

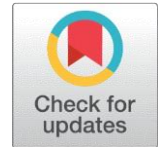
KNOWLEDGE AND REFERRAL PATTERNS OF PRIMARY CARE PHYSICIANS REGARDING INTERVENTIONAL RADIOLOGY IN SAUDI ARABIA (2025): A CROSS-SECTIONAL SURVEY



Sarah M. Althagafi¹✉, Sarah A. Al-Muammar²

¹Radiology Department, King Fahad Hospital, Madinah, Saudi Arabia

²Family Medicine Department, King Abdulaziz University, Jeddah, Saudi Arabia



ABSTRACT

Background and Aim: Interventional radiology (IR) offers minimally invasive, image-guided alternatives to surgery in areas like oncology, vascular disease, and trauma. However, its use remains limited, partly due to low awareness and referral rates by primary care physicians (PCPs). This study aims to evaluate the knowledge and referral practices of PCPs toward IR in Saudi Arabia.

Methods: A cross-sectional survey was carried out among 250 PCPs across Saudi Arabia to evaluate their knowledge, educational exposure, referral practices, and perceived barriers related to IR. Participants were selected using stratified random sampling. The survey included multiple-choice questions addressing five areas: demographics, IR knowledge, IR education exposure, referral behavior, and perceived barriers. Descriptive statistics and inferential analyses, such as chi-square tests and multivariate logistic regression, were employed to analyze the data.

Results: Most respondents were male (64.8%) and aged 30–39 years (43.2%), with nearly half working in Ministry of Health primary care centers. Only 29.6% rated their IR knowledge as good or excellent, and 37.6% had received formal IR education. Although 76.4% correctly identified common IR procedures, only 22.4% reported high confidence in referring patients to IR. Major barriers included a lack of IR knowledge (35.2%) and limited access to services (29.6%). Physicians with high IR knowledge were significantly more likely to refer patients ($p < 0.001$). Logistic regression showed that high knowledge (aOR = 3.41, $p < 0.001$) and formal IR education (aOR = 2.27, $p = 0.003$) were strong predictors of referral.

Conclusion: Primary care physicians in Saudi Arabia demonstrate variable awareness of IR, with knowledge gaps contributing to low referral rates. Educational interventions and improved referral infrastructure are urgently needed to optimize IR integration into primary care and enhance patient outcomes.

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Corresponding Author

Sarah Mohammed Althagafi
Radiology Department, King
Fahad Hospital, Madinah, Saudi
Arabia

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الخلفية والهدف: توفر الأشعة التداخلية (IR) بدائل طفيفة التوغل موجهة بالصور للجراحة التقليدية في مجالات مثل الأورام، وأمراض الأوعية الدموية، والصدفات. ومع ذلك، لا يزال استخدامها محدودًا جزئيًا بسبب انخفاض مستوى الوعي ومعدلات الإحالة من قبل أطباء الرعاية الأولية. يهدف هذا البحث إلى تقييم معرفة أطباء الرعاية الأولية وممارساتهم في الإحالة نحو الأشعة التداخلية في المملكة العربية السعودية.

المنهجية: تم إجراء دراسة مقطعية شملت 250 طبيب رعاية أولية من مختلف مناطق المملكة العربية السعودية لتقييم معرفتهم، ومدى تعرضهم للتعليم في مجال الأشعة التداخلية، وممارسات الإحالة، والعوائق المتصورة. تم اختيار المشاركين باستخدام أسلوب العينة العشوائية الطبقية. احتوى الاستبيان على أسئلة اختيار من متعدد تغطي خمسة محاور: الخصائص الديموغرافية، المعرفة بالأشعة التداخلية، مدى التعرض، للتعليم في المجال، سلوك الإحالة، والعوائق المتوقعة. تم تحليل البيانات باستخدام الإحصاءات الوصفية واختبارات مرجح كاي، والانحدار اللوجستي المتعدد.

النتائج: كان معظم المشاركين من الذكور (64.8%) وتتراوح أعمار 43.2% منهم بين 30-39 عامًا ويعمل نحو نصفهم في مراكز الرعاية الأولية التابعة لوزارة الصحة. قيم 29.6% فقط معرفتهم

بالأشعة التداخلية بأنها جيدة أو ممتازة، وتلقى 37.6% منهم تعليمًا رسميًا في هذا المجال. ورغم أن 76.4% تمكنوا من تحديد الإجراءات الشائعة في الأشعة التداخلية بشكل صحيح، إلا أن 22.4% فقط أعربوا عن ثقتهم العالية في إحالة المرضى. تمثلت العوائق الرئيسية في نقص المعرفة بالأشعة التداخلية (35.2%) وصعوبة الوصول إلى الخدمات (29.6%). أظهر الأطباء الذين يمتلكون معرفة

عالية بالأشعة التداخلية، (aOR = 3.41) أظهر تحليل الانحدار اللوجستي أن المعرفة العالية. (p < 0.001) احتمالًا أكبر للإحالة كلما من أقوى العوامل (aOR = 2.27, p = 0.003) والتعليم الرسمي في المجال (p < 0.001) المرتبطة بالإحالة.

الاستنتاج: يظهر أطباء الرعاية الأولية في المملكة العربية السعودية درجات متفاوتة من الوعي بالأشعة التداخلية، حيث تسهم فجوات المعرفة في انخفاض معدلات الإحالة. هناك حاجة ملحة لتدخلات تعليمية وتحسين البنية التحتية للإحالة من أجل دمج الأشعة التداخلية بشكل أفضل في نظام الرعاية الأولية وتعزيز نتائج الرعاية الصحية للمرضى.

Keywords: Knowledge assessment, Primary care physicians, Interventional radiology, Saudi Arabia.

1. INTRODUCTION

Interventional radiology (IR) is a rapidly evolving subspecialty that offers minimally invasive alternatives to traditional surgery, with broad applications in areas such as oncology, vascular disease, trauma, and organ transplantation. Utilizing advanced imaging technologies, IR procedures provide notable advantages, including shorter recovery times, reduced risk of infection, and decreased post-procedural pain

compared to conventional surgical approaches. Despite these benefits, the integration of IR into routine clinical practice remains limited in many healthcare systems. A significant contributing factor to this underutilization is the level of knowledge and referral practices among primary care physicians (PCPs), who often serve as the initial point of contact for patients and play a crucial role in guiding referrals to specialist care.

In Saudi Arabia, primary care serves as the cornerstone of the healthcare system, delivering comprehensive services across both urban and rural regions. However, the integration of interventional radiology (IR) within primary care settings remains largely underexplored. While some studies have addressed general awareness of IR among healthcare professionals, limited data exist regarding primary care physicians' understanding of IR procedures, their confidence in making IR referrals, and the factors that influence these practices [2,3]. As IR continues to evolve and expand, assessing the knowledge gaps and referral behaviors of primary care physicians is essential to ensure timely, appropriate patient access to specialized care.

Several international studies have indicated that primary care physicians often lack sufficient knowledge of interventional radiology (IR), which may contribute to low referral rates and missed opportunities for patients to benefit from these minimally invasive procedures [4]. In addition, perceived barriers—such as limited access to IR services, unclear referral pathways, and concerns about patient safety—have been identified as significant challenges to effective IR utilization [5,6]. Despite these global findings, few studies have specifically examined primary care physicians in Saudi Arabia, where cultural, educational, and healthcare system-related factors may uniquely influence referral behaviors.

This study aims to address this gap by evaluating the knowledge and referral patterns of primary care physicians regarding interventional radiology (IR) in Saudi Arabia. The general objective is to assess physicians' understanding of IR and the frequency with which they refer patients for IR procedures. Specifically, the study seeks to identify factors influencing referral behavior and to inform the development of targeted interventions to improve IR utilization. By highlighting key educational and infrastructural needs, the findings may support better integration of IR into the Saudi healthcare system and contribute to enhanced patient care and outcomes nationwide.

This study aims to assess the knowledge and referral patterns of primary care physicians regarding interventional radiology (IR) in Saudi Arabia. Specifically, it

seeks to identify the factors influencing IR referral behavior among primary care physicians and to support the development of targeted interventions that enhance IR utilization, ultimately improving patient care and outcomes nationwide.

2. METHODS

2.1 Study Design

This study employed a cross-sectional survey design to assess the knowledge and referral patterns of primary care physicians in Saudi Arabia regarding interventional radiology (IR). The survey was designed to collect both quantitative and qualitative data through structured, closed-ended questions to evaluate physicians' awareness of IR procedures, confidence in making referrals, and perceived barriers to IR utilization in primary care settings.

2.2 Study population

The target population for this study consisted of primary care physicians practicing in various healthcare settings across Saudi Arabia. A stratified random sampling method was used to ensure adequate representation of physicians from different regions and healthcare facilities, including the Ministry of Health (MOH) primary health care centers, private clinics, government hospitals, and military hospitals. Inclusion criteria included physicians currently practicing in Saudi Arabia who were involved in patient care and decision-making. Exclusion criteria were physicians not practicing in primary care settings or those who did not have direct patient interactions.

2.3 Sample size

A sample size of 250 physicians was determined to provide sufficient statistical power for the analysis, based on a 95% confidence level and a margin of error of 6%. The sample size was also calculated to ensure proportional representation across different regions and practice settings within Saudi Arabia. The participants were recruited through a combination of direct outreach and collaboration with regional health authorities.

2.4 Data Collection

Data were collected through an online survey distributed via email and social media platforms commonly used by healthcare professionals in Saudi Arabia. The survey was administered over 4 weeks from January to February 2025. Respondents were assured of their confidentiality, and participation was voluntary. Ethical approval for the study was obtained from the local research ethics committee, and informed consent was acquired from all participants before participation.

The survey consisted of multiple-choice questions (MCQs) that assessed several key domains, including demographic information such as age, gender, region of practice, type of facility, and years in practice. It also evaluated the participants' knowledge of IR, covering aspects like the definition of IR, common procedures, disease areas treated by IR, and its invasiveness compared to traditional surgery. The survey further examined exposure to IR education, specifically formal training in IR and self-reported knowledge levels. Additionally, referral practices were assessed, including the frequency of IR referrals, the physicians' confidence in making referrals, and the pathways they follow when referring patients to IR. Lastly, the survey explored perceived barriers to referral, focusing on factors that limit the referral of patients to IR.

2.5 Survey Instrument

The survey was developed following a comprehensive review of the literature and consultations with experts in IR and primary care. It was structured into five distinct sections: Demographic Information, Knowledge of IR, Exposure to IR Education, Referral Practices, and Perceived Barriers to IR Referral. These sections were designed to gather detailed information on the participants' background, their understanding of IR, the extent of their exposure to IR education, their referral practices, and the barriers they encounter when referring patients to IR.

A pilot test of the survey was conducted with a small group of primary care physicians (n=10) to assess the clarity and relevance of the questions. Based on feedback from the pilot group, minor adjustments were made to ensure the survey was clear, concise, and culturally appropriate.

2.6 Phases of the Study

The study was conducted in the following sequential phases:

1. Planning Phase (November – December 2024): This phase involved literature review, consultation with experts in interventional radiology and primary care, and the development of the survey instrument. Ethical approval was also obtained during this phase.
2. Pilot Phase (Late December 2024): A pilot test was conducted with 10 primary care physicians to assess the clarity and cultural appropriateness of the survey. Feedback from this group was used to refine the instrument.
3. Data Collection Phase (January – February 2025): The finalized survey was distributed electronically to primary care physicians across Saudi Arabia. Data collection was completed over 4 weeks.
4. Data Analysis Phase (March 2025): Data were cleaned, coded, and analyzed using SPSS version 26. Descriptive and inferential statistical analyses were performed to interpret the results.

2.7 Statistical Analysis

Descriptive statistics were used to summarize the demographic characteristics of the respondents, their knowledge of IR, and their referral practices. The results were presented as frequencies and percentages for categorical variables, and means and standard deviations for continuous variables.

Inferential statistical tests were performed to examine the relationship between various factors and referral practices. A chi-square test was used to assess the association between knowledge of IR and referral frequency. A multivariate logistic regression was conducted to identify independent predictors of referral practices, including knowledge of IR, formal IR education, years in practice, and practice location.

All statistical analyses were performed using SPSS version 26 (IBM Corp, Armonk, NY). A p-value of <0.05 was considered statistically significant.

3. RESULTS

3.1 Demographic Characteristics

A total of 250 primary care physicians participated in the survey. The majority of

respondents were between the ages of 30 and 39 (43.2%), followed by those aged 40–49 (28.8%). Only 16.8% of respondents were under 30, and 11.2% were 50 years or older. The gender distribution showed a higher proportion of male physicians (64.8%) compared to female physicians (35.2%). These demographic details are summarized in Table 1.

The respondents represented a broad geographical distribution across Saudi Arabia. The Central region had the largest number of participants (32.8%), followed by the Western (21.6%) and Eastern (16.4%) regions. Southern and Northern regions were represented by 15.6% and 13.6%, respectively. The majority of physicians worked in the Ministry of Health (MOH) primary health care centers (49.6%), while 18.0% practiced in private clinics or hospitals. Government hospitals (non-MOH) accounted for 15.2% of responses, with military or security forces hospitals contributing 12.4%, and university or teaching hospitals making up 4.8%. In terms of professional experience, 34.8% of respondents had between 5 and 10 years of practice, 28.4% had 11 to 20 years, and 15.6% had over 20 years of experience. The remaining 21.2% had been in practice for fewer than 5 years.

3.2 Knowledge of Interventional Radiology (IR)

Physicians' knowledge of interventional radiology (IR) varied across different domains. The majority of respondents correctly identified IR as a subspecialty of diagnostic radiology using imaging guidance for minimally invasive procedures (61.6%), while 38.4% were unsure about the definition of IR. A significant percentage of respondents correctly identified common IR procedures such as angioplasty and embolization (76.4%), and recognized that IR is primarily used for conditions like cancer, vascular diseases, and trauma (68.0%). On the other hand, knowledge about the invasiveness of IR procedures compared to traditional surgery was high, with 81.2% of respondents identifying IR as less invasive than surgery. Similarly, 63.2% of respondents correctly recognized that IR procedures often involve local or conscious sedation, with only 36.8% unsure of the typical anesthesia used in these procedures. These findings are shown in Table 2.

Despite the relatively high awareness of specific IR procedures and their advantages, only 29.6% of respondents rated their overall knowledge of IR as good or excellent (score ≥ 4 on a 5-point scale), with the majority (70.4%) rating their knowledge as average or poor (score ≤ 3).

3.3 Exposure to IR Education and Referral Practices

Exposure to formal education in IR was limited, with only 37.6% of respondents reporting having received formal IR training during medical school or residency. Despite this, when

asked about their confidence in referring patients to IR, only 22.4% felt very confident, with the majority (77.6%) reporting either moderate or low confidence in making referrals (Table 3).

In terms of referral practices, 40.4% of physicians reported referring patients to IR rarely, while 9.2% referred patients frequently (more than once a month). A significant proportion (35.2%) referred patients occasionally (a few times per year), and 15.2% had never referred a patient to IR. Regarding referral pathways, 42.4% of physicians reported consulting a radiologist before referring to IR, 26.8% consulted other specialists, and 20.8% made direct referrals to IR. Notably, 10.0% of respondents indicated they did not refer to IR at all.

3.4 Perceived Barriers to Referring to IR

Respondents identified several barriers as factors that hindered them from referring patients to IR. The most frequently cited barrier was a lack of knowledge about IR (35.2%), followed by limited access to IR services (29.6%). Preference for surgical options was another common reason for not referring (17.2%), while concerns about patient safety were raised by 8.4% of respondents. A lack of clear referral pathways was also identified by 9.6% of respondents as a limiting factor (Table 4).

3.5 Association Between IR Knowledge and Referral Frequency

There was a significant association between the level of knowledge about IR and referral frequency. Physicians with high levels of knowledge (score ≥ 4) were more likely to refer patients frequently or occasionally (72.0%) compared to those with low knowledge (27.9%), who were less likely to refer (67.6%). This association was statistically significant ($p < 0.001$), as determined by a chi-square test. The results suggest that better knowledge of IR is strongly correlated with a higher likelihood of referring patients to IR services (Table 5).

3.6 Multivariate Logistic Regression Predicting IR Referral

A multivariate logistic regression analysis was performed to identify factors that predict the likelihood of physicians referring patients to IR. The analysis revealed that physicians with high IR knowledge (score ≥ 4) were significantly more likely to refer patients to IR (adjusted odds ratio [aOR] = 3.41, $p < 0.001$). Additionally, those who had received formal IR education were also more likely to refer (aOR = 2.27, $p = 0.003$). Physicians with over 10 years of practice experience did not show a significant relationship with

referral frequency (aOR = 1.19, p = 0.51). Interestingly, physicians practicing in urban areas were more likely to refer patients to IR compared to those in rural areas (aOR = 1.76, p = 0.045) (Table 6).

Table 1 Demographic Characteristics of Respondents (N = 250)

Variable		Frequency (n)	Percentage (%)
Age Group	Under 30	42	16.8
	30–39	108	43.2
	40–49	72	28.8
	50 and above	28	11.2
Gender	Male	162	64.8
	Female	88	35.2
Region of Practice	Central	82	32.8
	Western	54	21.6
	Eastern	41	16.4
	Southern	39	15.6
	Northern	34	13.6
Type of Facility	MOH PHC Center	124	49.6
	Private Sector	45	18.0
	Government Hospital (non-MOH)	38	15.2
	Military/Forces Hospital	31	12.4
	University/Teaching Hospital	12	4.8
Years in Practice	<5 years	53	21.2
	5–10 years	87	34.8
	11–20 years	71	28.4
	>20 years	39	15.6

The data are presented as frequencies (n) and percentages (%)
Abbreviations: MOH: Ministry of Health

Table 2. Knowledge of Interventional Radiology Among Respondents (N = 250)

Knowledge Item	Correct (%)	Incorrect/Unsure (%)
Definition of IR	61.6	38.4
Common procedures (angioplasty, embolization)	76.4	23.6
Disease areas IR is used in	68.0	32.0
Invasiveness of IR vs surgery	81.2	18.8
Typical anesthesia used in IR	63.2	36.8
Self-rated IR knowledge ($\geq 4/5$)	29.6	70.4

P-values were calculated using a chi-square test, and significance was determined at p < 0.05. Abbreviations: IR: Interventional Radiology, NS: Not Significant

Table 3 Exposure to IR Education and Referral Practices (N = 250)

Variable	Frequency (n)	Percentage (%)	
Formal IR education (any stage)	94	37.6	
Confident about when to refer	56	22.4	
Frequency of IR referral	Frequently (>1/month)	23	9.2
	Occasionally (few/year)	88	35.2
	Rarely	101	40.4
	Never	38	15.2
Preferred referral pathway to IR	Direct referral	52	20.8
	Through radiologist	106	42.4
	Through other specialist	67	26.8
Do not refer	25	10.0	

Statistical significance was considered for p-values < 0.05

Abbreviations: IR: Interventional Radiology, NS: Not Significant, PHC: Primary Health Care

Table 4 Perceived Barriers to Referring Patients to IR (N = 250)

Barrier	Frequency (n)	Percentage (%)
Lack of knowledge about IR	88	35.2
Limited access to IR services	74	29.6
Preference for surgical options	43	17.2
Concerns about patient safety	21	8.4
No clear referral pathway	24	9.6

The data are presented in frequencies (n) and percentages (%)

Significance was set at p < 0.05

Abbreviations: IR: Interventional Radiology, NS: Not Significant

Table 5 Association Between IR Knowledge and Referral Frequency

Knowledge Score Group	Frequent/Occasional Referral (n = 111)	Rare/Never Referral (n = 139)	p-value*
Low (score ≤2)	31 (27.9%)	94 (67.6%)	<0.001
Moderate (score = 3)	42 (37.8%)	30 (21.6%)	
High (score ≥4)	38 (34.2%)	15 (10.8%)	

P-values were calculated using a chi-square test, and the relationship was statistically significant (p < 0.05)

Abbreviations: IR: Interventional Radiology, NS: Not Significant

Table 6 Multivariate Logistic Regression Predicting IR Referral

Variable	Adjusted Odds Ratio	95% Confidence Interval	p-value
High IR Knowledge (score ≥4)	3.41	1.95 – 5.96	<0.001
Formal IR Education	2.27	1.33 – 3.86	0.003
Years in Practice >10	1.19	0.71 – 2.02	0.51
Urban Practice Location	1.76	1.01 – 3.07	0.045

A significance level of p < 0.05 was considered statistically significant

Abbreviations: IR: Interventional Radiology, OR: Odds Ratio, CI: Confidence Interval, NS: Not Significant

4. DISCUSSION

4.1 Overview of Key Findings

This study aimed to assess the knowledge, confidence, and referral practices of primary care physicians in Saudi Arabia regarding IR. Our findings indicate that while primary care physicians generally have a basic understanding of IR, significant gaps exist in both their knowledge and their confidence in referring patients for IR procedures. Despite recognizing the potential benefits of IR, many physicians report insufficient formal education in this subspecialty, leading to under-referral and suboptimal utilization of IR services. The study also highlights critical barriers, including a lack of access to IR services, a lack of clear referral pathways, and concerns regarding patient safety, which limit the integration of IR into clinical practice.

4.2 Knowledge of IR Among Primary Care Physicians

Our results suggest that while the majority of physicians demonstrated an understanding of the general concept of IR (61.6%), their overall knowledge was far from comprehensive. A significant proportion (38.4%) lacked clarity on the definition of IR, which could hinder their ability to make informed decisions regarding patient care. Similar findings have been reported in studies from other regions, where physicians' knowledge of IR was often found to be superficial, despite awareness of its existence [7-10]. This knowledge gap is concerning, as it can lead to missed opportunities for patient referral to IR procedures that offer less invasive alternatives to surgery.

Moreover, although a large proportion of respondents correctly identified common IR procedures (e.g., angioplasty and embolization), fewer recognized IR's applicability in diverse clinical areas such as trauma and cancer care (68.0%). This suggests that physicians may be aware of a few high-profile IR procedures but lack a comprehensive understanding of the breadth of conditions that can benefit from IR. Previous studies have shown similar trends, with primary care physicians often underestimating the scope of IR and its potential role in managing conditions beyond vascular diseases [11].

4.3 Referral Practices and Confidence in Referring to IR

Our study also found that despite recognizing the value of IR, primary care physicians exhibited limited confidence in referring patients to IR specialists. Only 22.4% of respondents reported being very confident in making referrals, and 40.4% rarely referred patients to IR. This low referral rate may be influenced by several factors, including a lack of formal education on IR and insufficient knowledge of its full capabilities. A similar pattern has been documented in other studies, where physicians often feel less confident in referring to subspecialties that they have limited exposure to [12,13].

The findings further highlight that physicians who had received formal education on IR were significantly more likely to refer patients to IR services. This underscores the importance of incorporating IR training into medical curricula and continuing medical education programs. The positive impact of education on referral behavior has been well-documented in the literature, where training programs have been shown to enhance physicians' knowledge and confidence in utilizing specialized medical services [14-16].

4.4 Barriers to Referral and Access to IR Services

The study also identified several barriers that hinder the referral of patients to IR. Notably, 35.2% of respondents cited lack of knowledge as the primary barrier, while 29.6% pointed to limited access to IR services. These findings align with previous research, where limited availability of IR services and lack of awareness among primary care physicians were consistently reported as significant obstacles to referral [17,18]. Interestingly, 17.2% of respondents mentioned a preference for surgical options, reflecting a potential perception that surgery is the more definitive treatment option compared to IR. This may be due to a lack of familiarity with IR's less invasive nature or a historical reliance on traditional surgical approaches in managing certain conditions. Addressing this perception through targeted educational interventions and promoting the advantages of IR—such as shorter recovery times and fewer complications—could help shift referral patterns and optimize patient outcomes.

Another important barrier identified was unclear referral pathways, cited by 9.6% of participants. A clear, standardized referral system is essential for ensuring that patients have timely access to IR services. Previous studies have emphasized the need for well-

defined referral pathways to streamline the referral process and reduce delays in patient care [2,19].

4.5 The Role of Physician Knowledge in Referral Behavior

Our analysis revealed a strong association between knowledge of IR and the likelihood of making a referral. Physicians who scored higher on knowledge of IR were significantly more likely to refer patients, indicating that knowledge directly influences referral behavior. Interestingly, our study also found that physicians practicing in urban areas were more likely to refer patients to IR, likely due to the greater availability of IR services in urban centers compared to rural areas. This geographic disparity in access to care is a well-documented issue in many healthcare systems, and efforts to address these disparities through telemedicine or mobile IR units could help improve referral patterns in underserved areas.

4.6 Implications for Education and Policy

The results of this study have important implications for both medical education and healthcare policy. Our findings suggest that increasing exposure to IR during medical school and residency programs, as well as offering continuing medical education opportunities for practicing physicians, could help bridge the knowledge gap. Tailored educational initiatives that emphasize the broad range of conditions treatable by IR, as well as hands-on training or case-based learning, may enhance physicians' confidence in making IR referrals.

Moreover, healthcare policies aimed at improving access to IR services, particularly in rural and underserved areas, are crucial. Establishing clearer referral pathways and promoting interdisciplinary collaboration between primary care physicians and IR specialists could improve the timely management of conditions that benefit from IR procedures. Standardizing referral guidelines across regions could further reduce variability in referral practices.

4.7 Limitations

This study has several limitations. First, its cross-sectional design limits the ability to establish causal relationships between knowledge and referral practices. Second, the survey relied on self-reported data, which may be subject to response biases. Although we aimed for a representative sample, the study may still have sampling biases, particularly concerning geographic distribution and the underrepresentation of physicians working in non-urban areas. Lastly, the generalizability of our findings may be limited to primary care physicians in Saudi Arabia, and further studies are needed to assess the applicability of these results in other regions.

5. CONCLUSION

This study highlights significant gaps in the knowledge and referral practices of primary care physicians in Saudi Arabia regarding IR. Despite a general awareness of IR, many physicians lack in-depth knowledge and confidence in making appropriate referrals. Combined with barriers such as limited access to services and unclear referral pathways, this results in the underutilization of IR in clinical practice. These findings emphasize the urgent need for enhanced educational programs in medical curricula and continuing education to improve physicians' understanding of IR. Additionally, efforts to streamline referral pathways and improve access to IR services, particularly in underserved regions, are crucial for optimizing patient care. Addressing these challenges will ensure that the potential benefits of IR are more effectively realized, ultimately contributing to better patient outcomes and more efficient healthcare delivery.

In light of these findings, several recommendations are proposed to address the identified gaps. First, interventional radiology should be more comprehensively integrated into undergraduate and postgraduate medical education to equip future physicians with a solid foundation in IR. Continuing professional development programs, including workshops and seminars, should be organized regularly to raise awareness and reinforce IR knowledge among practicing physicians. Second, the establishment of clear and standardized referral protocols is essential to guide primary care physicians in making appropriate and timely IR referrals. Third, improving the accessibility of IR services—particularly in rural and underserved areas—by expanding

infrastructure and resources can help ensure equitable patient care. Finally, promoting interdisciplinary collaboration between primary care providers and IR specialists will facilitate more efficient referral processes and better patient management. Implementing these recommendations can enhance the utilization of IR in primary care settings and contribute to a more effective and integrated healthcare system in Saudi Arabia.

6. DATA AVAILABILITY

The data that support the findings of this study are available in our radiology information system, GE web-based, as well as the Cerner system at King Saud Medical City, Riyadh.

7. CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

8. FUNDING

No funding was received

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