

# Inappropriateness of brain MRI prescriptions and its financial burden

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## Research

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## Abstract

**Background** Diffusion of diagnostic tests such as (Magnetic Resonance Imaging) MRI is one of the main reasons for increasing growth of health care expenditure. So the current study aimed at estimation of the rate of brain MRI inappropriate prescriptions and their financial burden in Iran.

**Methods** In this cross-sectional study 385 patients were selected by systematic stratified sampling in three public teaching hospitals in Shiraz, Iran. The selected participant's information was collected through data collection form which consisted of patients' demographic information, questions related to prescription and brain MRI prescription indications checklist. The completed indications checklist was compared to the appropriateness status table of indications and scenarios to detect the percent of appropriateness of prescriptions.

**Results** About 21 percent of total brain MRI prescriptions are inappropriate. Previous treatment, number of refers to physician, having other diagnostic tests and the applicant of MRI ( $P < 0.01$ ) had significant relationships with prescriptions appropriateness. The estimated financial burden of inappropriate brain MRIs in Shiraz teaching hospitals was 99988 US dollar in 2017.

**Conclusions** More than one fifth of brains MRIs were inappropriate. It caused about one hundred thousand United States Dollar (USD) financial burden which is 17 times of Iran's Gross Domestic Product (GDP) per capita. In order to better allocation of health system resources for provision of MRI services rationing policies for controlling consumer moral hazard and reducing provider induced demand can be helpful.

## Background

Neurological diseases are one of the common causes of death and physical and mental disabilities in different societies(1). Early and precise diagnosis of brain and neurological disorders and damages will assist in better and fast treatment of those illnesses. Para clinic imaging methods have important roles in diagnosing these illnesses(2). In addition to assisting in the early diagnosis of illness, imaging prevents more aggressive measures for treatment(3). In this respect, one application of Magnetic Resonance Imaging (MRI) is diagnosis of brain and neurological illnesses(4).

MRI is one of the expensive diagnostic tests which recently have been increasingly used for diagnosing different illnesses (5). Although MRI has some benefits for patients but unnecessary demand for it have become major challenges in health systems. If MRI services be used wastefully, it will cause some concerns regarding optimum use of resources and it will cause major financial burden for healthcare systems(6) (7).

There is substantial growth in MRI acquisition and utilization in Iran(8). According to a local research in Iran, about 80% of demanded MRIs by physicians for the patients suffering from headache had normal results and it shows that MRI prescriptions in many cases are illogical and inappropriate(9). Also according to Salari, et al. (2012), 167 lumbar spine prescriptions among 300 prescriptions were inappropriate and the cost of these inappropriate prescriptions was estimated 7178 US dollar(10). So, health economists and policy makers believe that evidence-based and appropriate use of these services is the solutions for reduction of health services costs and promotion of services quality(6).

According to mentioned points, present study aimed to evaluate the level of brain MRI inappropriate prescriptions and their financial burden in public teaching hospitals in Shiraz in 2017.

## Methods

This research is a cross-sectional study which was carried out in 2017 to evaluate the level of inappropriate prescriptions of brain MRIs and their financial burden in teaching hospitals of Shiraz University of Medical Sciences.

The research population was the patients who referred to the public teaching hospitals which provide brain MRI services including Chamran Hospital, Namazi Hospital and Faghihi Hospital. Samples (385 patients) were selected by systematic stratified sampling.

In order to collect data, one nurse attended in patients' readiness rooms and examined the prescriptions of the patients who were selected previously through systematic sampling from the waiting list of MRI. The prescriptions which did not have patient history or the reason for MRI prescription was not mentioned were excluded from the study.

The selected participant's information was collected through data collection form. This form consisted of two parts. The first part was about patients' demographic information and the questions related to prescription and the second part was the brain MRI prescription indications checklist. We used the checklist that was developed by Salari et al in 2017(11).

The data obtained from data collection forms was compared to the appropriateness status table of indications and scenarios to detect the percent of appropriateness of prescriptions. These indications and scenarios appropriateness status table were developed by Salari et al. In that consensus based study, experts in the field of brain disorders (neurosurgeons and neurologists) scored the scenarios according to Rand Appropriateness Method. The scenarios were classified in the categories of appropriate, uncertain and inappropriate(11)

Finally, by multiplying the number of inappropriate prescriptions by the tariffs of brain MRI procedure for the patient and insurer in 2017 the overall imposed financial burden was estimated. It should be noted that in current study the financial costs of inappropriate MRI was estimated and comprehensive economic burden of them was not studied. For converting Iranian Rial to United States Dollar (USD) the exchange rate reported by central bank of Iran was used(12). Statistical analysis was performed by Stata 14.

## Results

About 60% of patients were female and 96 percent have basic health insurance. Education level of patients were elementary and secondary (33.2), academic (28.7), high school diploma (25.5) and illiterate (13.5), respectively. 37% of patient had complementary health insurance.

Table 1 shows descriptive statistics of appropriateness status of brain MRI in studied patients and also the relationship between examined patients' socio-demographic variables with appropriateness of brain MRI descriptions. The results indicate that generally 21.6% of total prescriptions are not appropriate.

Table 2 also indicates the mentioned statistics based on clinical variables. Results demonstrated that previous treatment, number of times of visit, having other diagnostic tests and the applicant of MRI ( $P < 0.01$ ), type of treatment and the specialty of physician ( $P < 0.1$ ), had significant relationships with prescriptions appropriateness.

Among 16,200 brain MRIs that were done in studied (three) hospitals in 2017, 21.6%, it means 3500 cases were brain MRIs without indication, among which 2240 cases (64%) were with injection and 1260 cases (36%) were with and without injection. The tariffs of doing a brain MRI procedure without injection was 22.7 USD and the tariffs of doing a brain MRI procedure with and without injection was 39 USD in 2017.

So the financial burden of inappropriate brain MRIs in "without injection", "with and without injection" and all MRIs were 50 848, 49140 and 99988 USD, respectively (Table 3).

## Discussion

Given the high importance of doing MRI in diagnosis and treatment procedure, high cost of purchasing and maintaining MRI machines for centers and also high cost of using MRI for patients and health insurers(13), the appropriateness of

brain MRI prescriptions and its related factors were investigated in this study.

Findings show that 21.6 % of brain MRI prescriptions were without indication (inappropriate). Researches which especially assessed the brain MRI appropriateness are few, so other MRI services are also compared with our findings. Piersson et al (2017) reported that about 19 percent of brain MRIs in a single center in Ghana were inappropriate(14). It seems the use of MRI procedure in Iran is similar to that of USA which has a very costly health system; because Lehnert & Bree (2010) found that 26% of MRI and CT prescriptions in USA are inappropriate(15). Oikarinen et al (2013) indicated that 7% of MRIs done in an academic hospital in Finland were inappropriate(16). Saadat et al (2008) found that 17.2% of conducted MRIs in private centers in Tehran were normal that 9.8% of them were for headache examinations(17). Barzin et.al demonstrated that 81% of requested MRIs by physicians for patients suffering from headache in an educational hospital in Sari city had normal results(9). Sheehan et al (2016) reported that 45% (106 cases) out of 237 prescribed MRIs for shoulder in a department of veterans affairs tertiary care hospital were inappropriate(18). In a recent research in Ontario, the inappropriate rate of hip MRI is estimated at 32.1%(19).

Comparison also shows that there are different results on different MRI services (all MRI, brain, shoulder, hip, ... ). There are also different inappropriate rate of MRI prescriptions across different countries and setting which associate with their health system structure and policies to control physician and patient behavior. However, it seems these differences should be mainly explained by different methodology, indications criteria and instrument which are used by different researchers.

Analytic findings show that there are no significant relationships between socio-demographic variables and brain MRI appropriateness. However, several clinical factors have significant relationship with appropriateness of brain MRI.

We found that having previous treatment and also other diagnostic tests are related to appropriateness of brain MRI. Manta (2019) showed that having no previous radiographic examination was the most predictor of inappropriate prescription of hip MRI in Ontario(19)

Also Sheehan et al (2016) showed that ultrasound could be a cost saving substitution for 66 percentage of shoulder MRIs(18).

Finding also indicates that 27.74% of 191 patients at first visit to the physicians were without indication for brain MRI. We found also the more number of times a patient visits a physician, the less likelihood of inappropriateness of brain MRI. Patients with more visits to doctors likely have chronic and severe symptoms(20), so their MRIs probably are necessary and appropriate. It also can be explained by defensive medicine. Physician in first visit in order to reduce and compensate the risk of malpractice liability apply more tests and treatments which may be unnecessary(21).

One of the main results is that the primary applicant of MRI has significant relationship with the appropriateness of brain MRI. About 19 percent of prescriptions requested primarily by physicians were inappropriate, but on the contrary more than 60 percent of brain MRIs which requested primarily by patients were inappropriate. Patients usually appeal diagnostic tests e.g. MRI from their physician; however in many times their request is unnecessary. Although it likely increases satisfaction of patient and health outcome, it waste health system resources and maybe increases the side effects of these tests(22). It is also related to consumer moral hazard concept which itself results from information asymmetry between purchasers and patients(23).

There are some macro factors which can effect on volume of unnecessary diagnostic tests and interventions which we couldn't assess their effect. For example Andrade et al. found that more supply of imaging services (imaging centers, MRI machines, radiologists) by itself increase the demand for such services(24). This phenomenon can be explained by provider induced demand or more accessibility of these services.

The present study showed that the financial burden resulted from inappropriate prescriptions of brain MRIs in 2017 was 99988 USD in Shiraz teaching hospitals which is about 17 times of Iran's Gross Domestic Product (GDP) per capita in that year (5680 USD)(25). This financial burden is related only to one MRI services (brain MRI), in one city and in only public centers. So with considering all mentioned factors there are noticeable financial burden of inappropriate MRI services in Iran. It should be asserted that according to a national study in 2018, there were 276 MRI machines in Iran (about 3.5 per one million population)(26)

A major limitations of current study is that there are not clear statistics about utilization of brain MRI in Iran, so we cannot estimate overall financial burden of brain MRI in Iran. Another limitation was lack of similar studies on brain MRI with respect to relevant factors to inappropriate prescriptions of brain MRI.

## Conclusions

About one fourth of brains MRIs were inappropriate. It caused about one hundred thousand USD financial burden which is 17 times of Iran's GDP per capita. In order to better allocation of health system resources for provision of MRI services rationing policies for controlling consumer moral hazard and reducing provider induced demand can be helpful.

## List Of Abbreviations

**MRI:** Magnetic Resonance Imaging

**USD:** United States Dollar

**GDP:** Gross Domestic Product

## Declarations

### Ethics approval and consent to participate

This study was conducted in accordance with the International Declaration of Helsinki. The study protocol was approved by the Ethics Committee of Shiraz University of Medical Sciences. All participants were informed both verbally and through written information of their right to withdraw from the study at any time. All participants gave their written consent to participate in the study.

### Consent for publication

The participants gave their written consent to publish findings of the study.

### Availability of data and material

The data used in this study are not publicly available because the participants were promised that the raw data would remain confidential. However they are available from the corresponding author on reasonable request.

### Competing interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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## Authors' contributions

Study design: ZK, AS; Data gathering: AS, MB; Data analysis: AS, HS; Data interpretation: ZK, FL, HS; Manuscript drafting: ZK, AS, MB; Final review of manuscript: ZK, AS, FL, HS, MB.

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## Tables

Table 1. Appropriateness of brain MRI prescriptions based on patients' socio-demographic variables in Shiraz teaching hospitals in 2017

		With Indication		Without Indication		Total		P-value
		Frequency	Percent	Frequency	Percent	Frequency	Percent	
Overall		302	78.45	83	21.55	385	100	
Gender	Male	116	76.82	35	23.18	151	100	0.535
	Female	186	79.5	48	20.5	234	100	
Education level	Illiterate	39	75	13	25	52	100	0.094
	Elementary & secondary	105	82	23	18	128	100	
	High school diploma	82	83.67	16	16.33	98	100	
	Academic	76	71	31	29	107	100	
Job	Employee	53	76.81	16	23.89	69	100	0.949
	Worker	38	79.17	10	20.83	48	100	
	Housewife	126	79.24	33	20.76	159	100	
	Self-employed	65	76.47	20	23.53	85	100	
	Other	20	83.34	4	16.66	24	100	
Basic insurance status	Not insured	11	84.61	2	15.39	13	100	0.743
	Insured	291	78.22	81	21.78	372	100	
Insurer	Social security organization	128	81	30	19	158	100	0.211
	Iran health insurance organization	143	78	40	22	183	100	
	Armed forces insurance organization	10	66.6	5	33.4	15	100	
	Other insurers	10	62.5	6	37.5	16	100	
Complementary insurance coverage	Yes	81	77.88	23	22.12	104	100	0.921
	No	221	78.64	60	21.36	281	100	

Table 2. Appropriateness of brain MRI prescriptions based on clinical variables in Shiraz teaching hospitals in 2017

		With Indication		Without Indication		Total		P-value
		Frequency	Percent	Frequency	Percent	Frequency	Percent	
Overall		302	78.45	83	21.55	385	100	
Having previous treatment	Yes	115	68.86	52	31.14	167	100	0.001
	No	187	85.78	31	14.22	218	100	
Type of treatment	Drug	137	84.05	26	15.95	163	100	0.068
	Rest	6	75	2	25	8	100	
	Surgery	42	95.45	2	4.55	44	100	
	Others	2	66.67	1	33.33	3	100	
Treatment duration	Less than 1 Year	59	78.67	16	21.33	75	100	0.112
	1-5 years	73	86.90	11	13.10	84	100	
	More than 5 Years	55	93.22	4	6.78	59	100	
Number of times of visit	First time	138	72.25	53	27.74	191	100	0.001
	Second times	68	75.56	22	24.44	90	100	
	Third times or more	96	92.3	8	7.7	104	100	
Having other diagnostic tests[1]	Yes	159	85.48	27	14.52	186	100	0.001
	No	143	71.86	56	28.14	199	100	
Applicant	Physician	279	80.63	67	19.37	346	100	0.001
	Patient	6	37.5	10	62.5	16	100	
	Physician & patient	17	73.91	6	26.09	23	100	
Referral center	Public hospital	194	79.83	49	20.17	243	100	0.254
	Private hospital	20	66.67	10	33.33	30	100	
	Private office	88	78.57	24	21.43	112	100	
Specialty of the physician	Neurosurgery	78	80.41	19	19.59	97	100	0.064
	Neurologist	123	67.95	58	32.05	181	100	
	Other	101	94.39	6	5.61	107	100	

Table 3. Financial burden of inappropriate brain MRIs in teaching hospitals in Shiraz, 2017

	Number of inappropriate brain MRIs	Tariffs of one MRI	Total cost (USD)
Without injection	2240	22.7	50848
With and without injection	1260	39	49140
Total	3500		99988

[1] CT scan, electroencephalography, etc