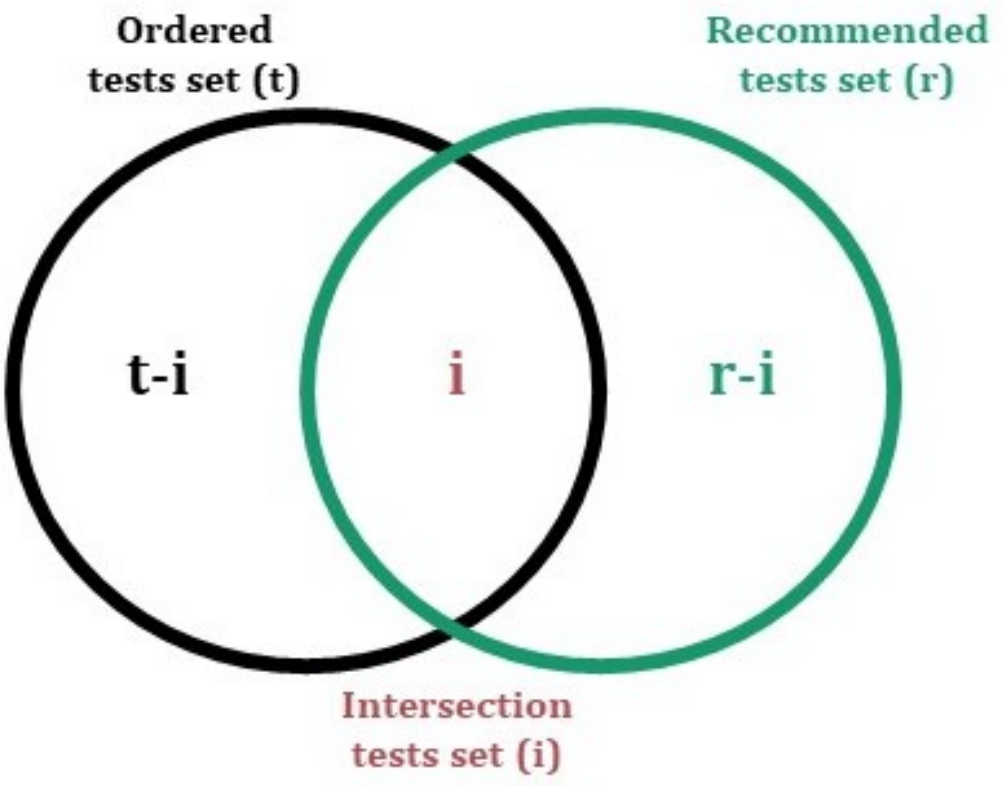


Figure 5.2 Ordered and recommended set illustration

Figure 5.2 provides a visual overview of this analysis; if i >= r-i, the physician will use the recommended set. In a different notation, i>=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.

| | % decrease in number of clicks | |
|---|---|---|
| ICD Code | 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).

| | % decrease in number of clicks | |
|---|---|---|
| ICD Code | 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.

# BIBLIOGRAPHY


Akman, M., Sakarya, S., Sargın, M., Ünlüoğlu, İ., Eğici, M. T., Boerma, W. G., & Schäfer, W. L. (2017). Changes in primary care provision in turkey: A comparison of 1993 and 2012. *Health Policy*, *121*(2), 197–206.

Biljak, V. R., Honović, L., Matica, J., Krešić, B., & Vojak, S. Š. (2017). The role of laboratory testing in detection and classification of chronic kidney disease: national recommendations. *Biochemia Medica*, 153–176.

Bodenheimer, T., Grumbach, K., Lo, B., Kierszenbaum, A., Tres, L., Ferrier, D., Lieberman, M., Marks, A., & Peet, A. (1995). *Understanding health policy: A clinical approach*. New York.

Boztuğ, Y. & Reutterer, T. (2008). A combined approach for segment-specific market basket analysis. *European Journal of Operational Research*, *187*(1), 294–312.

Chen, R.-F. & Hsiao, J.-L. (2012). An investigation on physicians' acceptance of hospital information systems: A case study. *International Journal of Medical Informatics*, *81*(12), 810–820.

Dahbi, A., Balouki, Y., & Gadi, T. (2018). Using multiple minimum support to auto-adjust the threshold of support in apriori algorithm. In *Advances in Intelligent Systems and Computing* (pp. 111–119). Springer International Publishing.

Daniels, M. & Schroeder, S. A. (1977). Variation among physicians in use of laboratory tests II. relation to clinical productivity and outcomes of care. *Medical Care*, *15*(6), 482–487.

Deckard, G., Meterko, M., & Field, D. (1994). Physician burnout: An examination of personal, professional, and organizational relationships. *Medical Care*, *32*(7), 745–754.

Doddi, S., Marathe, A., & Ravi, S. S. (2001). Discovery of association rules in medical data. *Medical Informatics and the Internet in Medicine*, *26*(1), 25–33.

Heaton, J. (2016). Comparing dataset characteristics that favor the apriori, eclat or fp-growth frequent itemset mining algorithms. In *SoutheastCon 2016*, (pp. 1–7). IEEE.

Huang, Y. C. (2013). Mining association rules between abnormal health examination results and outpatient medical records. *Health Information Management Journal*, *42*(2), 23–30.

Leskovec, J., Rajaraman, A., & Ullman, J. D. (2020). *Mining of massive data sets*. Cambridge university press.

Loenen, T. V., van den Berg, M. J., Heinemann, S., Baker, R., Faber, M. J., & Westert, G. P. (2016). Trends towards stronger primary care in three western european countries 2006-2012. *BMC Family Practice*, *17*(1).

Muslim, A., Mutiara, A. B., Suhendra, A., & Oswari, T. (2018). Expert mapping development system with disease searching sympthom based on ICD 10. In *2018 Third International Conference on Informatics and Computing (ICIC)*. IEEE.

Rathod, A., Dhabariya, M. A., & Thacker, C. (2014). A survey on association rule mining for market basket analysis and apriori algorithm. *International Journal*

*of Research in Advent Technology*, *2*(3).

Roshanov, P. S., You, J. J., Dhaliwal, J., Koff, D., Mackay, J. A., Weise-Kelly, L., Navarro, T., Wilczynski, N. L., & Haynes, R. B. (2011). Can computerized clinical decision support systems improve practitioners diagnostic test ordering behavior? a decision-maker-researcher partnership systematic review. *Implementation Science*, *6*(1).

Sacks, D. B., Arnold, M., Bakris, G. L., Bruns, D. E., Horvath, A. R., Kirkman, M. S., Lernmark, A., Metzger, B. E., & Nathan, D. M. (2011). Position statement executive summary: Guidelines and recommendations for laboratory analysis in the diagnosis and management of diabetes mellitus. *Diabetes Care*, *34*(6), 1419–1423.

Sarıyer, G. & Öcal Taşar, C. (2019). Highlighting the rules between diagnosis types and laboratory diagnostic tests for patients of an emergency department: Use of association rule mining. *Health Informatics Journal*, *26*(2), 1177–1193.

Solomon, D. H., Hashimoto, H., Daltroy, L., & Liang, M. H. (1998). Techniques to improve physicians use of diagnostic tests. *JAMA*, *280*(23), 2020.

Staes, C. J., Bennett, S. T., Evans, R. S., Narus, S. P., Huff, S. M., & Sorensen, J. B. (2006). A case for manual entry of structured, coded laboratory data from multiple sources into an ambulatory electronic health record. *Journal of the American Medical Informatics Association*, *13*(1), 12–15.

Wang, B., Chen, D., Shi, B., Zhang, J., Duan, Y., Chen, J., & Hu, R. (2017). Comprehensive association rules mining of health examination data with an extended FP-growth method. *Mobile Networks and Applications*, *22*(2), 267–274.

Whiting, P., Toerien, M., de Salis, I., Sterne, J. A., Dieppe, P., Egger, M., & Fahey, T. (2007). A review identifies and classifies reasons for ordering diagnostic tests. *Journal of Clinical Epidemiology*, *60*(10), 981–989.

Yılmaz, F. M., Kahveci, R., Aksoy, A., Özer Kucuk, E., Akın, T., Mathew, J. L., Meads, C., & Zengin, N. (2016). Impact of laboratory test use strategies in a turkish hospital. *PLOS ONE*, *11*(4), e0153693.

## 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 |
| ADACİK 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 TARAFLİ | 803780 |
| ALT EKSTREMİTE PERFORAN VEN RENKLİ DOPPLER US, TEK | 803640 |
| ALT EKSTREMİTE VENÖZ SİSTEM RDUS, TEK TARAFLİ | 803790 |
| Ambulatuar kan basıncı ölçümü (24 saat) | 700470 |
| AMİLAZ | 900370 |
| AMİP ANTİJEN (GAİTA) | 907350 |
| AMPHETAMİNES (AMP) | 901794 |
| ANATOMIK KORELASYON ISKELET SISTEMI UYGULAMALARI I | 800902 |
| ANKİLOZAN SPONDİLİT YATKINLIK ALLELLER (HLA B27) | 908735 |
| ANTI NÖT. SITOPLAZMIK ANTIKOR (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 MİTOKONDRİYAL 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 DUYARLİLİK 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 GRUPLARİ (HER BİRİ) | 900490 |
| APOLİPOPROTEİN B ALT GRUPLARİ (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 TANİMLANMASİ (MANUEL) | 905680 |
| BAKTERİ TANİMLANMASİ (YARİ 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 SİVİSİ (BOS) KÜLTÜRÜ (ÖZEL ZENGİNLE | 905730 |
| BİKARBONAT | 900681 |
| BİLİRUBİN (DİREKT) | 900691 |
| BİLİRUBİN (İNDİREKT) | 900693 |
| BİLİRUBİN (TOTAL) | 900692 |
| BİOTİNİDAZ AKTİVİTESİ | 900700 |
| BOĞAZ KÜLTÜRÜ | 905670 |
| BORRELİA BURGDORFERİ İGG | 907050 |
| BORRELİA BURGDORFERİ İGM | 907060 |
| BOYALİ MİKROSKOPİK İNCELEME | 905761 |
| BOYALİ MİKROSKOPİK İNCELEME (GRAM, M.MAVİSİ, WRİGH | 905762 |
| BOYASİZ 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, ANGİOGRAFİ, TEK ANATOMİK BÖLGE İÇİN | 803880 |
| BT, BEYİN | 803910 |
| BT, BOYUN | 803920 |
| BT, DİNAMİK, TRİFAZİK, BİFAZİK İNCELEME | 804140 |
| BT, EXTREMİTE (20-50CM BÖLGE) | 803940 |
| BT, MAKSİLLOFASİAL 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 (KARSİNOEMBRİYONİK 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 |
| DEHİDROEPİANDROSTERON | 900990 |
| DEHİDROEPİANDROSTERON SULFAT | 901000 |
| DELTA ANTİKORU | 907240 |
| DEMİR (SERUM) | 901020 |
| DEMİR BAĞLAMA KAPASİTESİ | 901040 |
| DERİ, EKSİZYONEL BİYOPSİ 1-2 LEZYON | 910270 |
| DERİ, KİST/ UZANTİ (TAG) /DEBRİD. /PLASTİK ONARİM | 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 |
| EKTOPİK 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 |
|---|---|
| ESTRADİOL | 901160 |
| FAKTÖR İİ | 904537 |
| FAKTÖR İX | 904532 |
| FAKTÖR V | 904536 |
| FAKTÖR VIII İNHİBİTÖR TAYİNİ | 904550 |
| FAKTÖR Vİİ | 904538 |
| FAKTÖR X | 904539 |
| FAKTÖR Xİ | 904534 |
| FAKTÖR Xİİ | 904533 |
| FAKTÖR Xİİİ | 904535 |
| FAKTÖRVİİİ | 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 ARANMASİ (MANUEL) | 905930 |
| GALAKTOMANNAN ANTİJENİ | 907390 |
| GAMMA GLUTAMİL TRANSFERAZ (GGT) | 901390 |
| GASTRİN | 901400 |
| GASTROÖZAFAGİAL REFLÜ ÇALİŞMASİ | 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 |
| HEPATOBİLİER US | 803390 |
| HERPES SİMPLEKS TİP 1 İGG | 907520 |
| HERPES SİMPLEKS TİP 1 İGM | 907530 |
| HERPES SİMPLEKS TİP 2 İGG | 907560 |
| HERPES SİMPLEKS TİP 2 İGM | 907570 |
| HİSTOKİMYASAL BOYAMALAR | 911160 |
| HLA-B5 | 904810 |
| HOMOSİSTEİN | 901680 |
| HUMERUS GRAFİSİ(SAĞ) | 801672 |
| HUMERUS GRAFİSİ(SOL) | 801671 |
| HÜCRE BLOĞU HAZİRLANMASİ | 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.(DAKİKALİK) | 802150 |
| İDRAR KÜLTÜRÜ | 905671 |
| İDRAR MİKROSKOBİSİ | 901730 |
| İDRAR TETKİKİ (STRİP İLE) | 901750 |
| İDRAR TETKİKİ (TAM OTOMATİK İDRAR BİYOKİMYASİ 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 ASPİRASYONU, 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 GAZLARİ | 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 |
| KATEKOLAMINLER VE METABOLITLERI 24H İDRAR | 902042 |
| KATEKOLAMİNLER VE METABOLİTLERİ | 902041 |
| KEMİK DANSİTOMETRESİ (LOKAL) | 802900 |
| KEMİK DANSİTOMETRESİ, TÜM VUCUT | 802910 |
| KEMİK İLİĞİ ASPİRASYON DEĞERLENDİRMESİ | 704720 |
| KEMİK İLİĞİ ASPİRASYONU | 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 EKOKARDİYOGRAFİ | 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 TARAMASİ | 905010 |
| LÜTEİNLEŞTİREN HORMON (LH) | 902411 |
| MAGNEZYUM | 902421 |
| MAGNEZYUM (24 SAATLİK) | 902422 |
| MAMMOGRAFİ (SAĞ) | 801591 |
| MAMMOGRAFİ (SOL) | 801592 |
| MEME RENKLİ DOPPLER US | 803700 |
| MEME US (BİLATERAL) | 803430 |
| MEME US (UNİLATERAL) | 803440 |
| MEME, BİYOPSİ | 910400 |
| METANEFRİN | 902043 |
| METHADONE (MDN) | 901802 |
| METİL MALONİK ASİT (İDRAR) | 902492 |
| METİL MALONİK ASİT (SERUM) | 902491 |
| MİDE BOŞALMA ZAMANİ ÇALİŞMASİ | 801050 |
| MİDE, BİYOPSİ TEK LOKALİZASYON | 909820 |
| MİKOBAKTERİ (PCR) | 908290 |
| MİKOBAKTERİ KÜLTÜRÜ | 906160 |
| MİKOBAKTERİ 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 ANJİYOGRAFİ | 804340 |
| MR ENTEROKLİZİS | 804412 |
| MR KOLANJİYOGRAFİ | 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 ÜROGRAFİ | 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 TARAFLİ | 804250 |
| MR, HİPOFİZ | 804270 |
| MR, KULAK | 804310 |
| MR, NAZOFARİNKS | 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 |
| NAZOFARİNKS/OROFARİNKS, BİYOPSİ | 909840 |
| NORMETANEFRİN | 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 UZATİLMİŞ (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 |
| OPİATES (OPİ) | 901803 |

**Table A.1 continued from previous page**

| Test Name | Test ID |
|---|---|
| ORGANİK ASİDEMİLERİN PRENATAL TANİLARİ (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 |
| PERIFERIK 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 SİVİLARİ) | 903251 |
| PROTEİN S | 905280 |
| PROTEİN S ANTİJENİ | 905290 |
| PROTROMBİN ZAMANİ (KOAGÜLOMETRE) | 905320 |
| PSA (SERBEST) | 903280 |
| PSEUDOKOLİN ESTERAZ | 903290 |
| REKTOSKOPİ VE/VEYA SİGMOİDOSKOPİ | 701390 |
| RENAL KORTİKAL SİNTİGRAFİ | 801170 |
| RENAL RENKLİ DOPPLER US ( BİLATERAL) | 803760 |
| RENAL US | 803480 |
| RENİN DİREKT | 903330 |
| RENİN DİREKT AYAKTAN | 903331 |
| RETİKÜLOSİT SAYİMİ | 905360 |
| REVERSETRANSCRIPTASE PCR MULTIPLEX | 908732 |
| RİB-P0 (İMMUNOBLOTTİNG) | 906800 |
| ROMATOİD FAKTÖR (RF) (NEFELOMETRİK) | 903381 |
| ROTAVİRUS ANTİJENİ | 907980 |
| RUBELLA İGG AVİDİTE | 908000 |
| RUTİN EEG (ÇOCUK-BÜYÜK) | 703020 |
| SAFRA KESESİ | 909960 |
| SAKROİLİAK EKLEM GR | 801871 |
| SEDİMENTASYON | 903400 |
| SEDİMENTASYON (BEŞEVLER) | 903401 |
| SEKS HORMON BAĞLAYİCİ GLOBULİN (SHBG) | 903410 |
| SELENYUM | 903420 |
| SELLÜLER KAN ÜRÜNLERİNİN İŞİNLANMASİ | 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 BAZLİ 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 SİVİLARİNDA, 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 ÇALİŞMASİ (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 AVİDİTE | 908070 |
| TP53 (17P13.1) DELESYONU FISH | 908707 |
| TRANSFERRİN | 903952 |
| TRANSFERRİN SATÜRASYONU | 903951 |
| TRANSKRANİAL VEYA TRANSFONTANEL RENKLİ DOPPLER | 803830 |
| TRANSÖZOFAGEAL EKOKARDİYOGRAFİ | 700610 |
| TRANSTORASİK EKOKARDİYOGRAFİ | 700600 |
| TRANSVAJİNAL US | 803550 |
| TREPONEMA PALLİDUM HEMAGLÜTİNASYON (TPHA) | 908090 |
| TRİCYCLİC ANTİDEPRESSANTS (TCA) | 901801 |
| TRİGLİSERİD | 903990 |
| TROMBİN ZAMANİ | 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 FAZLİ 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 ÇALİŞMA | 704460 |
| ÜROFLOWMETRİ | 704470 |
| ÜST EKSTREMİTE ARTERİEL SİSTEM RDUS, TEK TARAFLİ | 803800 |
| ÜST EKSTREMİTE VENÖZ SİSTEM RDUS, TEK TARAFLİ | 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 SİVİLARİ VE EKSFOLİATİF SİTOLOJİ | 909360 |
| VÜCUT SİVİLARİNDA HÜCRE SAYİMİ | 905772 |
| VÜCUT SİVİLARİNİN PH ÖLÇÜMÜ | 904200 |
| YARA KAZINTI/ASPİRASYON 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