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ORIGINAL ARTICLE

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Appropriateness of Brain Magnetic Resonance Imaging (MRI) Prescriptions and Imposed Financial Burden: Evidence from Iran

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ABSTRACT

Background: The use of advanced and expensive technologies requires financial, human and capital resources. Brain Magnetic Resonance Imaging (MRI) has high contrast sensitivity for visualizing differences among the tissues. Unnecessary diagnostic imaging imposes excessive cost on health systems. This study aimed to determine the appropriateness of brain MRI prescriptions in 2021.

Methods: This cross-sectional study recruited 274 patients who referred to Bushehr teaching hospital. They had been prescribed MRI of the brain due to headache and dizziness. We used the data collection form developed in the previous study. The appropriateness of the brain MRI prescription was determined based on the appropriate indications during 2021.

Results: About 61 % of the referrals were due to headache and 39 % were because of dizziness. Overall, MRI was evaluated as inappropriate for about 38 % of the patients. The appropriateness of prescriptions had a significant relationship with age, gender, education, job status, complaint, prescribing physician, and MRI applicant with P-value < 0.050.

Conclusion: Findings revealed more than one-third of brain MRI services were not clinically appropriate. Due to the high cost of MRI, it is necessary to make prescriptions in accordance with indications to prevent unnecessary diagnostic procedures and to prevent induced demand. Health system policymakers and healthcare providers should develop clinical guidelines and implement them to reduce the costs of health systems.

Key words: MRI, Brain, Appropriateness, Clinical guidelines, Headache

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Introduction

Medical imaging techniques play an important role in the early diagnosis of injuries (1). But in recent years, excessive use of these diagnostic methods has imposed huge costs on health system in different countries (2). Headache is one of the most common problems, and Magnetic Resonance Imaging (MRI) is a common imaging technique to diagnose its cause.

Magnetic Resonance Imaging (MRI) is currently used in Europe and across the world and increasingly applied in both clinical and preclinical studies for diagnostic purposes (3).

Magnetic Resonance Imaging allows for the noninvasive interrogation of brain structure and brain function (4).

Some of the previous studies indicated that the prevalence of headache was 3.130 cases per 100 adults. Within 1 year of their index headache attack, 37.700 % experienced recurrence. Moreover, the prevalence and recurrence of headache increased significantly with age (5). Migraine and lifelong dizziness had been reported in the general population to have the lifetime prevalence of about 16 % and 7 %, respectively (6). In another study, the total prevalence of primary headaches was estimated to be 78.200 %, of which migraine was the most common type with a prevalence of 41.600 %. It was followed by tension headache in 31.600 % of the study population (7).

MRI is an expensive diagnostic imaging device. Inappropriate and unnecessary care imposes economic burden and affects the quality of services, payment systems, and financing. Iran, like other developing countries, suffers from insufficient and limited resources. With such a scarcity of resources, existing resources must be used effectively (8).

Today, health care facilities face new challenges due to changing population needs and rising costs. Epidemiological studies on general population indicate an average of 46 % prevalence for one year and 64 % for a lifetime regarding headache. The prevalence of the migraines, according to the studies on general adult population in Western Europe and North America is reported to be between 5-9 % percent in men and 12-25 % in women. (9).

One of the fastest growing services in the healthcare is diagnostic services. Policymakers around the world make efforts to decease unnecessary services as a method to reduce health care costs and increase the quality of services (10, 11).

Appropriate use of MRI technology can help in the diagnosis and treatment of diseases (12). However, if we use these services inappropriately, the cost of medical services will increase (13). Previous studies have shown that unnecessary prescriptions of MRI impose a significant financial burden on insurers and patients (14).

Bushehr province is a low-income province which is facing a shortage of MRI machines. This has created a queue to receive the service. Therefore, this study is designed to determine the appropriateness of brain MRI prescriptions and its financial burden in Bushehr teaching hospital in 2021.

Materials and Methods

This was a descriptive quantitative study. The participants consisted of 274 patients. Data were collected using the collection form based on the appropriate indications developed in previous study (15).

The study population included all patients for whom MRI was prescribed in Bushehr during 2021. Using a convenient sampling method, the researchers recruited 274 patients; the estimation was P-value = 20 % (16), d = 0.050 and CI = % 95.

The researchers referred to the MRI center of the teaching hospital affiliated with Bushehr University of Medical Sciences. The clinical interviewers were trained general physicians. They were present in the patient preparation room of MRI center and reviewed the prescriptions of all the referred patients. All patients whose prescriptions were related to brain MRI due to headache or dizziness were eligible for the study. The objectives of the study were explained to the patients; after obtaining an informed consent, the researchers asked questions, performed the examination and collected the required data. To determine inappropriate

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prescriptions, the authors matched the clinical indications in the data collection with the patients' physical examination. Therefore, the prescriptions of patients whose physical examinations were not in accordance with the indications were considered inappropriate.

The duration of examination and interviewing for each subject was about 15 to 30 minutes. In order to analyze data, we used SPSS $_{22}$ software. Descriptive statistical tests and Chi-square test were used.

This study was approved and funded by the deputy of research and technology of Buhehr University of Medical Sciences with the approval code: IR.BPUMS.REC.1398.126. The authors also obtained informed consent from all the participants and assured them of their anonymity. All methods were performed in accordance with the relevant guidelines and regulations.

Results

Information on 274 patients was analyzed. About 40 percent of patients were females, and 52 percent were aged between 31- 45. Almost 91 percent of them were not illiterate and 46 percent were housewives. Moreover, 99 % were insured and 67 % had supplementary insurance. The results showed that 38 percent of the prescriptions were inappropriate.

Table 1 indicates descriptive statistics of the appropriateness of brain MRI and the relationship between socio-demographic variables and appropriateness in participants.

The most and the least unnecessary prescriptions were in the age groups of 31-45 (50.000 %) and above 60 years (0.000 %), respectively. The percentage of inappropriate prescriptions was 27 % in men and 45.400 % in women (P-value = 0.002).

Information about clinical variables including the patient's complaint, the applicant, type of referring, and the specialty of the physician is also provided in Table 2. About 50 % of inappropriate prescriptions were in the chronic headache group (P-value = 0.001). More details can be seen in Table 2.

The number of all appropriate prescriptions was equal to 170 (62 %) in 274 cases, which was shown in Table 3 by type of indication. The highest frequency of indications was related to red flag and the lowest was related to neurologic symptom.

This study demonstrated that inappropriate brain MRI was prescribed for 38 % of the subjects. Therefore, if we generalize this percentage to the total annual prescriptions, a very high number will be obtained. Table 4 estimates the total financial burden imposed due to unnecessary prescriptions in one year of the study.

Table 1. Appropriateness of brain MRI prescriptions based on patients' socio-demographic factors in Bushehr 's referral center in 2021

Variable	Grouping variable	Appropriate Frequency (percent)	Inappropriate Frequency (percent)	P*
Age	5-30 years	18 (10.600)	43 (41.300)	< 0.000
	31-45 years	45 (26.500)	52 (50.000)	
	46-60 years	49 (28.800)	9 (8.700)	
	Above 60 years	58 (34.100)	0 (0.000)	
Gender	Male	81 (47.600)	30 (28.800)	0.002
	Female	89 (52.400)	74 (71.200)	
Education level	Academic and nonacademic	146 (85.900)	104 (100.000)	< 0.001
	Illiterate	24 (14.100)	0.0 (0.000)	
Job status	Worker	9 (5.300)	3 (2.900)	< 0.001
	Employee	24 (14.200)	28 (26.900)	
	Housewife	74 (43.500)	52 (50.000)	
	Self-employed	22 (12.900)	6 (5.800)	
	Retired	35 (20.600)	0 (0.000)	
	Student	6 (3.500)	15 (14.400)	

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Medical insurance status	Insured Not insured	167 (98.200) 3 (1.800)	104 (100.000) 0 (0.000)	0.173
Complementary insurance Coverage	Yes No	57 (33.500) 113 (66.500)	34 (32.700) 70 (67.300)	0.886
Total		170 (100.000 %)	104 (100.000 %)	

* P-value< 0.050 is significant.

Table 2. Appropriateness of brain MRI prescriptions based on clinical variables in Bushehr's center referred in 2021

variable	Variable grouping	Appropriate Frequency (percent)	Inappropriate Frequency (percent)	Total Frequency (percent)	P*
Complaint*	Acute headache	43 (64.200)	24 (35.800)	67 (100)	0.001*
	Chronic headache	48 (48.000)	52 (52.000)	100 (100)	
	Dizziness	79 (73.800)	28 (26.200)	107 (100)	
Type of referring	outpatient	152 (60.800)	98 (39.200)	250 (100)	0.171
	inpatient	18 (75.000)	6 (25.000)	24 (100)	
Applicant*	Physician	170 (66.400)	86 (33.600)	256 (100)	< 0.001*
	Patient	0 (0.000)	18 (100.000)	18 (100)	
Specialty*	Neurologist	156 (65.300)	83 (34.700)	239 (100)	0.014*
	Neurosurgeon	5 (45.500)	6 (54.500)	11 (100)	
	Others	9 (37.500)	15 (62.500)	24 (100)	

* P-value<0.050 is significant.

Table 3. Indications of brain MRI prescriptions in Bushehr's center referred in 2021

Appropriateness		
Inappropriate		104 (38.000)
Appropriate		170 (62.000)
	Red flag	76 (44.700)
	Chronic headache	6 (3.500)
	CT abnormal	9 (5.300)
	Vertigo episodic	12 (7.000)
	Vertigo persistent	6 (3.500)
	Neurologic symptom	2 (1.300)
	Stroke factor	59 (34.700)
Total		274 (100.000)

Table 4. The annual financial burden of brain MRI prescriptions in Bushehr's center referred

	Frequency	Tariffs of one MRI	Total cost (USD)
Without injection	1560	2.400	3853.200
With and without injection	1550	4.200	6634.000
Total cost of prescriptions	3110		10487.200
Cost of inappropriate prescriptions		3985.100	
Note: Currency rates, Iran, 2021: 1 US$ ~42105 Rials			

Discussion

The aim of this study is to evaluate the clinical appropriateness of brain MRI in patients with headache or dizziness referred to the MRI center of Bushehr University of Medical Sciences. Furthermore, factors related to MRI prescription and financial burden were also investigated.

The results of this study showed that a considerable percentage (more than one-third of prescriptions) of services were inappropriate. They can have serious consequences for health system. There is difference in the level of appropriacy in different studies. In a study by Salioti et al. (17), inappropriate knee MRI prescriptions were found to

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be 21 %. In a study by Ebrahimipour et al. (18), out of 115 knee MRI prescriptions, 63 (54.800 %) were incorrect. Several studies in Iran have focused on prescriptions without indication (19, 20, 21). Kavosi et al. (19) reported that 21 percent of brain MRI prescriptions were inappropriate. Jahanmehr et al. (20) reported that 39.700 % of lumbar MRI was inappropriate. In a study conducted by Salari et al. (21), 56 percent of lumbar spine prescriptions were incorrect. In a descriptive, cross-sectional study by Sadeghi et al (20), the appropriateness of MRI services in Shahid Chamran Hospital in Shiraz was approximately 24 % (22). Therefore, it is clear that the number of unnecessary MRI prescriptions in Iran is high. Studies conducted outside Iran have shown that the percentage of inappropriate prescriptions were lower than Iran. Oikarinen et al. (21) found that only 7 % of MRI services at a university hospital were incorrect. In that study 150 MRIs (23) were examined. In a study by Bruce E. Lehnert et al. (16), the appropriateness of using CT and MRI for patients referred to the hospital and primary care clinics of the Medical University Center was analyzed. This was to evaluate the clinical appropriateness of prescribing CTs and MRIs based on evidence-based guidelines. About 74 % of prescriptions were correct and 26 % had no clinical accuracy.

Although, the percentage of unnecessary prescriptions in above studies was approximately consistent with the findings of this study, the appropriateness rates in the developed countries are much lower than Iran. Providing unnecessary services is a reason for inefficiency of health care systems. This indicates a waste of health system resources.

It seems that one of the reasons for inappropriate MRI prescriptions in Iran is culture and the prescribing behavior of physicians. In this study, researchers showed that the percentage of prescriptions depended on the request of patients.

One of the advantages of this study, comparing to other similar studies, is that in the data collection process, the researchers examined the patients according to indications, not just based on the results of a radiologist's MRI report. Of course, the authors spent more time and resources in order to achieve more accurate results. The authors found that the normal or abnormal radiologist report was not a definite reason for correctness of prescriptions. Because even the result of an appropriate prescription may be normal (no disorder), but it was necessary to do so.

The results suggested that there was a statistically significant relationship between gender and the accuracy of prescriptions. It seems that women do health checkup and screening more than men. Moreover, women have more requests for MRI prescriptions. Furthermore, in consistent with other studies, the authors found a statistically significant relationship between patients' jobs and appropriateness. It was the least accurate prescription in the workers' occupational group. The researchers observed that there was more indication in jobs where people had heavy workload. (24-26).

The results also revealed that there was a statistically significant relationship between the applicant and the appropriateness of the prescription; thus, most of the prescriptions requested by the patients were inappropriate. It seems that patients have asked their doctors for an MRI for checkup to make sure of their health. This finding was consistent with a similar study (26).

In this study, 61 % of the complaints were from headache and 39 % from dizziness. There was a significant relationship between the chief complaint and the appropriateness. This seems to be due to the high prevalence of migraines, which were more common in women.

In this study, there was a significant relationship between the appropriateness of prescriptions and the age group. Incorrect prescriptions were common at younger ages.

According to the results of this study, a significant percent of prescriptions of brain MRI has not been clinically appropriate. Incorrect prescribing will increase waiting lists for MRI and prolong the diagnosis and treatment for patients who need MRI.

It seems that the difference in the percentage of unnecessary prescriptions in different studies is

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due to differences in the context of prescriptions. Prescriptions should be based on accurate history, physical examination, and clinical indication. If clinical examinations of patients are performed more carefully, unnecessary cases would be reduced.

This present study showed that more than one-third of prescriptions of MRI services in the context were inappropriate, which imposed a high financial burden on health system.

A major limitation of the current study is that we estimated the only direct medical financial costs of inappropriate brain MRI.

Conclusion

According to the present study, people overuse MRI diagnostic technology. This can be seen in the studies in different cities of Iran. At the same time, we are witnessing a long queue for MRI in public hospitals.

Some interventions are essential to improve prescribing behavior. Evidence-based clinical guidelines are an essential step in improving service quality. In addition, interventions such as training, reminder systems, financial incentives, and organizational support appear to be effective and necessary. Developing, implementing and monitoring of national guidelines in the country should be at the core attention of policymakers.

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Conflict of interests

The authors declared no conflict of interests.

Authors' contributions

Yazdanpanah A, Yazdankhahfard M, Kalantar hormozi M, Amiri B, Sohrabi Shekafti M, Nemati R, Esfandiari A and Salari H designed research; Yazdanpanah A, Yazdankhahfard M, Kalantar hormozi M, Amiri B, Sohrabi Shekafti M, Nemati R, Esfandiari A and Salari H conducted research; Sohrabi Shekafti M, Esfandiari A and Salari H analyzed data; and Sohrabi Shekafti M, Esfandiari A and Salari H wrote the paper. Esfandiari A had primary responsibility for final content. All authors read and approved the final manuscript.

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