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INTERVENTIONAL RADIOLOGY—ORIGINAL ARTICLE

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A cross-sectional study assessing the role of interventional radiology services in regional and remote Australia

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Abstract

Introduction: It is estimated that 8% of hospitalised patients require treatment from Interventional Radiology (IR). However, little is known about the potential impact of IR on regional and remote Australians, including Indigenous patients. This study aimed to assess treatments performed by IRs on regional/remote patients to predict future IR workforce and governance needs.

Methods: Single-centre cross-sectional study at a tertiary Victorian hospital. Patients were identified when they had an advanced IR treatment between 1 January 2022 and 2024. Basic procedures such as biopsy and drain insertion were not included. The primary outcome was the type and volume of IR treatments performed on patients who were transferred from a regional or remote home location for treatment.

Results: Of 3485 advanced IR interventions, 908 procedures (26.0%) from patients who lived in a regional or remote location were included with 36.5% female, of mean age 55.6 years (SD 17.9). 1.4% identified as Indigenous which is similar to the Indigenous population incidence in Victoria of 1.0%. Of this group, 350 (38.5%) were either a day procedure, overnight elective admission, or simple inpatient procedure which could have been performed in a regional centre, which included 1.1% Indigenous patients.

Conclusion: There is an unmet need for IR services in regional and remote Australia, with many patients being transferred to our metropolitan centre for treatment that could be performed in regional IR hubs. This data will be important to drive government and hospital planning including capital infrastructure, workforce modelling and future recognition of IR as a new specialty in Australia.

Key words: interventional; IR; radiology; regional; remote.

Introduction

Interventional Radiology (IR) is an evolving medical specialty which has carved an essential role into modern healthcare practice.[1,2] It is estimated that 8% of all hospitalised patients in the United States require treatment from an IR.[2] Major hospitals in Australia now have dedicated IR teams providing patients with access to 24-hour 7-day specialist treatment and consultation services in addition to elective outpatient programs[3–5] and having IR within the multidisciplinary trauma team is a requirement for Level 1 trauma centre accreditation.[6,7] However, this evolution is recent with many hospitals beginning to recognise these changes only in the last 10–15 years.[1]

Existing studies have shown that patients who live in a regional or remote location have a higher burden of disease and higher rates of premature and avoidable mortality.[8–12] Other socioeconomic stressors that affect metropolitan Melbourne are also seen to affect regional and remote Australians including income stress, cost of living stress and unemployment.[8,12] This is impacted by the geographic challenges in Australia where patients are separated into small population hubs dispersed by large distances.[13] From a healthcare perspective, these issues impact the willingness of patients to present for primary healthcare.[9] Once accessing primary services, the availability of infrastructure and staffing when referring for secondary-level or specialist services is lacking in many areas, including that of medical interventions.[14–16] In the experience of the authors, it is a common occurrence that patients are transferred from regional sites for low-complexity IR services that do not always need tertiary-level care, but just need access to an IR.

To date, there are few studies on the role of IR for regional and remote Australians, providing a major gap in evidence needed to provide adequate data-driven workforce planning. A 2023 study from Spittle *et al*. assessed the role of splenic artery embolisation for blunt abdominal trauma in the Northern Territory (NT). The authors showed that the absence of IR services in the NT led to 12.8 times increased odds of requiring laparotomy for splenic injury.[17] Other case reports show disparities in management of women's health issues in regional Australia where surgery, often hysterectomy, is the only available option for benign pathologies unless women are willing to travel to a metropolitan service to consult an IR.[18] This is supported by a recent publication from the Australian Commission on Safety and Quality in Healthcare, which showed that rates of hysterectomy were higher in regional areas than major cities, and that rates of hysterectomy in the Indigenous population were 9% higher than for other Australian women. The authors conclude that one contributor to this is a lack of access to services that provide a less-invasive option,[19] and this includes IRs who can offer uterine-sparing treatments such as embolisation.[1,6]

Some IR workforce data from other countries exist, including a recent study from Zealley *et al*. where the authors surveyed hospitals throughout the 14 geographical health networks in Scotland. They showed that only 10 of 14 networks offered IR services in-hours while only three of 14 offered IR services after hours.[20] The authors show that many patients have no access to minimally-invasive services, requiring a healthcare redesign to meet regional and remote patient needs. Similarly, a 2023 study in the United States surveyed hospitals to identify if IR services were available.[2] When adjusting for hospital size, tertiary hospitals with >500 beds were 15-times more likely to offer IR services than smaller hospitals with <100 beds, and remote hospitals had 50% reduced odds of having IR programs.[2]

In addition to lacking data on regional and remote IR services, there is also a lack of data concerning IR activity within Aboriginal and Torres Strait Islander (Indigenous) populations in these locations, despite a general increase in literature concerning Indigenous health in recent years.[21] According to the 2016 census, 63% of Indigenous Australians live in a regional or remote location.[21] When measuring disability-adjusted life years (DALYs), Indigenous Australians have a higher burden of many diseases, with the highest cardiovascular diseases, diabetes, mental health and chronic lung disease.[22] There are several important treatments that IRs can offer that may be of benefit to Indigenous healthcare needs. Strategies have attempted to improve health outcomes for Indigenous patients[23]; however, the role of IR services for Indigenous patients is still yet to be quantified and thus there is a lack of data to support evidence-based healthcare planning and interventions for this important population.

This study aimed to assess the type and volume of advanced IR treatments performed on patients who reside in a regional or remote setting, as well as for Indigenous patients as a subpopulation. This will provide data on which to model a future IR workforce needed in these locations, and discuss governance changes to support such changes.

Methods

Ethics

This single-centre cross-sectional study was approved by the Alfred Human Research and Ethics Committee (approval number 172/24) and was conducted according to the STROBE checklist.

Location and infrastructure

The Alfred is a tertiary referral centre in Melbourne, Australia and located on the traditional land of the Boon Wurrung people. The hospital has a catchment for inner south/south-east Victoria, but also offers several

statewide services including major trauma, adult burns, heart and lung transplantation, HIV, malignant haematology, cystic fibrosis, bariatric medicine and extracorporeal membrane oxygenation (ECMO) services. The Alfred IR infrastructure is typical of many major metropolitan hospitals around Australia and includes a 24-hour 7-day program with a team of trained and certified IRs, radiographers and nurses. There are three interventional suites where advanced IR treatments are performed. Basic image-guided procedures are also performed using a nearby fluoroscopy suite, as well as procedural rooms with an ultrasound and/or CT. Basic image-guided interventions were defined according to the RANZCR Standards of Practice for Clinical Radiology version 11.2,[24] for example image-guided corticosteroid injection, biopsy and drain insertion. However, these basic procedures were predominantly performed by Procedural Radiologists (Diagnostic Radiologists who are trained to perform simple image-guided procedures) or radiology trainees under supervision.

Data collection and inclusion criteria

Patients were identified for the study through a query of The Alfred Hospital Electronic Medical Record (EMR) and Radiology Information System. Data were included when a treatment was performed by an IR between the 2-year period of 1 January 2022 and 1 January 2024. Data collected included baseline demographics, place of residence, Indigenous status, as well as the type, acuity and complexity of the intervention performed. As mentioned above, this study was limited to advanced IR procedures – basic procedures performed by procedural radiologists as well as Interventional Neuroradiology (INR) procedures were both not included. Clinical IR workflow duties such as ward rounds, multidisciplinary meetings, attendance at IR outpatient clinic or telehealth consultations were also not included in this study.

Exclusion criteria

Patients were excluded if they resided within an Australian Bureau of Statistics (ABS) defined metropolitan location,[25] or if the intervention was performed as part of a prospective clinical trial.

Definitions

- Specialist IR practice: this was defined by the RANZCR Standards of Practice for Interventional Radiology version 1.0 and includes all advanced IR procedures comprising 'the full range of image-guided interventions… that contribute to safe and effective clinical management of patients'.[26]
- Regional and remote home location: this was defined according to the ABS statistical geographic standard, by assessment of the patient's home postcode.[24] The study defined regional or remote as all patients within inner regional, outer regional, remote or very remote categories.[24]
- Indigenous status: this was recorded in the EMR when self-reported by the patient at the time of hospital admission.
- Type of procedures: all procedures were given a classification according to the general type of advanced intervention performed as shown in Table 1.
- Procedure acuity: all procedures were classified according to acuity as either outpatient, inpatient or emergency.
- Procedure complexity was defined as one of the following:
  - Day case, or elective overnight admissions where IR provided the primary clinical care.
  - Simple inpatient procedures, where care was provided by IR and no more than one other specialty unit during the patient's admission. These IR procedures did not require anaesthetics support or intensive care unit admission.
  - Complex inpatient procedures, where more than one IR consultant was required, patient required anaesthetic support for medical co-morbidities, required high-dependency or intensive care unit admission, or where two or more other specialty units provided clinic input during the patient's admission. This category was felt to represent patients who required metropolitan transfer and care for reasons beyond solely access to IR treatments.

Table 1. Classification of types of procedures performed by Interventional Radiologists

Procedure type	Example procedure
Venous access	Insertion of totally implantable venous ports, Hickman catheter or Permacath
Venous embolisation	Embolisation of ovarian vein or varicocele
Arterial embolisation	Embolisation of uterine artery (UAE) for fibroids, prostate artery embolisation, Transarterial chemoembolisation (TACE), aneurysm coiling, gastrointestinal bleed embolisation and embolisation post-trauma
Venous angiography	Including stent insertion and diagnostic venography
Peripheral arterial angiography	Aortic, mesenteric, peripheral vascular disease treatments and dialysis arteriovenous fistulography
Gastrointestinal or genitourinary	Nephrostomy insertion, ureteric stenting, gastrostomy and feeding tube change
Inferior vena cava (IVC) filter	Inferior vena cava (IVC) filter insertion and retrieval.
Thoracic interventions	Pulmonary angiography, pulmonary embolectomy and pulmonary angioplasty
Musculoskeletal and spine interventions	Vertebroplasty, genicular artery embolisation, pain interventions
Other advanced interventions	Interventions that do not fit into a general category as mentioned above

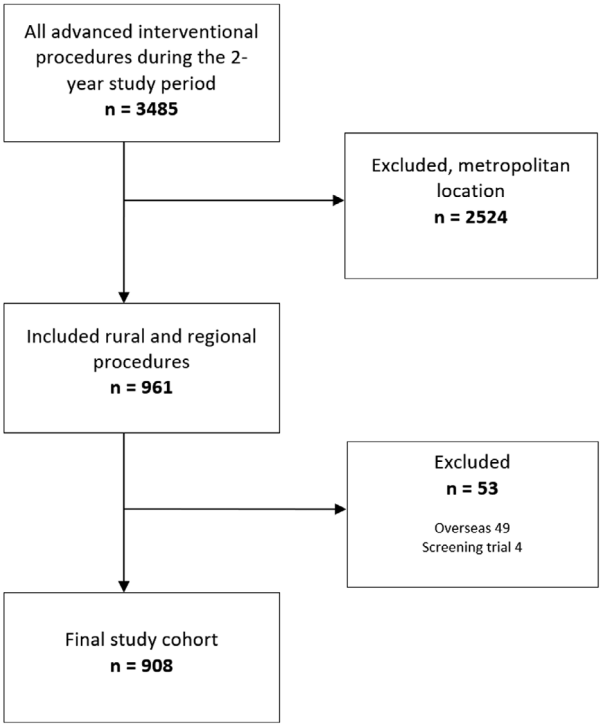

Fig. 1. Flow chart showing patient recruitment into the study.

- Future regional cohort: this term was given to a subset of regional or remote patients who had either a day procedure, overnight elective admission or simple procedure as an inpatient. This was felt to represent a subpopulation that may not need metropolitan transfer in the future if IR services could be provided in a regional setting.

Results

During the study period, 3485 advanced IR interventions were performed. After applying exclusion criteria, 908 interventions on patients from regional or remote locations were included in the analysis (Fig. 1). This included 331 procedures on females (36.5%) with mean age 55.6 years (standard deviation 17.9). Thirteen patients (1.4%) identified as Indigenous. Further summary statistics are shown in Table 2.

The majority of procedures (770, 84.8%) were on Victorian patients; however, some patients were transferred to our institution from remote or regional areas from other states/territories, including New South Wales (8.0%), South Australia (3.6%) and Tasmania (2.5%).

Figure 2 shows the distribution of procedure types performed at our centre. The majority were vascular access interventions (255, 28.1%) followed by arterial interventions (combined arterial embolisation and peripheral arterial 247, 27.2%), and IVC filter interventions (190, 20.9%). As shown in Table 2, most interventions were on inpatients (661, 71.8%) and were of high complexity (558, 61.4%) showing the need for a tertiary centre and multidisciplinary care among patients transferred to metropolitan Melbourne.

Table 2. Summary statistics of the cohort

Parameter	Result
Total regional or rural procedures	908
State of origin (number, percentage)	Victoria: 770 (84.8%) New South Wales: 73 (8.0%) South Australia: 33 (3.6%) Tasmania: 23 (2.5%) Queensland: 5 (0.6%) Western Australia: 4 (0.4%)
Female sex (number, percentage)	331 (36.5%)
Age in years (mean, standard deviation)	55.6 (17.9)
Identifies as Indigenous (number, percentage)	13 (1.4%)
Types of procedures	Venous access: 255 (28.1%) Venous embolisation: 22 (2.4%) Arterial embolisation: 123 (13.5%) Venous stent or other endovascular: 12 (1.3%) Peripheral arterial: 124 (13.7%) Gastrointestinal and genitourinary: 114 (12.6%) IVC filter: 190 (20.9%) Thoracic intervention: 50 (5.5%) Musculoskeletal and spine: 4 (0.4%) Other: 14 (1.5%)
Procedure acuity (number, percentage)	Outpatient: 203 (22.4%) Inpatient: 661 (71.8%) Emergency: 44 (4.8%)
Procedure complexity	Day case or simple overnight: 189 (20.8%) Simple inpatient: 161 (17.7) Complex inpatient: 558 (61.4%)

Table 3 shows summary statistics of the future regional cohort and this included 1.1% Indigenous patients. Figure 3 shows the frequency of interventions, with comparison between the whole cohort and the future regional cohort. This shows that the highest frequency interventions were venous access procedures (112, 32.0%) followed by arterial interventions (combined arterial embolisation and peripheral arterial 95, 27.1%), and IVC filter interventions (56, 16.0%).

Discussion

This study shows there is potential for a large IR workforce need to provide healthcare to Australians living in regional and remote locations. Many patients in this study were transferred to metropolitan Melbourne but underwent a low complexity intervention or day procedure, and this group has been termed a 'future regional cohort' as these interventions could be performed in a

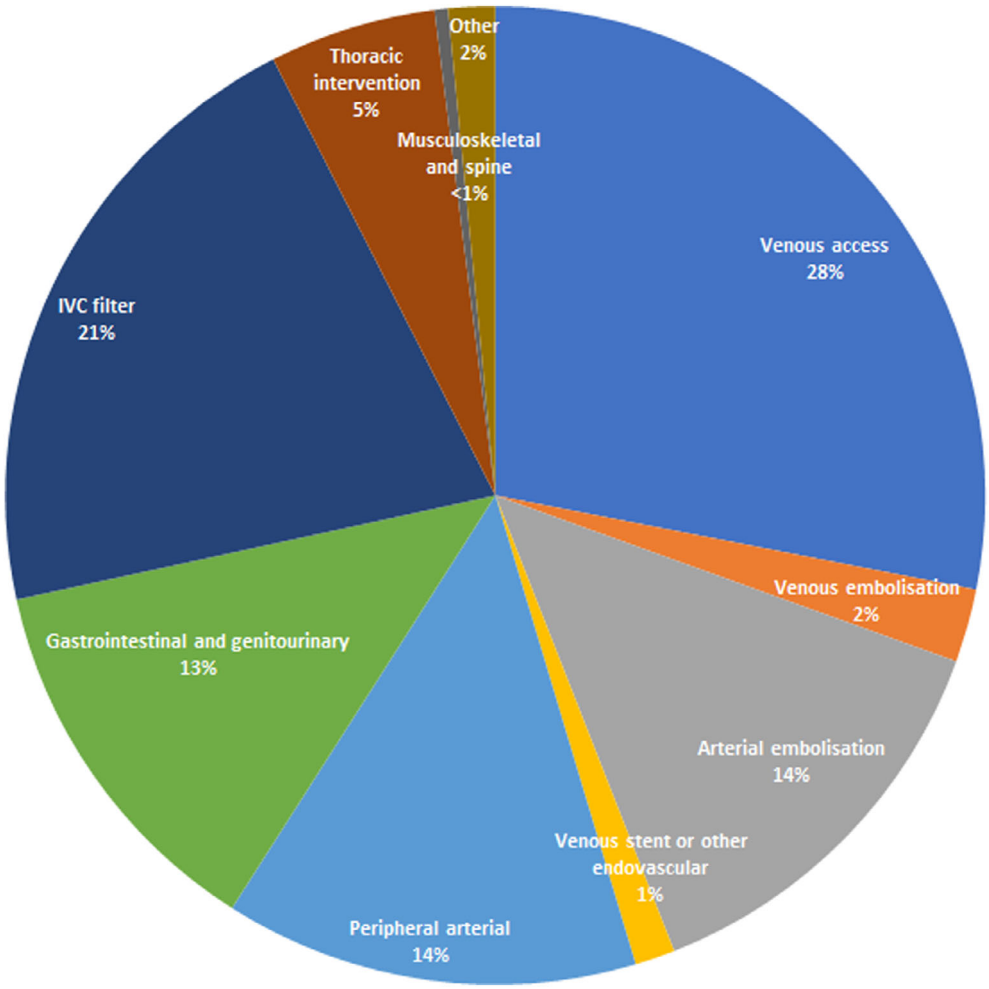

Fig. 2. Pie chart showing the types of Interventional Radiology procedures performed on regional and remote patients during the study period.

regional centre with appropriate support services in the future. In context, these transfers were for only one of seven major metropolitan hospitals in our state, indicating a likelihood of similar results for other hospitals with a different regional catchment. The future regional cohort highlights the potential unmet need for IR healthcare services in regional Australia and could be addressed by a model where IR can be organised into regional hubs as proposed in Figure 4. This would model workforce in a similar manner to other procedural specialties and would further enhance both direct and indirect costs savings for the patient, while potentially reducing the likelihood of loss to follow-up. Shifting services back to smaller sites would also reduce pressure on metropolitan hospital IR waitlists where the opportunity cost of a bed is significant. Suitable procedures for regional IR hubs may include retrieval of implanted inferior vena cava filters, placement of totally implantable venous ports, low-complexity inpatient embolisations such as GI bleeding or splenic trauma, and outpatient low-complexity embolisation procedures such as uterine artery or varicocele embolisation.

A major barrier to this process remains the relative 'invisibility' of IR as a specialty, despite healthcare models already being modified to treat IR as a specialty. In most metropolitan hospitals, IR is treated as its own specialty unit with a dedicated roster including on-call services. In some hospitals, IR has even separated into a different department to diagnostic radiology. However, these changes are often developed from the bottom-up with individual healthcare services changing workflow to suit modern needs. Without a major regulatory change including top-down acknowledgement of IR as a specialty, smaller hospitals are likely to remain in a position where the need to offer these services is not recognised because the regional centre is not aware of the difference between IR and diagnostic radiology. In the United Kingdom, IR is recognised as a subspecialty, while in the United States IR is recognised as a specialty,[27] and this governance change is already propagating to other countries around the world.

Table 3. Summary of cohort of patients who were day case or simple complexity

Parameter	Result
Total procedures	350
Female sex (number, percentage)	149 (42.5%)
Age in years (mean, standard deviation)	56.2 (17.7)
Identifies as Indigenous (number, percentage)	4 (1.1%)
Types of procedures	Venous access: 112 (32.0%) Venous embolisation: 14 (4.0%) Arterial embolisation: 33 (9.4%) Venous stent or other endovascular: 6 (1.7%) Peripheral arterial: 62 (17.7%) Gastrointestinal and genitourinary: 35 (10.0%) IVC filter: 56 (16.0%) Thoracic intervention: 25 (7.1%) Musculoskeletal and spine: 2 (0.6%) Other: 5 (1.4%)
Procedure acuity (number, percentage)	Outpatient: 174 (49.7%) Inpatient: 175 (50.0%) Emergency: 1 (0.3%)

The results of this study include an Indigenous population, and while the 1.4% incidence in our cohort is below that of the 3.8% rate throughout Australia, it is closer to the Indigenous population incidence in Victoria of 1.0% where our study was based.[28] Given the relative disparity of healthcare outcomes with Indigenous Australians, efforts to improve access to regional and remote IR services will also have a direct effect on the Indigenous population. In addition, many IR treatments have an impact on medical conditions which adversely affect Indigenous health, such as treatment of aortic and peripheral vascular disease, access for haemodialysis or peritoneal dialysis, and optimisation of arteriovenous dialysis fistula. While little literature currently exists concerning IR and the Indigenous population, considering and reporting the impact of IR on this group in studies moving forward will be an important prospective change for academic IR in this country, and a future IR regional workforce should partner with existing local Indigenous community health services.

In planning for a sustainable regional workforce, there are many additional factors to be considered. While

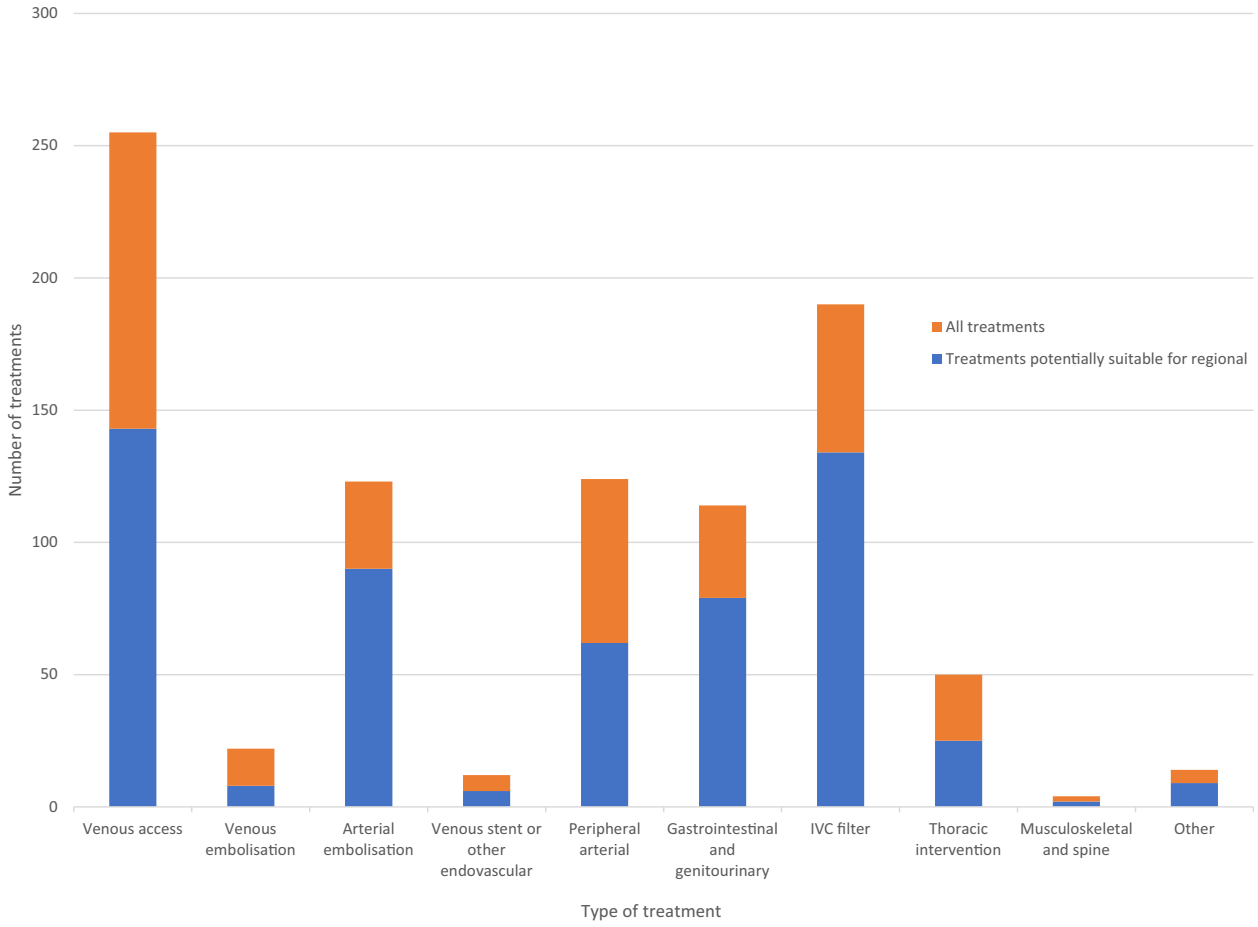

Fig. 3. Bar chart showing the types of treatments performed, comparing the entire cohort of regional/remote patients with a subset of low-complexity or day procedures which could be performed in a regional location of IR services were available.

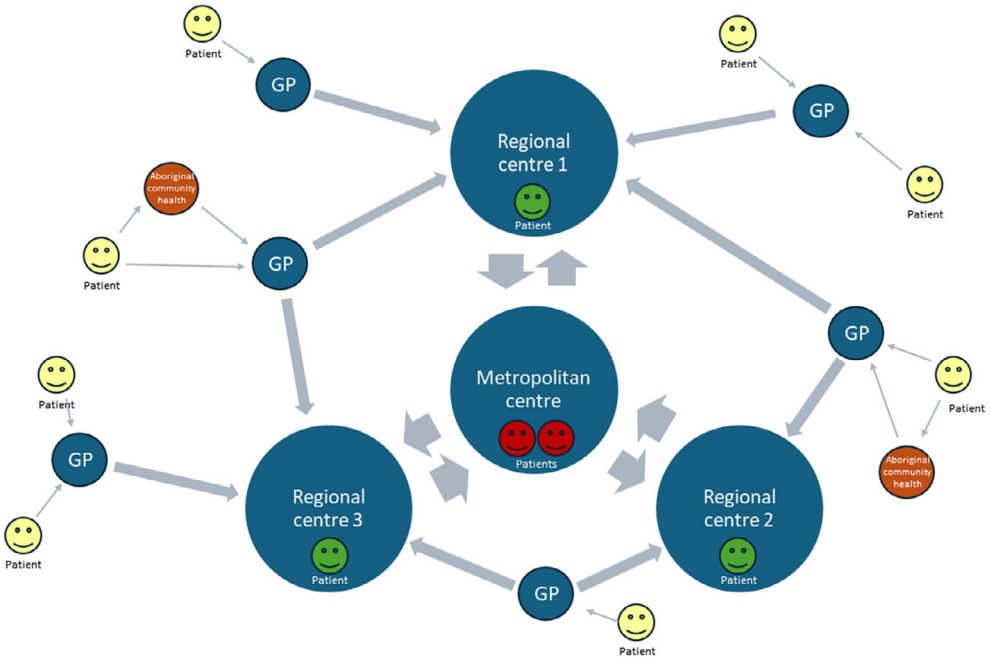

Fig. 4. Representation of a model where regional and remote patients access Interventional Radiology services through regional hubs.

specialty status will identify a hospital need, we need to continue to increase IR trainee numbers and consider strategies to encourage working in regional environments. This may include development of regional hubs where IRs can co-locate with other specialist services, financial incentives or the use of regional bonding incentives. Another important consideration is that of attrition, and this has been shown to be problematic for the United States regional IR workforce.[29] Having a sufficiently large workforce to allow rotation through an on-call program will also contribute to sustaining any workforce change. Given the reliance on technology in our specialty, providing and updating to the latest angiography equipment would help to encourage IRs to remain within these centres. This would be complemented by strengthening of the broader IR team including training and support for IR radiographers and IR nurses. Ancillary services such as IR outpatient clinics and efficient peri-operative day units would further support the sustainability of regional IR services, and it is likely that as these sites grow, so too will other specialist services in a positive-feedback loop.

As a study of a single-centre with unique tertiary services, the study acknowledges the difficulty of translatability of these results more broadly. In addition, the results are based on relatively unique definitions which are not universally applied in healthcare. It is also easy to overlook the multidisciplinary nature of modern healthcare, and many essential ancillary hospital services were not considered in this study. Conversely, the study also excluded basic image-guided procedures and while these are normally performed by procedural radiologists rather than IRs, positioning IR within a regional hub would still allow many basic interventions to be offered to regional patients by placing them under the remit of the IR team. As the volume of these basic interventions is large, this may further improve access to adjunct regional imaging services. The study is also an assessment of a public hospital and it is unknown how these results would translate into the private sector.

In conclusion, this study showed that there is a large unmet need for IR services in regional and remote Australia, with many patients being transferred to our metropolitan centre for treatment that could be performed in regional IR hubs in the future. This data will be important to drive government and hospital planning including capital infrastructure and workforce modelling. Top-down governance changes will be the biggest step to address this issue, and recognition of IR as a new specialty will provide the best system for regional and rural Australians to access modern health care.

Checklist

The authors confirm that the manuscript conforms to the STROBE checklist (see Appendix A).

Acknowledgement

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Data availability statement

Research data are not shared.

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Appendix A

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item no.	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State-specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders and effect modifiers. Give diagnostic criteria, if applicable
Data sources/measurement	8†	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding
		(b) Describe any methods used to examine subgroups and interactions
		(c) Explain how missing data were addressed
		(d) If applicable, describe analytical methods taking account of sampling strategy
		(e) Describe any sensitivity analyses
Results		
Participants	13†	(a) Report numbers of individuals at each stage of study—for example numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14†	(a) Give characteristics of study participants (e.g. demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
Outcome data	15†	Report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g. 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(b) Report category boundaries when continuous variables were categorised
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—for example analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results

Appendix A. (continued)

	Item no.	Recommendation
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based on

An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

†Give information separately for exposed and unexposed groups.

The authors confirm that the STROBE checklist has been adhered to for this manuscript.

Prof Warren Clements
14 June 2024