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A comprehensive framework identifying readmission risk factors using the CHAID algorithm: a prospective cohort study

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Abstract

Objective: To identify frequency of readmission after discharge from internal-medicine wards, readmission risk factors, and reasons and costs of readmission.
Design: Prospective cohort study.
Setting: A tertiary-care hospital in Turkey.
Participants: 2622 adult patients discharged from internal-medicine wards of the hospital between 1 February 2015 and 31 January 2016.
Main outcome measures: Thirty day all-cause readmission rates, reasons and costs of readmission. To identify readmission risk factors Chi-square Automatic Interaction Detector (CHAID) analysis was conducted.
Results: The same hospital readmission rate was 17.9%, while the same hospital or different-hospital readmission rate was 21.3%. Receiver operating characteristic (ROC) curve analysis showed that the predictive performance of the CHAID algorithm was high. According to the CHAID algorithm, the most significant readmission risk factor was the main diagnosis of neoplasm at the index admission. In other diagnosis groups, higher Charlson comorbidity score, higher level of education, having a regular physician, and three dimensions of Readiness for Hospital Discharge Scale were significant risk factors for readmission. The most frequent reason for readmission was neoplasm, and the total cost of readmissions was ~$900 000.
Conclusions: The CHAID algorithm for readmissions had a high predictive strength and provided details that aid physicians in decision-making. Measures must be taken from initial diagnosis to post-discharge follow-up, to minimize readmissions, especially in patients with neoplasm.

Key words: patient readmission, hospital readmission, readmission rates, hospital, internal medicine

Introduction

Hospital readmissions shortly after discharge impose a high burden on patients, hospitals, healthcare systems and societies. The highest 30-day readmission rate has been reported for patients discharged with medical conditions than for those who were discharged after surgical or obstetric procedures [1, 2]. Readmission rates are increasingly used for public reporting and performance payment programs. In the USA, hospital readmission rates for some diseases

are publically reported, and financial penalties are imposed on hospitals with high readmission rates. In the UK, hospital readmission rates for specific diseases are published, and the NHS has initiated a new regulation for reimbursement for emergency readmissions. In Australia, readmission rates have been monitored [3].

In Turkey, the healthcare system has undergone serious structural changes following the introduction of the Health Transformation Program (HTP) in 2003. This led to the establishment of a general health insurance system which combined all social security programs under one umbrella, the Social Security Institution (SSI). Enrollment in the general health insurance system is mandatory, with contribution rates proportional to ability to pay and all beneficiaries entitled to the same basic benefits package, including inpatient care [4]. Those who want additional services may buy private insurance or pay the services out-of-pocket. Another important component of the HTP is strengthening primary healthcare through the implementation of family medicine. One key feature of family medicine in Turkey is the assignment of individuals to a family physician [5]. Family physicians provide primary care for the people on their lists. They may refer the patient to secondary or tertiary healthcare institutions, if necessary. Currently, however, patients do not need a referral from their family physicians to be admitted to a hospital. Patients may go to hospital without a referral and may be admitted by a physician who sees them in the outpatient or emergency department of the hospital. In fact, about 60% of consultations have taken place in hospital outpatient departments to which many patients refer themselves directly, without going through a primary care 'gatekeeper' [4].

Previous studies in other countries have shown that several factors, including patients' age [6–9], sex [7, 8], marital status [10], comorbidity status [6, 7, 9–12], length of stay at index admission [6–12] and specific clinical conditions [7, 8, 12, 13] were associated with readmission. Many studies in different countries suggested that access to effective primary care will reduce readmission rate [1, 14–18]. In a workshop held in Turkey on readmissions, it was also concluded that an effective post-discharge follow-up system will reduce readmission rates, and family medicine should be integrated into the readmission reduction system. However, the lack of an integrated approach to measure and track readmissions is an important deficiency in the healthcare system of Turkey [19]. Few studies have addressed readmissions, most of which restricted to a single diagnosis or procedure [20–23]. To our knowledge, no previous study has prospectively analysed hospital readmissions for patients discharged from internal-medicine departments in Turkey. Therefore, we conducted a prospective cohort study to address four key questions: (i) What is the frequency of 30-day all-cause readmission after discharge from internal-medicine wards of a tertiary-care hospital in Turkey? (ii) What are the risk factors for readmission? (iii) What are the reasons for readmission? (iv) What is the cost of readmission? This information will be vital in the development and implementation of interventions to reduce readmission.

Methods

Population

This prospective cohort study was conducted at ~800-bed university hospital in Ankara, Turkey. All adult patients (aged 18 years and above), discharged from internal-medicine wards between 1 February 2015 and 31 January 2016, were included in the study. Patients who died inside or outside the hospital within 30 days of discharge, those who were transferred to other hospitals, or those who left the hospital against medical advice, were excluded (Fig. 1). All participants provided informed consent. The study design was approved by the university's ethics commission.

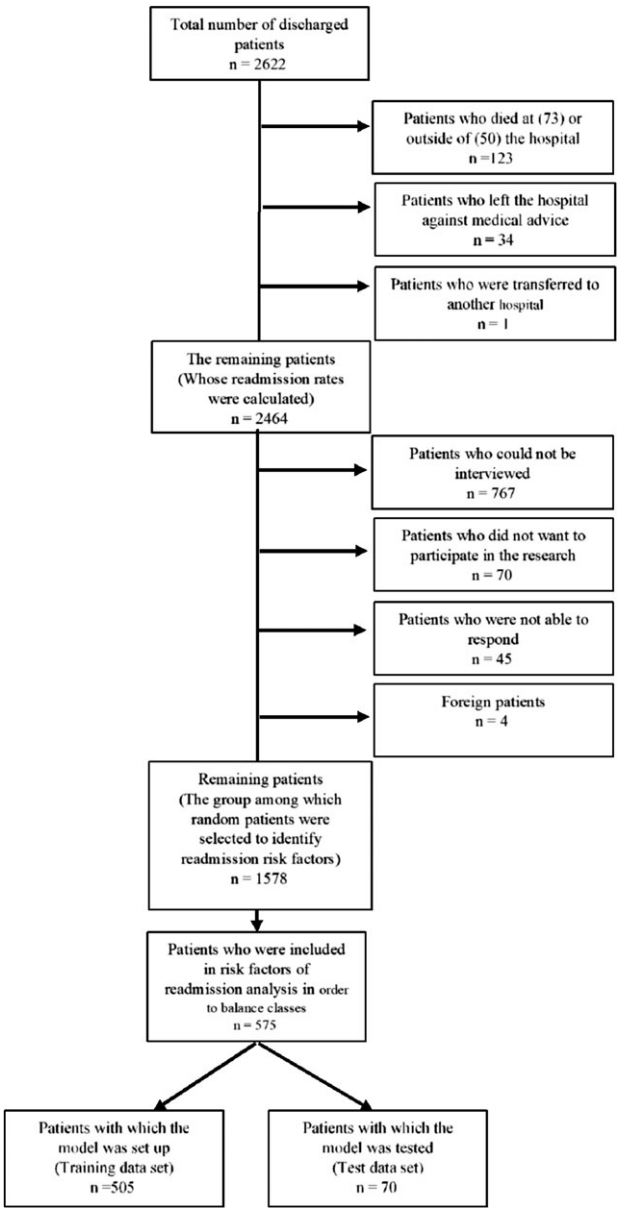


Figure 1 Flow chart of patient selection procedure.

Data collection and study variables

At discharge, trained research assistants collected data from patients regarding their age, sex, marital status, education level, place of residence, presence of family/caregivers as patients' support system post-discharge and presence of a regular physician. Patients were asked if they have a physician to whom they have been seen regularly, because having a regular physician emerged as a significant predictor of readmission in a previous study [10]. The regular physician may be a primary care physician or a specialist. Patients responded to the Readiness for Hospital Discharge Scale/Short Form (RHDS/SF) at the time of discharge. The RHDS/SF is a user-friendly and validated scale measuring patients' perceived readiness just prior to discharge. The RHDS/SF is evaluated on a scale from 0 to 10 and consists of eight

items and four dimensions: personal status, knowledge, coping ability and expected support [24]. The number of occupied and non-occupied beds in the discharging department was also recorded at discharge.

Two internal-medicine residents reviewed the patients' medical records from the hospital's information system and recorded the main discharge diagnosis for index admission (International Classification of Diseases, 10th revision [ICD-10] codes), the utilization of services in the intensive care unit (ICU), and the total Charlson comorbidity index score [25]. The cost of readmission (the sum of amounts billed to the Social Security Institution and to the patient) was also retrieved from the hospital's information system. Data on admissions in the past 12 months could not be collected, because retrospective data were not accessible at the beginning of the study due to an update process of the hospital's information system.

The hospital information system was accessed for data on discharged patients' visits to any outpatient departments, admissions to daycare, or readmissions to the same hospital within 30 days of discharge. Further, the discharged patients were contacted by telephone after 30 days to track readmissions to other hospitals. The residents reviewed the readmissions and assessed whether a readmission was planned, related to the index admission and preventable. Preventability of readmission was defined as the presence of factors that, if addressed before readmission, could have averted the readmission. For instance, readmission for recurrence or continuation of disorder leading to the first admission, readmission for recognized avoidable complication and readmission for social or psychological reason (which is probably within control of hospital services) were classified as preventable. On the other hand, readmission was classified as unpreventable if it was for factors such as unavoidable complication or completely different diagnosis from previous admission [26]. To evaluate the inter-reviewer reliability, two physicians independently reviewed the records of 107 patients, and the results were assessed using the Cohen's kappa coefficient. The analysis revealed an almost perfect agreement for classification of planned/unplanned readmissions ($\kappa = 84.3$), a substantial agreement for classification of readmissions into index admission-related or unrelated ($\kappa = 69.6$), and a moderate agreement for classification of preventable/unpreventable readmissions ($\kappa = 45.8$).

Assessment of readmission

The readmission rate was calculated by dividing the number of readmissions within 30 days of discharge by the total number of patients discharged from the hospital (excluding deaths). If a patient was readmitted more than once within this 30-day period, only the first readmission event was used to calculate readmission rates. However, all readmission events were regarded as index admissions.

Statistical analysis

The data were analysed using the Statistical Package for the Social Sciences (SPSS) 23.0 and SPSS Clementine 11.0. To address our second question, we examined the subsample of data, using Chi-square Automatic Interaction Detector (CHAID) analysis.

Results

In total, 2622 patients were discharged from the internal-medicine wards of the hospital during the study period, of which 158 were excluded. Figure 1 shows the flow chart detailing the number of patients included in the study on the basis of our inclusion and exclusion criteria.

Frequency of readmissions

Table 1 shows the readmission status of 2464 discharged patients for whom data were available by their characteristics. Among the 2464 patients, 440 (17.9%) were readmitted to the same hospital. Among the 440 'same hospital' readmissions, 128 (29.1%) were unplanned, 373 (84.8%) were related to the index admission, and 125 (28.4%) were preventable. The unplanned readmission rate was 5.2% (128/2464). Among the 128 unplanned readmissions, 95 were related to the index admission. Among these 95 unplanned and related readmissions, 25 were preventable. Therefore, 1 in 5 unplanned readmissions (19.5% [25/128]) was both related to the index admission and preventable. Nearly half (48%) of these 25 related and preventable readmissions were a result of insufficient treatment length.

As only 1440 of the 2464 discharged patients could be contacted by telephone, same hospital or different-hospital readmission rate was calculated on the basis of the contacted patients. Of the 1440 contacted patients, 248 were readmitted to the same hospital while 59 readmitted to different hospitals. The overall same hospital or different-hospital readmission rate was 21.3%. Since it was not possible to contact all patients by telephone, the risk factors for readmission were assessed on the basis of same hospital readmissions.

Risk factors for readmission

Of the 2464 study patients, complete data was available for 1578 patients and was used to identify the risk factors for readmission. Readmission was identified in 286 of the 1578 patients. As the number of non-readmitted patients was disproportionately higher and may have resulted in a classification bias, a subgroup of patients was included in risk factors analysis: all readmitted patients with complete data (286 patients) and an equivalent number of randomly selected, non-readmitted patients (22%: 289 patients). To overcome the classification bias, the sub-data set of analysis contained 575 patients, of which, 505 patients were included in the training data set, and 70 patients were included in the test data set (Fig. 1).

CHAID analysis was conducted on the 575 patients. The receiver operating characteristic (ROC) curve of the CHAID tree is shown in Fig. 2. The area under the curve (AUC) value obtained from the ROC curve was 80.5% in the training set and 79.0% in the test set. The misclassification ratio was 28.3% in the training set and 25.7% in the test set. These results showed that the predictive strength of the CHAID algorithm was high.

The resultant CHAID tree is shown in Fig. 3. The main diagnosis at discharge from the index admission was the most significant risk factor for readmission. Patients with C00–D48 (neoplasms) diagnosis were placed in the first diagnostic group; patients with J00–J99 (diseases of the respiratory system), K00–K93 (diseases of the digestive system), M00–M99 (diseases of the musculoskeletal system and connective tissue), and others were placed in the second diagnostic group; and patients with A00-B99 (certain infectious and parasitic diseases), D50–D89 (diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism), E00–E99 (endocrine, nutritional and metabolic diseases), I00–I99 (diseases of the circulatory system), L00–L99 (diseases of the skin and subcutaneous tissue), N00–N99 (diseases of the genitourinary system) and R00–R99 (symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified) were placed in the third diagnostic group.

The risk of readmission for the patients in the first group was higher than that for the patients in the second and third groups. Among patients in the second-group, those with comorbidity scores >2 were more frequently readmitted. Further, having a regular

Table 1 Patient characteristics at index admission according to 30-day readmission status

	Readmitted patients		Non-readmitted patients		Total		*p*-value[b]
	n	(%)	*n*	(%)	*n*	(%)[a]	
Sex							<0.001
Male	263	(24.8)	798	(75.2)	1061	(49.3)	
Female	177	(16.2)	912	(83.8)	1089	(50.7)	
Age group							<0.001
18–29	60	(23.5)	195	(76.5)	255	(11.8)	
30–39	50	(23.7)	161	(76.3)	211	(9.8)	
40–49	37	(15.5)	202	(84.5)	239	(11.1)	
50–59	103	(25.3)	304	(74.4)	407	(18.9)	
60–69	108	(23.0)	361	(77.0)	469	(21.8)	
70–79	58	(16.2)	300	(83.8)	358	(16.6)	
≥80	24	(11.2)	190	(88.8)	214	(9.9)	
Education							0.034
Illiterate	30	(13.0)	200	(87.0)	230	(14.1)	
Primary and secondary school graduate	131	(17.8)	607	(82.2)	738	(45.2)	
High school graduate	61	(19.1)	259	(80.9)	320	(19.6)	
Associate, bachelor and postgraduate degree	78	(22.5)	268	(77.5)	346	(21.2)	
Place of residence							0.027
Ankara	252	(21.0)	950	(80.0)	1202	(61.8)	
Out of Ankara	188	(25.3)	556	(74.7)	744	(38.2)	
Someone to help at home after discharge							0.021
Yes	267	(19.0)	1138	(81.0)	1408	(88.1)	
No	23	(12.1)	167	(87.9)	190	(11.9)	
Have a regular physician							0.018
Yes	184	(20.2)	728	(79.8)	912	(57.2)	
No	106	(15.5)	576	(84.5)	682	(42.8)	
Length of stay at index admission (day)							<0.001
1	41	(12.8)	280	(87.2)	321	(13.0)	
2	16	(11.7)	121	(88.3)	137	(5.6)	
3	21	(19.8)	85	(80.2)	106	(4.3)	
4	19	(13.2)	125	(86.8)	144	(5.8)	
5	20	(16.5)	101	(83.5)	121	(4.9)	
6	27	(21.6)	98	(78.4)	125	(5.1)	
7	25	(17.6)	117	(82.4)	142	(5.8)	
8–14	102	(14.6)	598	(85.4)	700	(28.4)	
15–30	109	(21.5)	399	(78.5)	508	(20.6)	
≥31	60	(37.5)	100	(62.5)	160	(6.5)	
Charlson Comorbidity Score							<0.001
0	19	(6.2)	290	(93.8)	309	(14.6)	
1	33	(8.8)	341	(91.2)	374	(17.6)	
2	175	(25.0)	525	(75.0)	700	(33.0)	
3	71	(21.6)	258	(78.4)	329	(15.5)	
4	31	(16.0)	163	(84.0)	194	(9.1)	
5	24	(28.6)	60	(71.4)	84	(4.0)	
6	19	(24.7)	58	(75.3)	77	(3.6)	
7	6	(18.8)	26	(81.2)	32	(1.5)	
8	9	(64.3)	5	(35.7)	14	(0.7)	
9	1	(16.7)	5	(83.3)	6	(0.3)	
10	1	(50.0)	1	(50.0)	2	(0.1)	
ICD-10 Code[c]							<0.001
A00–B99	9	(13.8)	56	(86.2)	65	(3.0)	
C00–D48	215	(46.3)	249	(53.7)	464	(21.4)	
D50–D89	8	(9.9)	73	(90.1)	81	(3.7)	
E00–E99	26	(8.8)	270	(91.2)	296	(13.6)	
I00–I99	15	(9.4)	145	(90.6)	160	(7.4)	
J00–J99	49	(16.2)	254	(83.8)	303	(14.0)	
K00–K93	29	(17.1)	141	(82.9)	170	(7.8)	
L00–L99	2	(9.1)	20	(90.9)	22	(1.0)	
M00–M99	25	(16.4)	127	(83.6)	152	(7.0)	
N00–N99	37	(15.0)	209	(85.0)	246	(11.3)	

Table continued

Table 1 Continued

	Readmitted patients		Non-readmitted patients		Total		*p*-value[b]
	n	(%)	*n*	(%)	*n*	(%)[a]	
R00–R99	18	(10.3)	156	(89.7)	174	(8.0)	
Other (G,H,O,P,Q,S,T,W,Y,Z)	7	(18.4)	31	(81.6)	38	(1.8)	

[a]Column percentages.

[b]Chi-square test.

[c]Disease groups (ICD-10 codes): A00–B99:Certain infectious and parasitic diseases, C00–D48:Neoplasms, D50–D89: Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism, E00–E99: Endocrine, nutritional and metabolic diseases, I00–I99:Diseases of the circulatory system, J00–J99: Diseases of the respiratory system, K00–K93: Diseases of the digestive system, L00–L99: Diseases of the skin and subcutaneous tissue, M00–M99: Diseases of the musculoskeletal system and connective tissue, N00–N99: Diseases of the genitourinary system, R00–R99:Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified.

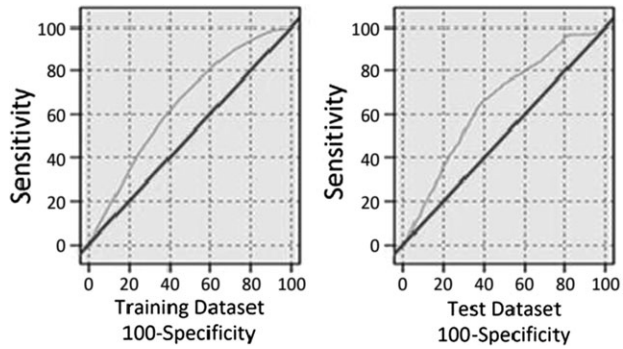


Figure 2 ROC Curves of CHAID.

physician increased the risk for readmission in second-group patients with comorbidity scores ≤2. Among patients in the third group, those with comorbidity scores >4 were readmitted more frequently. In addition, for patients in the third group with comorbidity scores ≤4, the readmission risk depended on the level of education and personal status and patient's expected support (dimensions of the Readiness for Hospital Discharge Scale) (Fig. 3).

Reasons for readmission

Neoplasms were the most frequent (50%) reason for all (n = 440) readmissions to the same hospital. For unplanned readmissions, neoplasms and respiratory system diseases were almost equally frequent reasons of readmission (Table 2).

Cost of readmission

The total cost of readmissions (n = 440) was ~$900 000, of which 25.0% was attributable to unplanned readmissions. Unplanned readmissions that were preventable and related to the index admission accounted for 6.2% of the readmission cost. The patients paid 4.9% of the cost of unplanned-related-preventable readmissions. The average cost of 440 readmissions was 1.4 times higher than the average cost of the index admissions. Furthermore, the average cost of planned readmission was 1.2 times higher than the average cost of unplanned readmission.

Discussion

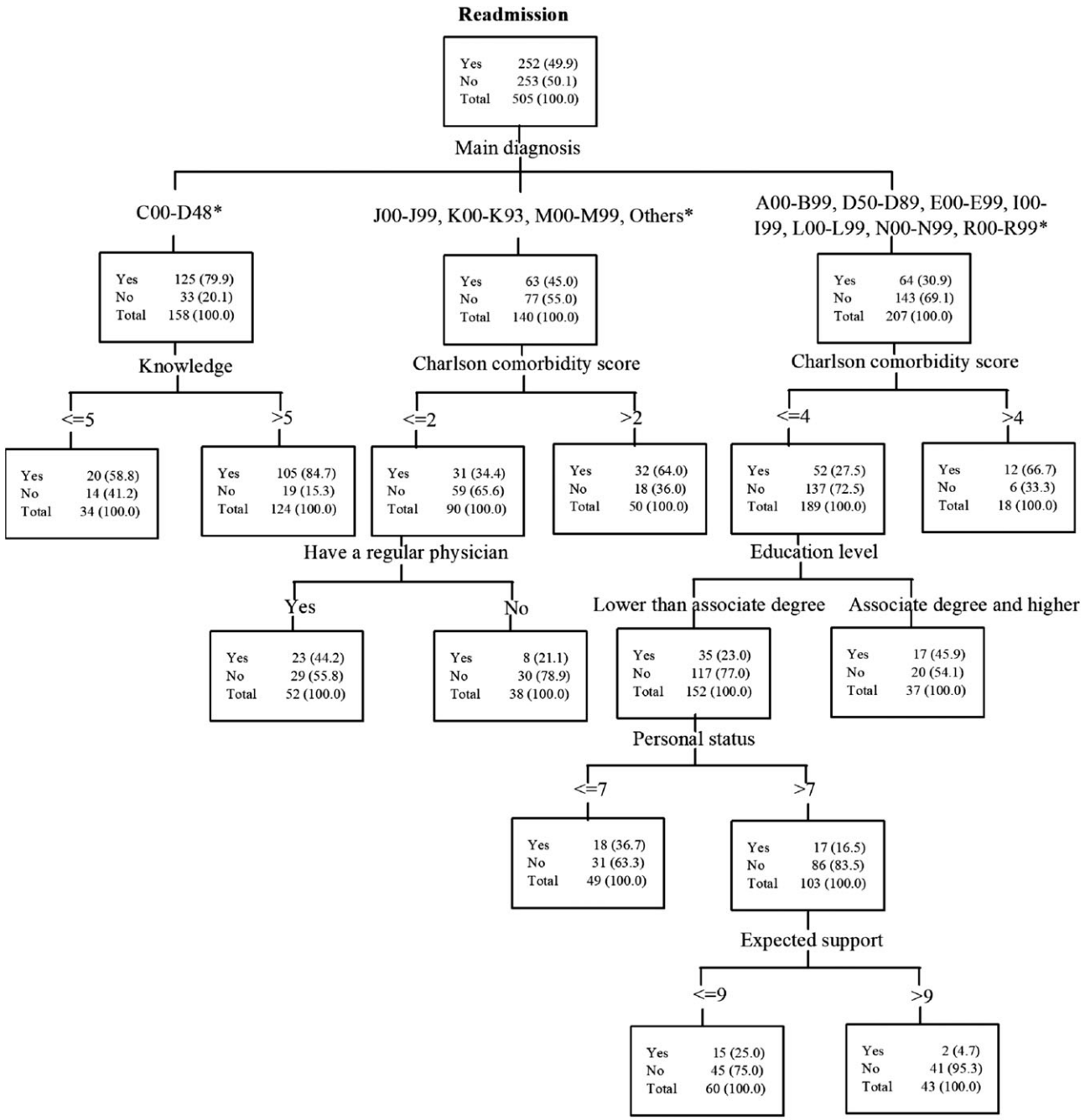
In our study cohort of discharged patients, the same hospital readmission rate was 17.9%, and the overall readmission rate to the same or different-hospital was 21.3%. A direct comparison of the observed readmission rates with those reported by different studies is difficult owing to wide variations in case identification, time period and other factors. However, the readmission rates of patients discharged from the general medicine wards, as reported by several studies (11.9–19.0%) [9, 10, 12, 27, 28], were similar to those we observed in this study. In some previous studies conducted in Turkey, readmission rates were 19.0% for heart failure [29], 7.6% for spinal cord injury [30], 20.0% for psychiatric patients [31] and 9.0% after colorectal cancer surgery [32].

In our study, the unplanned readmission rate was 5.2%. Another study conducted at the department of internal medicine of a university hospital in Switzerland has found this rate to be 5.8% [7]. Several other studies found unplanned readmission rates between 12% and 29% [13, 28, 33–36]. The lower rate of unplanned readmission in our study may be due to high frequency of neoplasms. Patients with neoplasms are discharged from their index admissions by planning their next chemotherapy/radiotherapy and scheduling their next admission. Therefore, readmissions of these patients are usually planned.

We observed 28.4% preventable readmissions, which is higher than that reported by another study conducted on general medicine patients (26.9%) [37]. One in five unplanned readmissions in our study was related to the index admission and was preventable. The most significant reason for these readmissions was the insufficient treatment duration; therefore, it was preventable. Approximately 40% of our patients were from outside Ankara, and some of these patients requested to be discharged before the completion of their treatments owing to family-related or financial issues. Apart from insufficient treatment duration, other reasons for preventability included patient-related reasons (e.g. not accepting procedure, not using medication), technical reasons (e.g. broken computerized tomography equipment, failure to perform tests, scheduling a late appointment) and other reasons such as adverse drug events and complications.

We used the CHAID algorithm to identify readmission risk factors. The algorithm provides detailed information by breaking down the inputs into more branches, and it was possible to use its results in making decisions. Therefore, the risk factors identified by the algorithm can help target interventions to prevent readmissions.

According to our CHAID algorithm, a discharged patient with an index diagnosis of neoplasm will be readmitted regardless of other variables. Similarly, neoplasm has been reported to increase the risk of unplanned readmission in another study [7]. Neoplasm is the most common diagnosis in the index admissions of all patients and in the readmissions of readmitted patients. The high incidence of cancer in Turkey (227.2 in 100 000) [38] is a possible reason for this observation. Even though there is a separate oncology hospital within the university,



*Disease groups (ICD-10 codes): A00-B99:Certain infectious and parasitic diseases, C00-D48:Neoplasms, D50-D89: Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism, E00-E99: Endocrine, nutritional and metabolic diseases, I00-I99:Diseases of the circulatory system, J00-J99: Diseases of the respiratory system, K00-K93: Diseases of the digestive system, L00-L99: Diseases of the skin and subcutaneous tissue, M00-M99:Diseases of the musculoskeletal system and connective tissue, N00-N99: Diseases of the genitourinary system, R00-R99:Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified.

Figure 3 A CHAID decision classification tree analysis to identify the risk factors of 30-day readmission.

owing to the high demand, patients with neoplasms are occasionally admitted to the internal-medicine departments where this study was conducted. Patients with neoplasms followed by the hematology department are also often admitted to the internal-medicine wards. Moreover, it is generally not possible to provide outpatient care to the patients with neoplasms coming from outside of Ankara without admitting them to the wards. Increasing the number of regional oncology clinics/hospitals throughout the country will allow these patients to receive healthcare services close to their hometown. The Ministry of Health of Turkey has comprehensively carried out regional health

Table 2 Most frequent main diagnosis of readmitted patients at index admission and readmission

Type of readmission	Main diagnosis (ICD-10 codes) at index admission	*n*	%	Main diagnosis (ICD-10 codes) in readmission	*n*	%
All readmissions	Neoplasms (C00–D48)	215	48.9	Neoplasms (C00–D48)	220	50.0
	Diseases of the respiratory system (J00–J99)	49	11.1	Diseases of the respiratory system (J00–J99)	34	7.7
	Diseases of the genitourinary system (N00–N99)	37	8.4	Diseases of the genitourinary system (N00–N99)	30	6.8
	Diseases of the digestive system (K00–K93)	29	6.6	Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (R00–R99)	29	6.6
	Endocrine, nutritional and metabolic diseases (E00–E90)	26	5.9	Diseases of the musculoskeletal system and connective tissue (M00–M99)	28	6.4
	Diseases of the musculoskeletal system and connective tissue (M00–M99)	25	5.7	Diseases of the digestive system (K00–K93)	25	5.7
Unplanned readmissions	Diseases of the respiratory system (J00–J99)	35	27.3	Neoplasms (C00–D48)	29	22.7
	Neoplasms (C00–D48)	32	25.0	Diseases of the respiratory system (J00–J99)	26	20.3
	Diseases of the digestive system (K00–K93)	15	11.7	Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (R00–R99)	20	15.6
	Diseases of the genitourinary system (N00–N99)	12	9.4	Diseases of the digestive system (K00–K93)	12	9.4
	Diseases of the musculoskeletal system and connective tissue (M00–M99)	11	8.6	Diseases of the musculoskeletal system and connective tissue (M00–M99)	12	9.4
Planned readmissions	Neoplasms (C00–D48)	183	58.7	Neoplasms (C00–D48)	191	61.2
	Diseases of the genitourinary system (N00–N99)	25	8.0	Diseases of the genitourinary system (N00–N99)	22	7.1
	Endocrine, nutritional and metabolic diseases (E00–E99)	21	6.7	Endocrine, nutritional and metabolic diseases (E00–E99)	18	5.8
	Diseases of the respiratory system (J00–J99)	14	4.5	Diseases of the musculoskeletal system and connective tissue (M00–M99)	16	5.1
	Diseases of the digestive system (K00–K93)	14	4.5	Diseases of the circulatory system (I00–I99)	13	4.2
	Diseases of the musculoskeletal system and connective tissue (M00–M99)	14	4.5	Diseases of the digestive system (K00–K93)	13	4.2

planning for oncology-related services from 2011 to 2023 [39]. As a short-term solution, increasing the number of outpatient chemotherapy units at the study hospital will allow more patients with neoplasms to receive necessary outpatient treatments without being hospitalized. Communication and cooperation between the patients' attending physician and primary-care physician regarding treatment process and possible complications may also reduce readmissions.

Diseases of the respiratory system were the second-most common reason of all readmissions and the most common cause of index admission in unplanned readmissions. Among the readmissions for respiratory system diseases, chronic obstructive pulmonary disease (COPD) was the most common diagnosis, and it was followed by pneumonia. The implementation of home-based follow-up programs providing support and care to the patients with COPD shortly after their discharge might prove beneficial. Communicating the benefits of pneumococcal and influenza vaccinations to the COPD patients could reduce pneumonia-related readmissions.

In our results, we noted that the comorbidity score gained significance as a readmission risk predictor when the patients' diagnosis belonged to the second or third group. Several other studies conducted on patients in internal-medicine wards have reported the association between a high comorbidity score and an increased risk of readmission [9, 12, 40, 41]. Therefore, patients with a high comorbidity score must be regularly followed-up by primary-care providers post-discharge, and an effective referral chain must be established. In practice, family physicians refer these patients to the specialist or patients keep going to the specialist without referral to be followed-up. But there is very little communication between family physicians and specialists.

In the second diagnostic group, comorbidity score ≤2 resulted in lower risk of readmission, as may be expected. However, interestingly, this readmission risk was found to increase with having a regular physician. One possible explanation for this observation is that having a regular physician allow for the early recognition of situations where the patient may need inpatient treatments. Having a regular physician may also be a marker of illness severity.

Among the patients with a comorbidity score of ≤4 in the third diagnostic group, an education level higher than high school was associated with higher readmission rates. Low-education level has often been reported as a readmission risk factor in the literature [42–44]. However, patients with high levels of education may be better able to recognize their health problems earlier, thereby being able to seek quick medical advice. Patients with a 'personal status' score ≤7 among those with lower levels of education had a high readmission rate. A previous study by Soley-Bori *et al.* [45] also reported that an increase in functional status reduced the readmission rate. Among patients with a 'personal status' score >7, those with an 'expected support' score ≤9 had a higher readmission rate. Other studies have highlighted the fact that social support reduces the risk of readmission [46–48]. To reduce readmissions, more attention must be paid to patients' readiness for discharge and a comprehensive discharge plan must be applied.

In our study, the cost of unplanned readmissions comprised 7% of the total cost of patients admitted to the department. A study conducted in Canada reported that the cost of unplanned readmission accounted for 11% of the total inpatient care costs [2]. Both the average cost of all readmissions and unplanned readmissions in our study were higher than the average cost of index admissions. Similarly, the

Canadian study found that the cost of unplanned readmissions for medical patients was more than the cost of index admissions [2]. The average cost of planned readmissions in our study was ~1.2-times more than the average cost of unplanned readmissions. This situation may have arisen from the fact that most of the planned readmission patients were those with serious diseases, such as neoplasms.

This study has several limitations. First, risk factors for readmission were assessed on the basis of all readmissions owing to the insufficient number of unplanned readmissions. Identifying risk factors for unplanned readmissions would require larger data sets. Second, while the inter-reviewer reliability in our study was high for evaluations of planned/unplanned readmissions and readmissions related/unrelated to the index admission, the reliability score was low for preventable/unpreventable readmissions. Similar low kappa values for inter-reviewer reliability in evaluating preventability of readmissions are present in the literature [49, 50]. To improve reliability, more structured methods are required. Third, since this study was performed in a tertiary-care referral hospital in Turkey, the results may not be relevant to smaller hospital settings; moreover, the model of risk factor identification requires further investigation to ascertain generalizability. Despite these limitations, our study has several strengths. Being a prospective cohort study, data on risk factors and patient characteristics were obtained directly from the patients and were thus more reliable than administrative data and encompassed the breadth of potential risk factors for readmission (administrative data did not include information such as social support or patient readiness for discharge). Furthermore, readmission to other hospitals, and patient deaths both inside and outside of the study hospital were identified. Unlike most other studies reported in the literature, the use of the CHAID algorithm in identifying risk factors for readmission is one of the stronger aspects of our study.

In conclusion, the use of the CHAID algorithm in identifying the risk factors for readmission is preferable, as it provides more detailed information, and physicians can understand the results more easily and use them in decision-making. Measures must be taken to reduce the readmission rate, especially for patients with neoplasms and those with diseases of the respiratory system, starting from the moment of diagnosis to post-discharge follow-ups. Furthermore, a nation-wide system must be established to facilitate monitoring of all readmissions from a single data source.

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