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Radiologists' perspectives about evidence-based medicine and their clinical practice: semi-structured interview study

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Abstract

Objectives: To describe radiologist's attitudes and perspectives on evidence-based medicine and their practice

Design: Face-to-face semi-structured interviews, thematic analysis

Setting: 24 institutions across six Australian states and New Zealand. Transcripts were imported into HyperRESEARCH software and thematically analysed.

Participants: 25 radiologists

Results: Six themes were identified: legitimising decisions (validated justification, prioritising patient preferences, reinforcing protocols), optimising outcomes (ensuring patient safety, maximising efficiency), availability of access (requiring immediacy, inadequacy of evidence, time constraints, proximity of peer networks, grasping information dispersion), overriding pragmatism (perceptibly applicability, preserving the art of medicine, technical demands), limited confidence (conceptual obscurity, reputation based trust, demands constant practice, suspicious and cynicism), and competing powers (hierarchical conflict, prevailing commercial interests).

Conclusions: Radiologists believe EBM can support clinical decision-making for optimal patient outcomes and service efficiency but feel limited in their capacities to assimilate and apply EBM in practice. Improving access to evidence, providing ongoing education and training supplemented with practical tools for appraising evidence; and developing evidence-based guidelines and protocols may enhance feasibility and promote the confidence and skills among radiologists in applying EBM in radiology practice for better patient care.

Article summary

Strengths and limitations of the study:

- Interviews were conducted until saturation and we recruited participants from a range of demographic characteristics, years of practice in radiology, and evidence-based medicine training.
- Participants were recruited from two countries and therefore transferability to other countries beyond Australia and New Zealand is uncertain.

Key messages:

- Radiologists believe EBM can support clinical decision-making for optimal patient outcomes and service efficiency.
- Capacities to assimilate and apply EBM were limited by barriers to accessing and appraising the evidence, perceived need for pragmatism and gaining practical experience, and contending with power hierarchies with referring physicians and commercial interests.
- Radiologists' perspectives on EBM are reflected in six major themes: legitimizing decisions, optimizing outcomes, availability of access, overriding pragmatism, limited confidence, and competing powers.

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Declaration of competing interests

The authors do not have any competing interests of conflicts of interest to declare.

Introduction

Evidence-based medicine (EBM) is the "integration of best research evidence with clinical expertise and patient values[1 2]" and is widely promoted as a tool to improve patient care. EBM was originally designed to address clinical problems within internal medicine, but has been generalised and expanded to enable applicability to other medical specialties. Recognised barriers to the optimal use of EBM in a variety of specialties include competing priorities and lack of time, inability to cope with "information explosion[3]", misconceptions about what constitutes quality evidence[4], lack of awareness of EBM resources[3], threat to professional autonomy[5 6], concerns about the trustworthiness of the data[5], fear of conflict with colleagues[7], and institutional dynamics and culture[8-10]. However, there is little information on how EBM is regarded and practised by radiologists and whether barriers to optimal use may differ.

For example, technological innovation in imaging and interventional technologies has intensified the demand on radiologists to assimilate the proliferation of new information to deliver safe and cost-effective care[11 12], and the promotion of new tests may occur prior to published evidence supporting widespread use. EBM use within radiology has not been examined, but a survey of radiation oncologists found widespread support for EBM, although most had not undertaken formal EBM training and were unaware of integral resources such as the Cochrane Library[3].

We aimed to describe radiologist's attitudes and perspectives on learning and applying EBM in practice, and in doing so, inform strategies for improving EBM training, and assist development of resources to facilitate greater use of EBM. This may help to foster appropriate decisions regarding imaging and interventional procedures for improved patient outcomes.

Methods

Participant selection and practice setting

Radiologists in Australia and New Zealand were purposively selected to capture a range of age, gender, years of clinical experience, radiology sub-specialties, EBM training, and practice locations. Invitations were emailed to radiologists enrolled in the critical skills appraisal program at The University of Sydney (July 2013) or were attending an Annual Scientific Meeting (October 2013). Radiologists known to the investigators were also invited and participants could nominate other radiologists who could offer a different perspective about EBM. Interviews were conducted in meeting rooms, clinic offices, conference venue. The University of Sydney provided ethics approval and all participants provided informed consent.

Data collection

The interview guide was based on a review of the literature [3-8 13 14] and discussion among the research team (Box 1). AT conducted a face-to-face semi-structured interview with each participant from July to November 2013. Participant recruitment ceased when theoretical saturation was reached i.e. when little or no new concepts were being raised in subsequent interviews. All interviews were audio-recorded and transcribed.

Analysis

The transcripts were entered into HyperRESEARCH software (ResearchWare, US Version 3.0, Randolph MA, United States) for coding qualitative data. Based on the principles of grounded theory (to develop a theory or explanation that is grounded in the data collected) [15] and thematic analysis, AT read the transcripts, conceptualised and coded all sections relating to radiologists' perspectives on EBM into concepts identified inductively in the data; and created new codes when necessary. These were reviewed by SM who also read the transcripts. This can help to ensure that ensure data were captured in the preliminary codes. Similar concepts were grouped into themes and subthemes. Patterns and conceptual links between themes were mapped into a thematic schema. Member checking was conducted whereby participants were sent a copy of the preliminary analysis and given two weeks to suggest additional opinions. These were integrated into the final thematic analysis. This ensures that the findings reflect and captures the full breadth of data from the participants.

Results

Twenty-five radiologists from 24 institutions across 6 Australian states and New Zealand participated. Non-participation (n=6) was due to travel and clinical commitments. The mean duration of interviews was 35 minutes. Participant characteristics are provided in Table 1.

We identified six major themes: legitimising decisions, optimising outcomes, availability of access, overriding pragmatism, limited confidence, and competing powers. Illustrative quotations for each theme are provided in Table 2/Supplementary File 1. A thematic schema illustrating the conceptual links among themes is shown in Figure 1. EBM was believed to support clinical decision-making for optimal patient outcomes and service efficiency, but radiologists' capacities to assimilate and apply

EBM were limited by barriers to accessing and appraising the evidence, perceived need for pragmatism and gaining practical experience, and contending with power hierarchies with referring physicians and commercial interests. A description of the themes and subthemes are provided in the following section.

Legitimising decisions

Validated justification

EBM provided a framework to make clinical decisions based on science, rather than anecdotal data. EBM "added weight, added experience and evidence behind decisions". And Some participants felt reassured when research "validated their own experiences", and EBM was regarded as an opportunity "to borrow information and techniques from other people who have been using them more."

Prioritising patient preferences

Shared-decision making was regarded as important though some felt that patient preferences contradicted EBM. For example, they felt unable to deny patients who wanted treatment even when the evidence suggested it would not be cost-effective or beneficial.

Reinforcing protocols

EBM was regarded as useful for developing evidence-based protocols and guidelines. This was particularly relevant in directing decisional pathways for inexperienced referrers. Protocols were seen to protect radiologist's decisions as "you get in trouble for missing something, you don't get in trouble for over-investigating something."

Optimising outcomes

Ensuring patient safety

Some were convinced that EBM had demonstrable impact on ensuring safe patient care. There was reference to studies assessing safe dosages of gadolinium in patients with renal impairment, reducing the incidence of nephrogenic systemic fibrosis. Participants remarked on the "increasing number of normal examinations which meant they were scanning more people, and that they were not selecting them correctly." They felt a burden of responsibility – "we definitely do cause the public harm, we just don't know how many [malignancies] is due to us yet" and believed that applying EBM could reduce over-exposing patients to unnecessary ionizing radiation and risk of malignancies.

Maximising efficiency

Participants felt certain that the financial costs to public hospitals incurred by performing excessive radiologic tests and procedures could be minimised by applying EBM. Some suggested that evidence-based referral guidelines may reduce the number of unnecessary tests ordered by referrers and improve economic and service efficiency.

Availability of access

Requiring immediacy

Simple and direct access to information was important. Most used Google or PubMed as their primary search engine. Some relied on email updates or review articles to keep up-to-date. Evidence summaries offered information that "had already been critically appraised, filtered out so most of the rubbish wasn't there." Being unable to access journals due to institutional restrictions "added an extra element of difficulty" however, some participants who had received EBM training felt confident about searching for high-quality scientific research using MEDLINE and the Cochrane Library.

Inadequacy of evidence

Radiological technologies often "progressed before the evidence could come out." Some observed that diagnostic procedures (for example, CT angiograms for vertebral artery dissection) were used without supporting evidence. In radiological research, some felt that relevant outcomes could not be feasibly measured, for example if it necessitated surgical or autopsy proof;. Research was unavailable particularly for rare clinical cases.. They felt that, "there's no culture of [radiology] research except in little pockets and enclaves in different institutions few and far between."

Time constraints

The "fast-growing field" of radiology meant participants felt without capacity to be "a true academic," engage in research, and "to go through everything we do and find the evidence to prove that that's the best method or way of doing something." Instead of an appointment-based patient caseload,

radiologists had to manage a continuous inflow of patients, which was more difficult to keep manageable particularly if working in a smaller radiology department, or in the private sector. Some reviewed the literature only when required to, for example when preparing for presentations.

Proximity of peer networks

Participants relied on their colleagues to discuss and resolve cases. In larger radiology departments, participants could readily contact experienced colleagues for advice. One participant stated, "my approach to medicine is a very practical approach and based on my experience and the knowledge of others, my skill set is complementary to others so I use their skills." Interventional radiologists valued practical suggestions from colleagues about proceduresand participants attended conferences to learn about new procedures and protocols, then turned to "selected articles on the nuts and bolts, assuming that somebody has looked at the utility of the procedure."

Grasping information dispersion

The field of radiology was described as broad, "dynamic," and all-encompassing of different sub-specialties which augmented the challenge of keeping up with the literature – "radiologists in most places are generalists, you have to be able to do neurology, gastroenterology, intervention, it's not actually possible to be at the top level of science in all those fields." They felt "confounded by the plethora of information that you can't filter anymore." Radiologists practising within a narrow sub-specialty felt better able to remain aware of the current literature in their area.

Overriding pragmatism

Perceptible applicability

From a practical perspective, some judged the clinical relevance of a research article rather than the methodology. One participant reflected, "I'm not an academic, I'm much more practical, I'm more operational." They would "look at what they do and the outcomes measures more than analysing the way they get the outcomes." Research results that were too broad or excluded relevant patient groups made it difficult to extrapolate or assess the transferability of the findings to their own patient population or to an individual patient – " like meta-analysis, you have to spend more energy on trying to pick out tiny fragments of useful data, so most of the time the article was justifying itself and talking about itself, I just want to get to the crux of the matter."

Preserving the art of medicine

There was anxiety that "if everything gets based on evidence based medicine, we lose the art of radiology." Participants with more years of experience believed in learning from practice, observing senior colleagues, and developing expert intuition, more so than "reading about things" as EBM could "never capture the whole story."

Technical demands

The technological advances in radiology placed demands on participants to prioritise their technical competence and knowledge of anatomy and pathology. They had to "keep on learning new tricks, as well as refine what they knew before" and studied textbooks and "didactic" articles rather than

scientific research publications – "What does such a condition look like on ultrasound? You don't need a research article."

Limited confidence

Conceptual obscurity

The perceived complexity of concepts, mainly relating to critical appraisal and statistical analysis, was overwhelming. Many described their judgment about study validity as "superficial" and felt they lacked a framework for critically appraising an article – "we all aspire to practice EBM but we don't necessarily know how to and I think there's a lot of quasi EBM going on." Some assessed articles based on sample size, participant characteristics, and blinding. Also, some believed a high-level understanding of statistics was required for EBM, perceived to be daunting, "we've come out of it with this monster that most of the radiologists don't know how to cope with, most of us left statistics behind in high school, we don't have this analysis in our brains."

Reputation-based trust

Participants trusted journals with high impact factors, and articles from reputable institutions with experienced authors. They placed confidence in editorial integrity and expertise to ensure that only high-quality and valid research articles were published.

Demands constant practice

EBM was a skill that required ongoing practice. Participants suggested regular EBM training, and journal clubs to maintain EBM proficiencies, such as conducting critical appraisal.

Suspicion and cynicism

Some were suspicious of authors who might be misusing research to push their own agenda, "People usually decide what they want the reality to be and then harness the appropriate evidence that they want to support it." For example, in cardiac imaging, one participant observed nuclear physicians advocating for nuclear medicine while cardiologists were promoting stress echocardiogram, and both presented compelling arguments supported by research. Contradictory results also perpetuated cynicism of EBM, "I've seen a few cases where different meta-analyses will draw completely different conclusions from the same set of data analysing the same papers." Some were wary of academic competition, and the "politics of journals, and personal egos." However, multiple independent studies which demonstrated confirmatory findings, provided reassurance.

Competing powers

Hierarchical conflict

Disempowerment prevented the practice of EBM. Some radiologists felt that referring physicians perceived them as service providers rather than as consultants. They viewed that "referrers don't feel that radiology should be gate keepers." Being "secondary referrals" most radiologists did not control patient management and lacked clinical information about the patient. Some resigned themselves to

"defeat" and "dogmatism" as they continued to perform tests they regarded as unnecessary. At times, there was a palpable tension between keeping referrers satisfied and advocating for the patient's safety and preventing them from being "irradiated just for expediency rather than a clinical indication". Some tried to "battle" with referrers but withdrew from the "uneven playing field". More senior participants felt that referrers respected their recommendations.

In certain radiology sub-specialties including pediatrics, oncology, and obstetrics, radiologists participated in multi-disciplinary meetings and valued the active engagement in patient management where their expert opinion contributed to the broader decision-making. Participants appreciated this "cross-pollination" of information and clinical history.

Prevailing commercial interests

Private radiology centres faced the pressure of "generating revenue to keep the practice going", which was perceived to nullify any impetus to implement EBM. Some believed that "evidence-based medicine will never work in an item for service based medical culture" and there was "no real incentives for doctors to do the right thing" in referring patients for radiological tests. To protect a thriving business, they kept referrers satisfied by fulfilling their radiologic requests, even when it was not evidence-based.

Discussion

Although radiologists appreciate the role of EBM in improving patient care, misperceptions of the definition of EBM, a lack of critical appraisal skills and an under appreciation of how EBM could help resolve common tensions within daily practice limited its optimal use. EBM is defined as the integration of best research evidence with clinical expertise and patient values however some participants thought that EBM supplanted clinical expertise and therefore rejected it as being exclusive of clinical wisdom. A common tension cited by many participants was the performance of unnecessary tests, contributing to excess cost and increased exposure to radiation, however many felt helpless to refuse the request. However, when evidence-based guidelines were available to support appropriate imaging pathways, radiologists felt more confident in negotiating referrals.

Some of the barriers to implementing EBM we identified have been reported in other areas of medicine and health. Studies conducted in internal medicine and surgery found that confusion about EBM terminology, team dynamics, staff disapproval, and time constraints prevented residents from practising EBM[7 8]. In primary care, EBM was perceived by some physicians as devaluing the "art" of medicine and a threat to their professional autonomy, and were concerned about industry influence[5]. Another study found that healthcare providers preferred tested, convenient and respected evidence sources including professional societies and expert colleagues[4]. There are unique features in radiological practice: the limitations of being perceived as a service provider rather than an "expert consultant", the demands of maintaining technical competence, the requirement for detailed but stable knowledge of anatomy and pathology, and the challenges of keeping up in a field of rapid technological advances.

While understanding and use of EBM is widely accepted as a core competency of clinical practice, this is the first study to explore understanding and barriers to use in radiology. We conducted interviews

until little or no new concepts were emerging from subsequent interviews (theoretical saturation), and included participants from a range of demographic characteristics, years of practice in radiology, and EBM training. Also, participants were asked to provide feedback on the preliminary findings (member checking). However, our study has potential limitations. Participants were recruited from Australia and New Zealand therefore the transferability of the findings to other regions may be limited, although similar barriers have been identified in studies conducted in different settings[16], suggesting broader applicability.

The acquisition and application of EBM skills including literature searching, critical appraisal of articles and interpretation of diagnostic tests and their limitations is essential to competent clinical care[12]. Several resources have been published in radiology literature[12 17]. However, barriers related to the availability and access to evidence, unmet education and training needs, pragmatic and structural difficulties that need to be addressed. Based on our findings, we suggest key target areas, strategies and actions for promoting EBM awareness and implementation (Table 3).

Moving EBM teaching from the classroom to clinical practice settings has been strongly advocated to improve knowledge, critical appraisal skills, attitudes and behavior[18]. The few strategies to clinically integrate EBM teaching which have been evaluated include daily EBM teaching rounds in which searches and study appraisals are based on cases presented at clinical rounds[19], journal clubs[20], and EBM ward round sessions led by a clinical specialist and epidemiologist to develop clinical questions, literature search, critical appraisal and development of evidence summaries[21]. While these teaching methods are effective, more specific evaluation of these strategies is needed in radiology.

It has been recognised that evidence-based practice should be taught from an early stage in medical and radiologic education[22 23]. Current models for educating evidence-based practice include having trained

epidemiologists to deliver regular teaching and interactive sessions which encompass theory, self-directed learning, and application to clinically relevant questions; or providing training workshops or teaching EBM in postgraduate meetings which cover the principles of EBM[22]. Our study has highlighted important implications for teaching EBM within radiology. Skills that require greater emphasis included literature searching and critical appraisal. A recent survey found that radiologists and trainees preferred Google, customised radiology-focussed produces and apps, and online resources to solve imaging questions[16]. Evidence summaries or EBM guidelines could be developed and disseminated via these channels. Confidence in appraisal skills could be improved with wider use of EBM tools[24]. For most EBM skills, a mix of educational strategies is likely to be most effective in increasing skills including interactive online courses, journal clubs and seminars[25].

While our findings are likely to have some commonality across geographic regions, further studies on barriers to EBM in different areas would be enlightening. Teaching strategies that are most helpful to radiologists should be clarified, as these may not be the same as those for bedside practitioners. Studies of implementation of evidence-based guidelines for imaging pathways and whether these improve patient important outcomes and cost are also needed.

Better access to evidence, ongoing education and training supplemented with practical tools for appraising evidence; and developing evidence-based guidelines and protocols may promote optimal use of EBM within radiology, and ultimately translate to better patient care.

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Contributions

AT participated in the design of the study, did the interviews, transcribed the interviews, carried out the thematic analysis and drafted the manuscript. SM, JCC, CL designed the study, participated in the thematic analysis, and provided critical review of manuscript drafts. GL, AJP participated in the design of the study, assisted with the analysis, and provided intellectural input into subsequent manuscript drafts. All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; drafting the article or revising it critically for important intellectual content; and provided final approval of the version to be published. All authors had full access to all of the data in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

Ethics approval

All participant provided writte and voluntary informed consent. The study was approved by the University of Sydney Ethics Committee (20130616).

Data sharing

No additional data are available.

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Box 1. Interview guide

1. Role as a radiologist/radiology trainee
    a. What is your current position and how many years have you been working in that role or what year of training?
    b. Working as a radiologist/trainee, what are the some of the most difficult, common, or complex issues/decisions you have faced and how do you deal with them (e.g. when interpreting images)?
2. Knowledge about evidence-based medicine (EBM)
    a. How would you define evidence-based medicine or what is the first thing that comes to mind when thinking about EBM?
    b. How you rate your knowledge or understanding about EBM from 0 (lowest) to 10 (highest – most knowledgeable) – why?
    c. What educational sources do you use to inform your practice? What resources or how do you go about interpreting diagnostic tests? (STATdx, Up to date, guidelines and protocols, experience and intuition, other colleagues' opinions, decision aids or online resources such as calculators)
    d. Can you comment on the level of trust you have in these resources – what makes you trust it more/less? (journal reputation, authors, sample size)
    e. What aspect of EBM do you find most challenging or difficult – why? (asking answerable questions, searching, appraising, analysis or synthesis, interpreting the data, applicability to individual patients or applying EBM in your day to day practice)
    f. What EBM concepts of terms do you feel you understand the least/most?
3. Evidence-based medicine training
    a. What was the most/least interesting or valuable thing you learnt in EBM – why?
    b. How you rate the importance of EBM training to your - clinical practice from 0 (least) to 10 (most important) – why?
    c. How would you improve EBM teaching i.e. what teaching methods do you believe would be most effective in helping radiologists apply EBM in their practice – why? (journal club, study appraisal)
4. Applying EBM in practice
    a. Can you describe the role EBM has in your overall clinical decision making? Have you applied EBM in practice – how/give an example?
    b. Do you believe there are benefits in applying EBM in radiology practice - why? (service efficiency, costs, patient care, develop guidelines)
    c. What are the challenges or barriers in applying EBM in day-to-day practice? (service provision vs. consultative, not sure where to find resources to guide its use (access), unsure of the validity of a checklist compared with clinical reasoning, competing priorities, concern about the trustworthiness of the evidence, threat to clinical autonomy, financial interests, potential to cause conflict, contradictory data, information overload)
    d. What can you suggest would facilitate the application of EBM into day to day practice? (Evidence summaries, technology and tools)
    e. Do you think EBM is more relevant for the clinical aspects of radiology such as interventional radiology rather than diagnosis - why?
    f. Compared with other medical specialties, do you think radiology lags behind, is equal or, or is more advanced in terms of EBM knowledge and application – why? (research culture, limited research evidence)
    g. Does learning about EBM make you more or less likely to undertake research to answer clinical issues you have encountered - why?

Figure Legends

Figure 1. Thematic Schema

Table 1. Participant characteristics

Participant characteristics (n=25)	No. of participants	%
Sex		
Men	20	80
Women	5	20
Age (years)		
30-39	3	12
40-49	11	44
50-59	5	20
60-69	6	24
Years of practice in radiology		
≤10	5	20
11-20	10	40
21-30	6	24
>30	4	16
Training in evidence-based medicine		
Yes*	12	48
No	13	52
Radiology subspecialty*		
Breast imaging	3	12
Cardiovascular	8	32
Chest	7	28
Emergency	9	36
Gastrointestinal	8	32
General radiology**	4	16
Genitourinary	8	32
Head and Neck	6	24
Interventional	11	44
Musculoskeletal	13	52
Neuroradiology	9	36
Nuclear radiology	3	12
Obstetrics and gynecology	1	4
Paediatric radiology	5	20
Vascular	1	4
Type of practice		
Public	23	92
Private	2	8

*Includes short courses, formal evidence-based medicine training during medical school; **Multiple subspecialties can be indicated by a participant; ***as identified by the participant and includes most subspecialties.

Table 2. Illustrative quotations

Theme	Illustrative quotations*
	Legitimising decisions
Validated justification	I suppose the antithesis would be anecdotal medicine, so you're getting away from what you perceive, or what you think is the correct way to behave, what you had thought before. What you're trying to do is be critical about what you do and see if there's scientific basis to support the way you practise medicine. (ID08) The most valuable is that if you can confront a clinician and say that a certain practice is the right practice. To do a certain test in a certain scenario, if you have evidence that shows that that's the best practice then it's easier to stand your ground and then say we shouldn't be doing this and we should be doing it the other way because there is research that suggests that's the best practice. If you don't have that sort of research it's very hard to back up your opinion. (ID05) So it's nice when research validates your own experiences. (ID17)
Prioritising patient preferences	How can I deny a patient treatment? That's the problem with it. Even if the evidence-based medicine says you shouldn't treat this patient. For example you are a patient, I can't say, this evidence says you shouldn't be treated but the patient still wants it, what do you do? That's the ethical dilemma. (ID15)
Reinforcing protocols	We have in the department guidelines to help people to request certain radiology procedures on the basis of what was published. This is the evidence that you should go down this pathway and don't ask for anything more. (ID21)
	Optimising outcomes
Ensuring patient safety	We would decrease the amount of ionisation radiation as we give to the public, which hopefully then would decrease the number of malignancies that we cause. We definitely do cause them, given on a population level, we just don't know how many is due to us, yet. (ID04) Perhaps one area where evidence-based medicine has had a benefit in paediatrics is the reduction in imaging for vesicoureteral reflux. There's been no improvement or change in the incidence of chronic renal disease in children as a consequence of treatment of urinary tract infection or treatment of reflux. So that has totally changed the management. Seven or eight years ago I was doing MCUs on children up to five years old and there were probably five or 10 on a list. Now it's down to less than one because of evidence-based medicine showing that the treatment doesn't - the investigation and treatment doesn't change outcome. (ID13) So the literature that appeared over that period of time has really changed the way that I think about using gadolinium in renal impairment. I'm not as scared to use it anymore providing I stick to guidelines with regard to the estimated GFR. (ID25)
Maximising efficiency	Service efficiency, there is a safety aspect in that they don't have to undergo other tests as well, more invasive tests, and economic from the point of view that they're not taking up further resources in the hospital which could be used for other people. (ID01)
	Availability of access
Requiring immediacy	If I really need an article that is not available I get the library to get it for me, but that adds an extra element of difficulty, so I tend to just ignore the ones - not ignore, but I tend to find a free access version if I can, not of the same study but as best I can. (ID04) MEDLINE - unfortunately a lot of the time you can't get in journals what you want and a lot of the time they only give you the abstracts there, so that's where the Google comes into it, because HighWire provides a lot of free journals there. You can actually go to the full journal rather than just the abstract. I guess I can always go to the university library and find out but it takes a long while to get in there. (ID24)
Inadequacy of evidence	The technology's there and you're playing catch up really. It jumps ahead, the lag is apparent. (ID07) Often the outcomes aren't measurable. So you may see certain findings but you'll never find out because that patient doesn't have the joint opened up or - so the outcome that you're measuring or the gold standard, there may not be a gold standard in a lot of the studies – where you have surgical proof or autopsy proof. (ID25)
Time constraints	It's a lot of time so sometimes it's obviously easier just to say it needs follow-up or repeat imaging rather than taking time out to consult a study. (ID13) I guess you can't be really a true academic because the clinical service is so demanding. You just don't get time to do it. (ID24)
Proximity of peer networks	Colleagues' opinions, because I'm doing some interventional stuff, and often, the interventional has much less research. If you get into trouble, try this, and, have you thought about doing this, and, here's another approach. They are not the stuff that gets written up. It's more just because it's a "doing" rather than a "thinking about" bit. So, for those things, talking to colleagues is much more important. (ID11) I haven't had any formal training in EBM. I don't actively practise EBM, I don't visit the Cochrane Institute. I'm aware of it but I don't actually regularly view it to see what's out there. My approach to medicine is a very practical approach and based on my experience and the knowledge of others. My skill set is complementary to others, so I

	use their skills. I'm not the sort of person who remembers detailed differential diagnoses or percentages but I know that that's not a good finding or a good finding or it requires this person to review and share their knowledge. We each have different skill sets. That's how I see my role.(ID13)
Grasping information dispersion	Because radiologists in most places are generalists, so you have to be able to do neuro, you have to be able to do gastro, you have to be able to do intervention, it's not actually possible to be at the top level of science in all those fields. (ID07) It's very hard to practice in a non-Google fashion in all of those fields. In some areas you'll be able to or if that's all you do you can, because you'd be up with the literature and you'll know about it otherwise you're kind of just going with a level of safety that's acceptable, but it's probably not the top end of care. (ID07)
Overriding pragmatism	
Perceptible applicability	[EBM] is completely foreign to my brain and I'm afraid that's why I haven't bothered to learn how to evaluate these things in a statistical analysis way…it's certainly not something I use for my day to day work. (ID14) I don't read journal articles to know about evidence based medicine per se, like meta-analyses I find less instantly useful. You have to spend a lot more energy on trying to pick out a tiny little fragment of useful data, so most of the time the article was justifying itself and talking about itself. I just sort of get to the crux of the matter, so yeah. (ID14) I look at their protocol in terms of what they do and then whether their outcome measures more than probably analysing the way they got the outcomes. (ID07) I'm not a boffin, I'm not an academic, I'm much more practical, and I'm not saying academics aren't practical…. I'm more operational. (ID23)
Preserving the art of medicine	They are probably more like spending time reading about things – learning from practice is more important than reading from it. You see a patient and if you make a mistake and know that you made a mistake you'll never do that again. But that is real medicine. That's real evidence-based medicine I tell you." (ID24) If everything gets based on evidence-based medicine we lost the art – this is my one piece of information you is that we lost the art of radiology...I don't think that is should be rigid. I think there needs to be room for the art of medicine. (ID14)
Technical demands	It's not looking for research articles, it's looking for information. As I said what does such and such a condition look like on ultrasound? You don't need a research article. (ID12) So I guess it's becoming more and more complex rather than just a film that you can read, but you have to go and find out how to do it and get the right sequences done and then on top of it you have to relearn your anatomy, because normally you don't see cartilage and soft tissues on other modality but the MR are coming on where you can see everything, so you have to know the tiny gritty bits there and capsules, the tendons and normally in old times you don't see it. So it's a fast-growing field that you have to keep on learning new tricks there, as well as refine what you knew before. (ID24)
Limited confidence	
Conceptual obscurity	I think we all aspire to practice it but we don't necessarily know how to and I think there's a lot of quasi - I'm not a victim and a perpetrator of it but there's a lot of quasi EBM going on. (ID07) if you asked me to list the different types of bias, I would have had great difficulty doing it. Just because I've never actually sat and thought through a framework. (ID03)
Reputation based trust	If it comes from a reputable journal within radiology… I would give more validity to or I tend to say oh well obviously if it's got through the editors it must be good. (ID08)
Demands constant practice	Certainly, going through critical assessment of particular papers, I think those sorts of exercises do develop our understanding and confidence in appraisal with more experience. I guess even in the department, having journal clubs and again, practising critical appraisal would help everyone in our department. (ID01)
Suspicion and cynicism	Lies, more lies, and statistics. You can make anything into anything when you know statistics. (ID 04) I've seen a few cases now where different meta-analyses will draw completely different conclusions from the same set of data analysing the same group of papers. (ID20) In my personal experience people usually decide what they want the reality to be and then harness the appropriate evidence that they want to support it, particularly in imaging. (ID20)
Competing powers	
Hierarchical conflict	We do not control the ultimate management of the patient because we are secondary referrals, so we are not the person that was in charge - that's the difficulty. (ID04) I mean there's a bit of a stigma in radiology, it's seen by some other specialties as being a bit of a service profession or service industry to the rest of medicine, in that we're just doing tests because the others decide that that test needs to be done that we do. (ID12)

	The doctors are covering their backside and being defensive; they're also being efficient. Right, you know it's quicker to get us to do a scan than it is to wait for the surgical registrar to get out of theatre and come and see the patient. And from their point of view it's probably also being of the patient's advocate in saying, I don't care if this only benefits one patient in a hundred; you do it for my patient. I'm just letting you know EBM to radiologists, it has that theme to it like it's all wonderful. But it's impossible for us to actually use. I shouldn't say impossible because that's an exaggeration, but it's difficult. (ID02)
Prevailing commercial interests	Radiology, cardiology, endoscopy, all the various other things where somebody gets paid for doing something, the temptation is to go and do it. You can always justify it to a certain extent. (ID18)

*Quotations identified only by ID to protect anonymity

Table 3. Suggested strategies for promoting evidence-based medicine in radiology

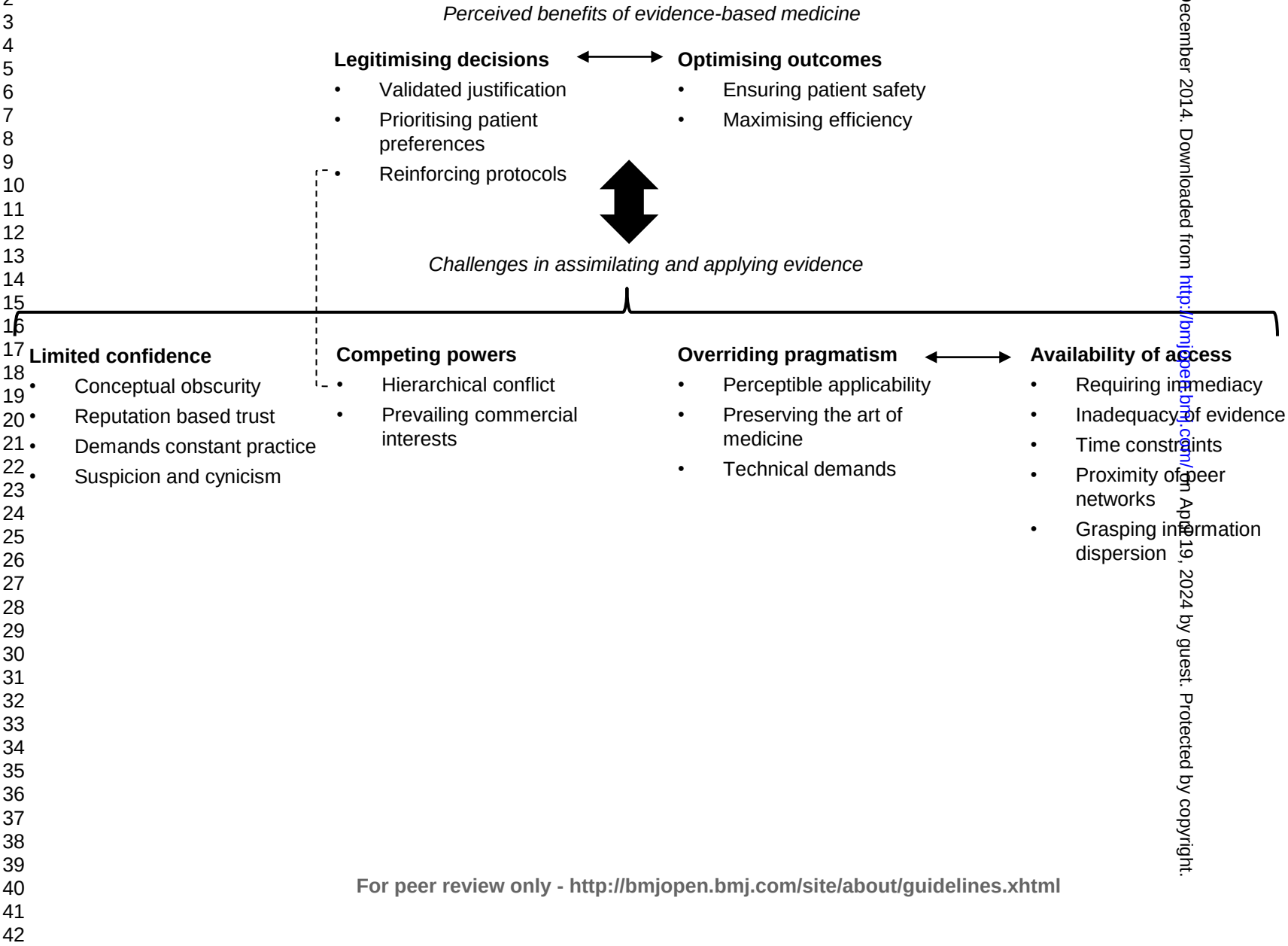
Key areas of improvement	Suggested strategies and action
Quality and quantity of evidence	• Fostering a research culture (e.g. clinician researcher interaction) • Link to academic institutions • Form multicentre research networks • Focus on the evidence base should be an integral part of multidisciplinary meetings
Access to evidence	• Mobile applications
Education and training	• Definition of EBM, emphasising the role of clinical expertise and patient preferences in EBM • Explain the pros and cons of Google and PubMed searches or other sources (STATdx) • Clarify the fundamentals of EBM being the evidence hierarchy • Demonstrate practice tips for using Cochrane to answer a clinical question • Provide a framework for critical appraisal • Setting EBM in context (not sacrificing clinical experience or the art of medicine) • Mandated training e.g. continuous medical education (CME) • Short courses in EBM (+ online support)
Applying EBM in practice	• Journal club meetings (include tools, feedback) – face to face or online • Ongoing training in using EBM, with assistance from experts such as clinical epidemiologists • Develop and disseminate evidence-based guidelines and protocols for referrers • Develop evidence summaries in clinical practice • Promote access to pre-appraised evidence based resources such as AJR guidelines
Empowerment	• Conduct audits of referral practices

CME, Continuous Medical Education, EBM, evidence-based medicine

List of Supplementary Files

Supplementary File 1. Additional quotations

Supplementary File 2. COREQ criteria



Supplementary File 1. Additional quotations

Theme	Illustrative quotaions
Legitimizing decisions	
Validated justification	That's an exciting way of doing medicine, rather than postulate what is going to be good for the patient or not. With this you've got a result to back you up that you're doing the right thing. (ID01)
	We're now looking at how the blood flows in the brain for all the sickle cell anaemia children. They are more prone for strokes there and the Americans experience more than us because they have more blacks than our population, so there are more sickle cell disease there and they publish their data there, then we have to use their techniques there and see whether - of course, we're getting more and more Africans coming to the country and in haematology one has to provide similar services there, then we have to borrow the information and techniques from other people who have been using them more than us. (ID07)
	I think we're sort of leaning the side that we think that there's enough evidence that it's reasonable to do in most patients, but then we have had some complications and so it's made us relook at that evidence. (ID07)
	It's a framework to make clinical decisions and actions which is supported by science effectively. It's a support for your day to day work based on what's known. (ID07)
	Everyone strives to best practice but we also are a bit defensive in terms of legalities of practice. So if you can have support from the academic - well the scientific knowledge base, if you're working on that principle obviously things go wrong but if your principles are based in that then you probably are on a more solid ground legally, but also in terms of giving adequate and safe patient care. (ID07)
	You would make a diagnosis or you would institute a certain type of treatment based on proper researched data, using control groups, so that you have data that really reflects what actually is happening rather than anecdotal data. A lot of the therapies like musculoskeletal injections that are done, a lot of that is anecdotal evidence. There's no good quality research where you have control groups that are given an injection of saline instead of cortisone. (ID25)
	That's what makes our profession stand out, is that we do by and large strive to have evidence-based practice. So rather than rely on anecdotal evidence like some of the allied - or some of these alternative medical practices do, we try and run proper scientific studies. I think that's one major thing that stands out. (ID25)
	I guess you're referring to the build-up of knowledge and nowadays that's usually in journals on the internet, so you're talking about the weight of knowledge up to the present that supports a particular viewpoint in decision-making. (ID14)
	EBM is forming clinical decisions, performing your job as a clinician basing your decisions on precedent. What's happened before us that has been proved or experience that has been gained and backed by evidence. If you have a case and you want to know a bit more about it you search the internet, you see that papers have been written that have been very well researched and have had really strong peer review and then those opinions are gold. They replace case based reports and anecdotes from people. So, it's kind of adding weight, adding experience and evidence behind your decisions. (ID17)
	I've tried to convince the clinicians that doing a CT scan before a lumbar puncture is not indicated, by giving them five or six very good articles on why it's useless and had no success. So that is a good example of how successful or unsuccessful we have been. I do a lot of intervention, I'm an interventional radiologist. A couple of interventions they have shown to be of benefit or of no benefit that I'm asked to do or not to do, and everyone still ignores it and does what they want anyway, even the clinicians. (ID04)
	Well I did this, because this is what our peers are suggesting should happen. If it went horribly wrong, I did my best. So there is protection for the practitioners by following the rules. (ID23)
	Especially cases with higher complication rate, the more evidence I want that I'm on the right track and I'm doing the right thing and that I'm not doing harm, other than also protecting myself against litigation of course. (ID21)
	[EBM is] a process whereby medicine is evolved based previous empirical data, and created a format for treatment and management and patients. So, there will be a question, then there'll be a patient population and then there will be either an intervention of some sort of understanding what to do with this patient - or what the problem is, and then working out what is most effective, and then finding out whether it actually is real or not real. (ID10)
	It's the processes and decisions are made - what we do has some sort of scientific basis to it. It's proven and not just assumed, just what people generally do, what's the habit. So I suppose it's that there is good evidence for what you're doing. (ID16)
	So because those researchers have done some evidence-based research work although it may not be the perfect, at least it's some evidence to direct me to yes or no to treat the patient. (ID15)
	Well it's using collective knowledge to actually ensure best practice rather than just using gut feeling or just a simple protocol, you're actually using the evidence of multi-institutional or multiple studies combined to give guidelines to that what is best practice or what works in the most number of patients. (ID13)

	Then if you have to change [the decision of referrers], you have to really - they have to undergo this evidence-based medicine to disprove them. (ID09)
	think after all you want results there, especially at this time where everyone wants to see whether they're justified or not. You can't do fancy things without anything backing it up. (ID24)
	It was a prospective paper where they changed a protocol and analysed the results after and before. It was of substantial size, there were enough to make it statistically significant, and it had enough power in it. I thought it was well designed. It was a simple paper that answered a simple question. I love research that does that, I don't like complexity. I've got one question, how do I answer it? There's the answer, move on. It came from a big centre, so there were a whole bunch of reasons why I liked it. I kind of liked it because it was agreeing with what I've always thought, but just hadn't been able to prove. So it's nice when research validates your own experiences. (ID17)
	EBM to me is current clinical practice that has been proven - I don't know whether proven is the right word - that that's the best practice or application for that particular problem in this point in time. Obviously that might change with new research coming out, but whatever is supposed to be best practice right now. (ID05)
Prioritizing patient preferences	But then you have a patient in front of you and how do you deny treatment? It's easy to deny when the patient is moribund, you can say you're not going to live for more than a few weeks, there's no point treating you and they accept it. But you can't tell the patient in front of you you're going to die in two years because you don't know. So how do you make a decision? (ID24)
	Shall we say for instance they come with an aneurism, so do you want to treat them or not because at that age their lifespan, they're crossing the - their expected lifespan has been crossed and do we want to treat them or not. There is no real clinical evidence such as we should treat them or not or we should - we don't know. So we treat them, but that's a money - usefully spent is a question that I always have to deal with in my work. Because each of the procedures costs $40,000 to $50,000. (ID15)
	The other difficulty I also face is a patient has a lot of vascular disease and therefore the foot is falling off it's very diseased. So whether you treat them or not - you are - true we spend a couple of about two hours three hours spent on them with a lot of catheters and vials and all that stuff you have to use. Then of course will the money, not as much as the other ones but it does cost a lot of money and your time which you can sometimes employ somewhere else. But we know by experience again not truly evidence-based but the evidence is still coming out they don't respond that well. So because in about six months and they lose their leg anyway. So my other question is, is a patient worth having their leg for six months before they go? (ID15)
	The patients do get a say. It is mainly patient dominated rather than doctor dominated so that's a bit difficult. Because even if you tell the patient it's going to recur but they always cling to the last rope like everybody does so that's difficult. (ID15)
Reinforcing protocols	What we need to do is to put some guidelines in place and then with regard to that we've looked for, we've done some research and looked in other guidelines and tried to bring in some direction for the departments which is obviously evidence-based. (ID08)
	Through my training, I've always questioned why we routinely give oral contrast. Some people do, some people don't, and I found that through my training I was using it less and less, because I didn't think it was as beneficial. The detriment is it takes about two hours for prep, for the patient to drink the contrast. So there's a two-hour delay before you can do the scan. So based on that paper, the paper basically said there was no need, and I changed our emergency protocol and I made it official through our whole department and I got emergency involved. They loved it because it meant that patients weren't waiting. So, I've used the paper to change a protocol and actually, a registrar and I are about to go through the statistics of 1000 cases; 500 before and 500 after the protocol changed to see if it did change turnaround times. (ID17)
	So, yeah, there has been - oh, another example, in subarachnoid haemorrhage, CT for subarachnoid haemorrhage in emergency patients. We found that we're being asked more and more to do CTA, CT angiography, after the initial non-contrast CT head was negative. There wasn't much support in the literature and we got a whole bunch of papers together and then I kind of coordinated a group led by a couple of neurosurgeons and a couple of emergency physicians, and I was the radiology representative. We formed a tri-departmental protocol that we use now in emergency so we're not over scanning patients. We haven't done any validation audits yet, but we plan to. But that was quite good because we were saving radiation for patients when there was no clear indication in the literature to support it. So those two are actually quite big, we should - amazing, I'd almost forgot about them. (ID17)
	I think it helps drive protocol. Protocol in a big department where you have lots of inexperienced people referring is quite important. A lot of people don't like protocol driven radiology because it means you don't really have to think, you just tick boxes and then if you meet a criteria, then you get a scan. But I think it's good to have protocols to fall back on. I think every case is an individual case and requires discussion. But forming protocols that allow junior doctors in the middle of the night to have a piece of paper to say, actually no, as a department we don't do that routinely, we do this. I think it offers good guidance for juniors… Oh, some people can treat them as gospel. You know if it's in the protocol and then doesn't require thinking and then you move on and I think you've got to - all protocols require some kind of individual thought, so that you're not so rigid in your thought processes. But that's probably more of a personality thing. We don't get that too much in radiology because radiology is a speciality of grey. We like to say, yes, that's that disease. But there's a whole bunch of processes and thoughts that we have where we can't absolutely rule something in, or rule something out. So there's a lot of grey in radiology. I'm not sure if you understand that as a non-radiologist. (ID17)
	For them now I'm trying to develop a guideline on anti-coagulation procedures for my department, so I need to go and find out all the evidence, what is the safe cut-offs

	for platelets clotting and take it from there. (ID4)
	One of the problems with using EBM in radiology is one of the ways it's often used is to make protocols. And to say, this set of patients you know should or shouldn't have this type of study because it's rarely of use. So say there are studies that show that quite a few people that turn up to ED departments with a head injury should not have a CT scan of their brain. Because if they don't have a period of unconsciousness or vomiting or whatever, then the chances of them having a significant brain injury are very low. And therefore it's not worth if you like, the expense and the very small risk of doing a CT scan. So they shouldn't have it. And that kind of work is obviously very laudable, but it's impossible to apply in real life. And the reason for that is it studies a population and it comes to a valid conclusion, but if an ED doctor comes round and says I want to do a scan on my patient, and you say well it doesn't fit the criteria for this to be very likely useful. He'd just say no but this is my patient, and this individual could have a significant head injury. And so they end up just fudging the thing and telling us that they've got more worrying features than they do. And we end up scanning them. And I'm pulling that example out, but with various things that happens all day every day. If EBM was strictly applied to the patients getting scans in our community, a lot less scans would be done. But as radiologists we're in absolutely no position to be gatekeepers of that because doctors to look after their patients, or even to look after themselves, will insist on the scan. (ID02)
	Having a written protocol is somewhat protective. Because one of the reasons people over-investigate is of course to cover their backside. And to not miss something. You know, you get in trouble for missing something, you don't get in trouble for over-investigating something. That's one of the factors in radiology. I mean, it makes us all very safe. (ID02)
	We regularly contact the referrers who ask for investigations on children that we don't think are necessary. So if they had a normal ultrasound, we say that we don't need to do the MCU. So we do contact patients on the basis of current practice. We don't just do it because it's been asked. We're in a public hospital, we have imaging protocols and we just know we don't need to do it unless there are special indications coming from a urologist for different reasons. So that has changed practice but that's over a period of time. That's probably the biggest one in our institution in terms of evidence-based medicine changing clinical practice. (ID13)
Optimizing outcomes	
Enduring patient safety	I think the only way we're going to improve our particular specialties that you have good quality evidence as to when to do a test, (ID01)
	What we're doing is, to the best of our ability then, making sure that the patient is getting the appropriate investigation - appropriate to diagnosis, based on what we know at the moment. Now, I think there's still a role for variation from the evidence base, and part of what we do is not just treating the patient, part of it is treating the referring doctor as well. So, we've got to sit there and think about what it is that will make them happy as well. But for areas where we think we're putting the patient particularly at risk - so, renal failure or children or pregnant women, with the radiation dose and things like that - I think that's much more of a time to be making sure that we're doing no harm and getting the diagnosis. (ID11)
	Because those researchers have done some evidence-based research work although it may not be the perfect, at least it's some evidence to direct me to yes or no to treat the patient. (ID15)
Maximizing efficiency	Well it's obviously clinical practice based on research and studies that have been performed and validated in literature, or obviously you can do your own research to help you implement the most effective and efficient clinical practice. (ID12)
	Let's say from a CT coronary angiography point of view, if you can rule out significant coronary artery disease on a CT angiogram then it means that they don't have to undergo other further more invasive tests like invasive coronary angiography. It also has economic benefits, not that we are applying it at the moment, but I think there is a trend now that we get a lot of chest pain, acute chest pain patients in emergency, a lot of them atypical. Often they need to be admitted and undergo a variety of tests and I think some institutions are doing CT coronary angiograms to help expedite discharge of these patients. So I guess they're economic benefits from that point of view; these patients aren't being admitted. If they've got no evidence of plaque at all on the coronary CTA they get discharged and then that saves hospital cost. (ID01)
	I think it's relevant to both aspects of radiology. Certainly in intervention it may be potentially easier to, I guess, extrapolate the benefits of certain endpoints, doing a particular test and whether they get different benefits out of it, but I think even in diagnostic radiology, those points that I outlined before, economics and safety, accurate diagnosis I think is still equally relevant to diagnostic radiology. (ID01)
Availability of access	
Requiring immediacy	I think Google is pretty good. I think you don't really need to go into details just searching for literature any more. I think they've really done a very good job. (ID24)
	More or less you can Google more of the information. Then, of course, if you're not satisfied with Google then you really have to go into journals and looking for special areas and talk to your peers and see how you can get more information about something I think. (ID24)
	I mean surely a lot of people practice Google-based medicine but I guess we're sitting in the front of a computer a lot of the time so you have direct access to it. (ID7)
	Well I'll Google and look for anatomical information, so for instance someone - just the other day, just as an example, there was a patient who had symptoms in the distribution of the saphenous nerve. So that's a small nerve that runs on the medial part of the thigh and it causes pain or numbness on the - just above the knee. Now

	that's a nerve that we don't - it's not a common nerve to image and it's not something that you retain in your mind as anatomical information. So when I read that on the request and was looking at the images, I Googled to get the anatomy of that nerve. I looked at the images that come up and cross-sectional images that came up with the nerve labelled so that I knew where to look on the MR images. (ID25)
	Generally I use Google. I find that that gives me the widest range of results. The other thing I do is I'll use PubMed. (ID25)
	There are a lot of papers out there but a lot of them are behind paywalls. My institution doesn't have access to all of them and I think this is pervasive to every other institution I've been with, there will always be some article somewhere that you can't get even though - you can't even see the abstract or parts of it, some of them don't have abstracts at all. So sometimes it's difficult. (ID04)
	It's a reference tool, like a mega online textbook where if you're scratching your head on a particular diagnosis or findings in a particular diagnosis using a different radiological modality, you just look it up and there it is in STATdx. So the internet and even Google, I mean you sit there at work and you just think oh, what's that such and such? I can't remember. You just Google it and usually you can find the information you want. (ID12)
	I don't read a lot of scientific articles I have to say, but it would be probably which journal it was published in. So obviously you go to the big journals, you go to *Radiology*. I use a lot of review type articles which are not the latest basic research, but like *RadioGraphics* which has got a lot of review articles again with the same sort of knowledge that you would get from STATdx, updates on particular imaging modalities or particular imaging of particular clinical problems. So just go to the major big name journals and I rarely have cause to go to the high level basic research that's been done. Some of it filters through in emails and from different - like I'm in the Breast Interest Group so they would send on articles from the latest research and different aspects of breast imaging and breast screening for example. So I see those but I have to say I haven't got time to go seeking them out most of the time. (ID12)
	And so the thing is day-to-day you need something very quick and fast, so you need to - you do rely on what's often said from the reputable journals. Although you make your own assessment about what you see. But a lot of it is actually appearances, it's not necessarily - for us in radiology - it's appearances, and then (ID10)
	I mean Medline, Cochrane all that - use those every now and then. I suppose a key on the weekend was that Google is just a broad - it doesn't tell you, doesn't analyse, doesn't put it in any order here, as these other websites seem to order things and make things more useful. That was the impression I got. NK (ID10)
	Actually, now I'm getting a bit lazy. Sometimes I used to use, after that course I was going onto Clinical Queries in PubMed, and searching there. I did search there a little bit, but now I must say I tend to just go to Google. There are some resources we have but often they have logins and stuff. Sometimes I go to, if I find in Google a journal article, I go back and look - because I can get access through the University of Melbourne to an awful lot of journals. I'll go and look up an original article for something. But often now I just Google it and see what comes up. (ID19)
	Or resources, like evidence summaries or something. Yeah. I mean I suppose the easiest thing would be if you could look up stuff that had already been critically appraised, it was already filtered out so that most of the rubbish wasn't there, that would be good. (ID06)
	Yes, Google is usually the most common. We also have - our department has access to STATdx, which is an online radiology resource. Our registrars all have access subscriptions to that so we all can access that. (ID01)
	In the hospitals I'll still use Medline or basically those searchers although I think most people, it's sad but true but probably the most commonly used medical research tool is Google. Things come up on it that at least lead you at other places, but yeah probably those two would be the ones you'd use the most or Google Scholar, just because also your access - the access to - funded access to medical journals is getting harder and harder now as well. As least if you work in a public hospital you'll get access to a decent amount, but I know they're trying to organise like say our access in private practice it costs an absolute fortune to get access to them and it's becoming harder and harder to get. Yeah it's part of the - one of the reasons a lot of us will keep an appointment in a public hospital. It's just you can actually use the online library even though strictly speaking it's all taxpayer funded so it should really be available to anyone who's servicing patients, but we won't get into that. (ID20)
	Reading the abstract and then I guess skimming over the more detailed sections and trying to make sense of it. (ID02)
	You do not have the time to read - I mean look at just something like radiographics. It's like a telephone directory comes out each month and you're not going to read that. You struggle to find the time - I mean we're getting busier and busier and busier. There's no - if there was some way to have condensed reviewed - peer reviewed articles and there's a basic little summary that came out once a month and you could read it and trust it, it would be great but I don't think we're going to get that. (ID 20)
	It would be very time consuming that you have to come up with a clinical problem to sit down and then to actually try and find the information quickly. (ID05)
Inadequacy of evidence	Things have progressed before the evidence can come out, often. (ID07)
	When we first starting doing CTA, which is when I was training for carotid dissection and vertebral dissection, we used to do a lot of angiography previously, but one of my consultants at the time said you know, we should do this study on vertebral artery dissection because no one's done it, and that's not that long ago - and I don't think anyone ever needed to do it. They didn't even really do it in the end, it should have been done and then we'll do it - but everyone just went ahead and started doing CTAs and that was the diagnostic tool, even though no one actually did the study. (ID07)
	There are a few. There are a few but not as much as in clinical medicine where you're looking at different types of treatment regimes. In radiology it's a little bit different

	because we're a diagnostic specialty. So we're not offering any specific treatments, we're making diagnoses so we're looking at pictures and different modalities. (ID25)
	Often the outcomes aren't measurable. So you may see certain findings but you'll never find out because that patient doesn't have the joint opened up or - so the outcome that you're measuring or the gold standard, there may not be a gold standard in a lot of the studies. Yeah, where you have surgical proof or autopsy proof. (ID25)
	These lesions are called incidentalomas, and everyone struggles with them. ARGANZ, which is the abdominal imaging group within the college have an annual meeting, and the last meeting was in Brisbane a few months ago, extensively on incidentalomas. So I thought, I'll go to this. I got about an hour lecture in the middle of this two and a half day conference, and I thought, well that wasn't very helpful. So there is no real evidence based, if you like - so if I do this, I'm going to capture 75% of the things which are going to really worry patients, I'll grab some more stuff which doesn't really worry them, but that's just collateral language if you were. So that's the hardest thing that I find at the moment. (ID23)
	There's no culture of research except in little pockets and enclaves in different institutions. There's always going to be individuals who are keen on it in any area of life, any profession really. There'll be people who are keen to do some research, not just in medicine. But in radiology I think they're fewer and further between so I think that's obviously what the college is trying to change slowly. I think I've seen it written that it's not going to happen overnight. (ID12)
	I think I'm reasonably efficient at reading, this is again mostly returning to high-level obstetric stuff, because that's what I would most commonly search, and that's all the weird and wonderful rare things. So, in practice actually, what I'm looking up more commonly would probably be studies which are not particularly robust, because the numbers are not great. And that's by virtue of the work that I do, I think, because it's all rare. (ID03)
	A lot of studies aren't evidence based, and there's a bias in the literature as well. There are many biases I suppose in the literature, but the main one is that the negative studies are much less likely to be reported than the positive studies. (ID22)
	Meta-analysis and systematic reviews are the evidence, and then we go into the PICO - looking at the Population Intervention Comparator and Outcome. But particularly, the population - make sure of the replies to population you've got at your hospital, because often the literature is a bit sketchy, and it talks about things that may be referring to either a very specialist hospital, or else unnecessary in the same population you've got. They exclude lots of patients, which don't necessarily go there. So, that's the thing - I mean, it's basically trying to work out, based on the research that's available, what the best thing to do is. (ID11)
	Obviously you can't have every disease in the evidence-based medicine guidelines because there just isn't enough data out there or it's changing so fast that you can't include old data with new data because the treatments often are different. (ID13)
Time constraints	We're really flat out. I think as far as we were doing the right thing, I don't think we have the luxury to sit down and go through medical school once more. You know, just to catch up with what you need to know is already exhausting I think. I think it's good to know, but I guess - there are so many things you need to know at the moment, I think, in our specialty there because it's such a fast-growing field. There are new things coming out all the time and I guess my time is running out too. I think I'm looking more like retirement in a few years' time rather than a punch at doing anything special. (ID24)
	I guess I'm a more practical man. I don't have time to sit down and read all the journals that much. (ID24)
	Giving presentations about topics forces you to at least try and analyse the literature. (ID07)
	Occasionally, like if I'm giving a talk, that's kind of the time that I'll look for that type of information. Not generally like when I'm doing my work, I don't tend to look for that type of information. But if I'm talking to a group of people about certain things then I'll look at the evidence for - to support what I'm saying. (ID25)
	You don't leave until the work's done. So if you spend 20 minutes, 30 minutes reading about a case the work is backing up and you don't go until it's gone. So, having a big department at a big tertiary centre where I work four days a week, you have the flexibility to - that's a really interesting case - you go around and ask opinions and look up the research and look up the web and try and work it out. Because there's a lot of other people who are reporting and pulling the weight. (ID17)
	I've got enough on my plate. We need people in our network who are interested and skilled. (ID12)
	Most of it is culture, and - but the other thing that we've got is, okay, say you're a respiratory physician. You might have, say, 20 patients, in-patients, and a certain number in the outpatient clinic. If I'm doing plain films, I'll be doing 120 cases a day. Right? So that gives me 120 patients, different patients, as opposed to that - and that's in one day, as opposed to over the week that you've got your busy respiratory unit. So, it tends - there's that. Also, particularly in the public - well, no, both public and private hospital systems, there's not the time allocated. Like with, say, a physician - I'm just using the example, or a surgeon - they've got their operating lists, they've got their outpatient clinic times, they've got their ward round times. But it doesn't normally fill up all that time, so you've got your ward round; you've only got five patients and you've got the rest of the morning to do something. If you've got your outpatient clinic, okay, that's probably going to fill up the time, but people might cancel, so there might be a bit of time in there. Whereas, in radiology, you know you've got a pile of things like this. Even if you go off to do a meeting - so, if they have a respiratory meeting, the respiratory guys aren't having work piling up for them, because they know that they're at that meeting, so they don't put patients in. Whereas, I'm doing the respiratory meeting and they're still scanning. So, when I finish, it's not like you go, okay, now we're starting from - now we're starting behind the eight ball. When you say, okay, we want to do some research on things - yes. (ID11)
Proximity of peer	When you make a mistake everybody will tell you. There's nothing better than to learn from your mistakes, as far as I can see. (ID24)

networks	Well, luckily in a big department there are lots of opinions, so I sought the opinion of more experienced colleagues. (ID17) Occasionally there are features about a lesion which make you think, well this might be a cyst but I don't think it will be, and you might organise a patient to have a contrast injection at the time because they're already there maybe, or even an MRI. Or you might just ask the person next to you, what would you do with this? Which happens quite a lot because we practice in that environment, it's quite handy. (ID24) You don't practice in isolation. So you don't just have the information that you started out with when you got your fellowship. You do come across things, but often the papers that you read and the information that you get is slightly contradictory, and there's a lot of parochialism in medicine; well this is the way we do it in our institution, as if to say, this is the only way to do it, and it isn't. (ID23) Fortunately working in a hospital like that you've got other people around and if you have a difficult case you can just ask people. (Man, 40s, ID06) So it's just a case of word of mouth, people pass onto you what is relevant to your specialty. (ID20) Because a lot of what we do I assume is not evidence-based. A lot of how we practise is handed down supposedly through experience, which does not necessarily mean that there is documented evidence that that's the best practice, but it's whatever you've been taught by more senior clinicians that this is how something is done and you just do that. I don't have the time to go through everything we do to prove or find the evidence to prove that that's the best thing - best method or the best way of doing something at a particular point in time, because you just don't have time to do that. (ID05)
Grasping information dispersion	We have to keep up-to-date. There are new tricks coming out and there's a proliferation. In fact, it's getting unmanageable in a way. There's too much clinical information coming out. The progress there - and it's so fast growing, you know. But luckily we're in a subspecialty. It's easier to narrow down our scope there. You don't need to learn everything. You know, it's amazing some of the general people working in the private health side, how do they cope, but anyway I think it's good to work in a hospital. At least you can stick to what you're supposed to know, rather than have to cover everything and the society requires you to know everything nowadays with the Internet coming up and all of the parents coming in know more than what you know about rare diseases there, so I guess that's very challenging as well. (ID24) I think it's good to know, but I guess - there are so many things you need to know at the moment, I think, in our specialty there because it's such a fast-growing field. (ID24) And it's very common for clinicians to come up - well, when they talk to us because their often talking about one or in sub-specialty areas that's their focus. We're supposed to be sub-specialty radiologists yet do everything general whereas they can sub-specialise. So they know a lot more, often, about the literature in their own area. (ID07) Well, I think most radiology can be difficult if you're not switched on and with the volume of work that we do, it's hard to stay switched on for everything. So, there are times where you kind of zone out a little bit or knowing when to concentrate for the important cases is difficult. I also struggle, and I suppose this is just because I finished my fellowship last year, so I've only been a qualified radiologist for a year. But the level of detail now for most scans is getting to subspecialty level. So, if you've done a year subspecialty fellowship in neuro then you really should be on top of neuro, head and neck reporting. For someone general like me it's difficult to stay on top and be good at everything. So I find I struggle a bit with certain cases that require more subspecialty input and involvement. (ID17) I think a lot of us probably keep an archive of the recent publications and stuff that we think are quality and relevant to our area, but other than that I think probably it's getting confounded by a plethora of information that you can't filter anymore. (ID20)
Overriding pragmatism	
Perceptible applicability	I think methodology, of course, is probably not the first one I would look at. I would look at what they're talking about; the clinical relevance and everything and then if I had any doubt I would look for the methodologies, the number of patients they looked through and everything, you know. I think there's so much to read out nowadays, you just can't afford to chew a paper very slowly and pick up every bit of it. In fact, a lot of the time I just read the abstracts and see whether I need to go into details of that. (ID24) I look at their protocol in terms of what they do and then whether their outcome measures more than probably analysing the way they got the outcomes, which I think I'll probably change a bit more now after this EBM course. So I kind of look at what they've reported as their outcomes versus their - be it their positive or negative and see whether it might fit into our population so they're characteristics of their population as well. (ID07) I do think from a practical point of view, that's something that you know when I go to work on Monday, that's something I can implement straight away that I can do differently and it's interesting. There was some of the applications with regards to searching that you need to get universities involved or college and I was thinking well when I get back that's something that I'm going to address. So I think that that was to me that was probably one of the biggest things that will probably change my practice the way towards evidence-based medicine. (ID08) Well something that would change your management of how you report. Something that would change how you approach a film, how useful a certain sign is. Is this a useful sign? Is it not a useful sign? Is it something you should actually just ignore and not pay so much weight on? That's the sort of really nitty gritty information we use. I mean a simple thing like CTR, it's taken for granted that an adult CTR of 50 per cent is normal but that's not true. What I'm really afraid of is that if everything gets based

	on evidence based medicine we lose the art - this is my one piece of information for you is that we lose the art of radiology. (ID14)
	I understand what it is, it's the difference of the two risk reductions but I don't see how they translate to clinical practice, personally. (ID04)
	To be able to look at these articles and actually read them, and analyse whether they are useful or not useful, in wider broader stage. I think that's probably a good thing. (ID10)
	A lot of the studies out of the States have techniques and contraptions that we can't afford and don't use within our system. So then by learning the concept I guess from a conference you then research other articles and what not, and then again, some of that's come out of conferences in Europe. We tend to do things slightly differently to the U.S. so we've followed a particular type of protocol that they've set out. (ID07)
	The guidelines are often they are written with big centres in mind. Because you're in a smaller centre, it can be a little bit more problematic. (ID11)
	Often then when they say come up with the final idea of the evidence says we should do this, in reality you've got to do what's practical in your area and in your place. I mean we live in Australia and what would be ideal even if you look at the evidence and say this is the best way to investigate this, this is the best way to do that, the money and resources and access may not be there in which case you can't necessarily do the best evidence-based option. You've just got to do the best option that's available to you or that's available to your patient. (ID20)
	You end up doing what you know is not the best but that's the best that you can get for that patient or that's the best you can get within the funding constraints that you have there. (ID20)
Preserving the art of medicine	Not from the journals you're reading trying to analyse these people, whether they got enough samples or they're whatever, you know, and use what they talk about and test on your patient and then - whether the science they talk about is just particularly applicable for their locality or their disease pattern is especially in the ethnic groups or not. You have to apply to our own patients there. So those are the real evidence medicines, as far as I can go. In practice, you get a few rather than in the books. (ID24)
	I know you have to be able to appraise whether what the people are talking about is real or not real and if with evidence-based medicine they're very basic steps of it, but you really need to know what they're talking about is actually truly effective in handling patients or not. You should be in the result that you get from treating the patients. (ID24)
	I'll go to the echo and the heart is big and there's something I'm referring to in my brain which is completely non-scientific. You can't put in words - I mean for a descriptive purpose it looks a bit tense and you just think oh, that heart's a big, CTR's normal. You go to the echo and it is abnormal and so that's where I think evidence based medicine will never capture the whole story. So I don't think that it should be rigid. I think there needs to be room for the art of medicine and I'm afraid that's the only point I've got to offer you. (ID14)
	Beyond the measurement there's an art and that's what we should actually be concentrating on. It's beyond the scientific evidence. (ID14)
	There's a whole bunch of processes and thoughts that we have where we can't absolutely rule something in, or rule something out. So there's a lot of grey in radiology. (ID17)
	Lots of grey in radiology. A lot of us do intrinsically do this, but we may not do it so effectively, and part of our experiences will tell us what the paper's trying to say as well without actually going into and dicing it up. Some of it is an art form. You can't actually put numbers and things into it and there'll be an experience related understanding of what's going on." (ID10)
	People don't necessarily like to justify an art form. (ID10)
	To some extent. It's hard to know just how much of an extent. I suppose a lot of what one does is you're looking at images, you're trying to work out is that an abnormality or not. That's the biggest step and that's based on experience and other reading and stuff that you do. Then I suppose in the interpretive part of it when you're actually giving recommendations, that's when it can alter it if you have a better understanding of the condition and the science behind it. But there's a lot of times when you don't actually have to do that, you've really got to just know what the diagnosis is and is it lung cancer or not? It's not going to make too much difference to that, but certainly in terms of what you might recommend potentially. (ID06)
Technical demands	The images are getting more and more well defined in detailed anatomies. You really need to relearn your anatomies altogether. Like the brains for the MRI coming in, you normally don't see different layers of the brain. Then now you see it and it's probably much more than what pathologist can see in a gross specimen state and it's so much detail there you just have to relearn your anatomy altogether and also there's a challenge how to get the best images up; all the new modalities there, you know, because there are so many more parameters that you can play with. (ID24)
	Main - well I'll Google and look for anatomical information, so for instance someone - just the other day, just as an example, there was a patient who had symptoms in the distribution of the saphenous nerve. So that's a small nerve that runs on the medial part of the thigh and it causes pain or numbness on the - just above the knee. Now that's a nerve that we don't - it's not a common nerve to image and it's not something that you retain in your mind as anatomical information. So when I read that on the request and was looking at the images, I Googled to get the anatomy of that nerve. I looked at the images that come up and cross-sectional images that came up with the

	nerve labelled so that I knew where to look on the MR images. I do that quite often to try and work out the anatomy, particularly when they're neurological cases, when they're a nerve problem, to work out what that nerve innervates, which muscles. (ID25)
	Well, I just had a difficult case yesterday where basically it was an MRI of a hand and there was some abnormal signal in some of the muscles but they were patchy everywhere and I couldn't quite put it all together, so I had to go back to my basic anatomy and review things like nerve supply to various muscles and whether there's a certain pattern. So I started Googling that and started looking up some textbooks and I think I got to fairly reasonable sort of differential diagnosis for that particular case. I realise there are some particular syndromes not quite completely fitting with that diagnosis but it was pretty close. (ID01)
	I've used *STATdx*. We've got it for all the registrars. But I mean, what you've got with that is a textbook like any other textbook. So I wouldn't say that it's necessarily kept up to date. It's the Amyrsis books. I still like books. I've got lots of books in my office, and I've got quite a few of the Amyrsis books, and I read through those. They are good, but the - it's not - I wouldn't say that's evidence-based. I would say that's just background knowledge. It may give you the answer of what it is and what's going on, but if it's a dilemma as to, what's the most recent stuff on that, that's not going to give you that. (ID11)
Limited confidence	
Conceptual obscurity	But I don't think I've really had a structure to critically analyse a lot of these type of papers and know that - I try to - I guess in basic terms looking at p-values and sensitivities and specificities, but I don't think I have a good structure. (ID07)
	I want to know how to approach different articles and recognise their strengths and weaknesses, and then have a slightly better approach to analysing the actual results section. (ID07)
	Yeah, I look at the methods too, how many patients they've studied, whether they've had a control group. If it's some sort of intervention - is it just an observational type of study, is it a study where they've eliminated biases? Are the observers blinded to - in a lot of imaging literature, the observers aren't blinded to certain things because of the nature of imaging. Those sorts of things I'll look at as well. (ID25)
	I think what would be good is to be able to analyse and critique papers more effectively, to actually know - the things that I look for may not be the most appropriate things in a paper. Just to learn what I should be looking at and focusing on rather than what I think I should be looking at. (ID25)
	Our worry is that a couple of weeks into a journal club, we'll stumble across one of these papers and we'll hit a rock or something like that, so it would be good to have that support and say well look, you've had a meeting now, we've maybe had a teleconference or something like you're all radiologists, what we'll do is we'll send out a paper to you once a month, you'll discuss it in your department, get some feedback and here's the answer sheet the next month. It would be good to have that support so you're not left floundering. (ID08)
	I don't know if I actively involve myself in it. I think having just gone through medical school in the last 10 years, I think the medical schools now have it so engrained in their curriculum that it's second nature and I don't know any different. So, I probably am of a generation that has always been okay with it. But I could imagine if I was 20 years older and going through medical school without knowing what EBM is, and then to have put in front of you it would be a bit daunting. (ID14)
	Well, I read it. It was a prospective paper where they changed a protocol and analysed the results after and before. It was of substantial size, there were enough to make it statistically significant, and it had enough power in it. I thought it was well designed. It was a simple paper that answered a simple question. I love research that does that, I don't like complexity. I like, I've got one question, how do I answer it? There's the answer, move on. It came from a big centre, so there were a whole bunch of reasons why I liked it. I kind of liked it because it was agreeing with what I've always thought, but just hadn't been able to prove. So it's nice when research validates your own experiences. (ID14)
	Kaplan-Meier curves I have a basic understanding, I think I do. I'm sure if I truly do so that one I'll put under don't know or very little. Multivariate analysis, a bit shaky in there. I roughly know what it is but again, I assume I know what it is but I'm not very sure if I do. (ID04)
	Very important, because I think I understand how all these studies are designed and I can read and know how they have arrived at what they have arrived and I can either look through the study and decide how reliable it is or not. (ID04)
	I'm not good at that. That's what I'm saying. I'm really not good at levelling. I basically just look at what the definitions say. It's got to be retro - not retrospective, prospective and it's got to be analysed, it's got to be blind or maybe open. (ID21)
	I have to say I struggled with the [EBM] course… in terms of the complexity of doing a proper literature search and things like that. It's just difficult to get my head around it without being able to dedicate myself to doing that fully, without actually putting it into practice. (ID12)
	I haven't been able to critically appraise their work very well just because of my own lack of in depth knowledge on the topic. (ID12)
	I think in first year we did a little booklet which was a biostatistics type of handbook, which to be honest went in one ear or in one eye and out the other because as I said I don't have much of a brain for it, never have. I don't think I retained too much of that knowledge. As I said I'm not that interested in doing research and I never really put it into practice. (ID12)

	I think it's more kind of the concepts. I mean, I think in practice it's something that we do every day, but it's the concepts behind it that I have a very poor knowledge of. You know, I read papers and studies all the time. Do I have the concrete knowledge behind it to be able to assess them in a proper way? Probably not. (ID03)
	I must admit, I do get lost in the statistics, but I'm not sure that it's probably necessary for me to know all about the statistics. So I don't know whether we're going through that or not. (ID03)
	I just have to get my head - I suppose just looking at the papers and then trying to - what sort of study is this? Just trying to sort out to have it clear in my mind the type of study and just doing the numbers and things that at the moment I'm a bit rusty on. (ID19)
	I suppose if we can find better articles more efficiently then that might help in terms of just trying to sort out which are the better ways of looking at things, and perhaps understanding the hierarchy of the different types of articles that there are would make it better, possibly. (ID19)
	Not particularly, no. I feel though my medical training I haven't developed all those skills, all the biostatistics. As I said, I did do a little bit of epidemiology at one stage for a couple of terms but that was quite a long time ago and all of that; statistics have filtered out of your brain after a while, you tune out. (ID01)
	I think it's the statistics because often when they start quoting statistics and where they've got those - why they use those particular tests to determine how relevant the findings are. I find it can be a little bit overwhelming trying to understand what it all means. (ID01)
	Yeah, I guess I would never have really had the proper training in terms of how to do a proper search, particularly if you want to do a paper yourself, trying to set up a trial. We've never really - I don't think I've ever felt comfortable having the skills to know how to go about even setting up a particular trial or study. So I think overall I just feel a little bit inadequate from that point of view. (ID01)
	Sensitivity, specificity, those sort of basic concepts are relatively easy to understand, and your positive predictive value, your negative predictive value, and a little bit about the confidence intervals. But things like how do they determine how many patients need to be recruited to get adequate power for a study. (ID01)
	Basically, it wasn't something that came up much through my medical school or medical career, so I don't have that background in it. Because we don't have that area of - that culture of evidence-based in radiology, it tends to be not played up as much. So, you feel that you're - you have to make an effort to do it, and you feel that you're sifting through a lot of stuff, and it's difficult to do, rather than easy and straightforward. (ID11)
	How to make sense of studies, and how to judge whether a study's good or not. I guess that's a real time saver if you can just dismiss studies as being not of high quality. (ID20)
	We don't have the statistical knowledge or ability or then in the end the staying power to actually do a proper trial. So that it's getting evidence-based medicine is very difficult and often you end up with possibly wrong conclusions because something which appears to be statistically acceptable when properly analysed isn't. (ID18)
	Well I haven't had any formal training in it. I don't actively practice EBM, I don't visit the Cochrane Institute or use - I'm aware of it but I don't actually regularly view it to see what's out there. (ID13)
	Understanding the methodology - that's very important in how research is done or how a paper is written, to know whether that is a well-constructed study and therefore the conclusions are robust. I think that's the hardest to do, which is part of why we do this course. (ID05)
Reputation based trust	Well, I guess your experience of what they say and I also look at where it came from; which research centre they come from. (ID25)
	Some of the things that I'd look for are the journal that it appears in. So if it's a journal that I know and trust, that is a high quality journal, I'll consider that a more relevant paper. If it's in one of the throwaway-type journals or if it's on a website without any peer review, like someone's own personal website, then that information is always - you view that with a lot of scepticism. (ID25)
	It's not a strong suit of mine, so that's why it comes down to what journal the stuff is printed in. If it's the yellow or the grey journal, the American ones, I'm confident that it's been peer reviewed meticulously, that the results are acceptable and the methodology is sound. That's not always the case, I know that. Things slip through, but I trust the experts who have reviewed and given me the information that actually - the assurance that this is a good study. That's what I do. (ID23)
	So you need to be able to understand how the statistics are done and question - work out whether it's been done correctly or not correctly - but you'd hope the editors of these magazines would be doing these things. (ID10)
	If it comes from one of the well-known Radiology journals, or in musculoskeletal imaging if it comes from some of the well-known orthopaedic journals, then I'll trust that. Or some websites that I know quite well, or names that I know. (ID19)
	STATdx I think is well refereed, so I put quite a bit of trust in that. (ID 22)
	A lot of the people who are big names will present there and a lot of them that are big names aren't necessarily that great. They're people who are on the speaker circuit and realise their publications are all by their underlings and when you go and see their presentation and the quality of the presentation you get an idea of whether or not you should be trusting their research. (ID20)
	Oh different experience of the authors. What they have done. First the authors, how much experience they have. (ID15)

	Yes I do because each author has certain experience, so that shows the bias to me straightaway. You see because if it a veteran radiologist who is doing it and he will say what he has done. So that gives me the bias and some of them also say they are industry-based. (ID15)
	I hold the editors of journals to task for that because they should be up-to-date with what's current nomenclature. If someone submits a paper using out-dated or non-preferred nomenclature then it should go back for revision. (ID13)
Demands constant practice	Like one of those things like use it or lose it. So I think that if you can implement the journal club, well then two things. What it means that you'll share it, which you have and then it keeps up those skills or hopefully it will keep those skills and obviously people will ask you difficult questions and then you'll have to go back and reread the information that you have. (ID08)
	So we're constantly being pushed to update, hearing papers presented, and so thinking about things like that. (ID19)
Suspicion and cynicism	There's always the risk of if [industry] fund a study then they're kind of trying to get a result that they want, so that you have to look at that data carefully. That's why it took several years for - more data from different sources - like it wasn't just one study, there were several studies done. Some of them were independent studies, non-funded by drug companies. (ID25)
	I've learnt there's a lot of publication bias in every aspect of research out there, every single one is publication bias, as in the bad results don't get published, the bad trials get buried somewhere in someone's drawer and filed into oblivion. That's why I hold a slight degree of scepticism. (ID04)
	I'd probably want to see another bigger study or somebody else doing it as well. I think there might be some - possibly, they were better at doing ultrasound or they had a particular type of patient. (ID19)
	That doesn't concern me so much, but there's a bias with pharmaceutical literature reports, because the pharmaceutical companies - as you know - maintain control over whether a paper is published or not. (ID22)
	So for instance, in cardiac imaging you're only looking at how should we be investigating chest pain and you can go to a session at a college meeting and see the nuclear physicians have their say in why you should do it starting with nuclear medicine. You have the cardiologists saying you should do it this way, you have the stress echo. people saying do it this way and you have the cardiac CT people doing it this way and they've all got plenty of good research that makes it very compelling that their argument is true, but the fact is if you look between them all and there's very - you can say yeah this is all evidence-based and in reality you can be blinded by what people call evidence-based anyway. So in theory yes it's great to have what you practice based on evidence but traditional practice hasn't been for a long time and similarly, even how we investigate things or things like people have got decision pathways and things which are a double-edged sword as you're probably aware as well and a lot of them may be based on various evidence that's been created to - a lot of the evidence gets created to support a particular agenda and it's used to support a particular agenda or preconceived notion of what you should actually be doing. (ID20)
	To be honest it's been a bit disillusioning because dealing with the whole academic side of it. You get into the politics of journals and egos and it's much worse when you deal with Americans as well because getting publications and stuff is such a big part of how they get their positions and get their funding and so on. You'll see people actively try to discredit each other's research and stuff for reasons that aren't necessarily medical or similarly re-present other people's findings and try to get it into print first. So I don't know I've probably become pretty cynical about the whole medical research and publication area. Similarly even when you read medical research in journals and stuff now because the - particularly in the American market but even to some degree in ours, getting publications on your CV is a very important part of how you build your career and get your positions or how the department gets its funding. The volume of publication has probably exploded and the quality of it has decreased considerably. (ID20)
	I mean even things - you had groups that tried to do it, like the Cochrane Research Institute and stuff like that and even the way that they filtered their information now comes under question. You'll have a Cochrane Review that says one thing and three years later it says the complete opposite because they've changed their methodology. I think even just recently they said they started looking at non-significant papers and non-significant - and of course that completely changes the whole evidence-base that you're using and can change your whole view on what you actually do. (ID20)
	We work in areas where new techniques and stuff are coming up all the time and it's 20 years before we know whether we've been doing the right thing or not, so we've just got to in good faith make the best guess [laughs]. But yeah I think I healthy cynicism is probably a good thing. (ID20)
	Yes I do because each author has certain experience, so that shows the bias to me straightaway. You see because if it a veteran radiologist who is doing it and he will say what he has done. So that gives me the bias and some of them also say they are industry-based. (ID15)
Competing powers	
Hierarchical conflict	If it comes from us - comes from senior people they will listen. But I think when it comes to junior people then he may not, but the trouble is you can't be there all the time, because there is so much case loading you have and you may know about that case only after somebody said it. (ID25)
	Yeah, there's that issue, because we're perceived as a service provider. The referrer will fill in the request and request a certain test, so oftentimes it's easier just to do the

test as requested, otherwise they send their work somewhere else. You want to keep the referrers happy. Also if you want to speak to the referrer to discuss the case and say look, I really think that this is more appropriate, it takes time. A lot of people don't have the time to get on the phone. The other issue is that sometimes they think he's requested this but this patient actually needs this, so they'll come back and have the right test later and there'll be more revenue generated for my practice. It's kind of a financial incentive for them to do more tests. There are financial - some radiologists who are running private practices may just do as many tests - they encourage as many tests and when they report studies they'll suggest another test to confirm the diagnosis even though it may not be - it may or may not be strictly required. (ID25)

We often image the brain and the cervical spine even if they don't have any particular symptoms in the neck. We often are battling with the emergency room people to - does this patient really need to have that done? (ID25)

Well to try and use clinical indicators. There's a website - the government of Western Australia set up a website and it gives you a decision tree. If someone with neck - some sort of trauma, query neck injury, and it will give you a decision tree. Do they have tenderness over the cervical spine? Yes, then do this. No, don't do anything. That sort of thing. (ID25)

Well yeah, because we - it is frustrating because we're trained to take note of the safety issues for the patients. Sometimes clinicians may be unaware or not interested in the safety issues of radiation on patients, so we see ourselves as the patient's advocate for safety as well. It's not because we don't want to do the test, it's also the other issue is patient safety. We feel - at least I feel that I should be an advocate for the patient. If they don't need to be irradiated or if they're being irradiated just for expediency rather than a clinical indication, I feel that I should advocate on their behalf that they don't do the test, they treat - they manage the patient in a different way or use another test that doesn't involve radiation. (ID25)

I think if you ring them and say look and you sell it to them and you say, look I have got something which is better for your patients and which is therefore as a consequence better for you, can make a more accurate diagnosis. Look I think that this is better well then that's a win win all round. Now occasionally you will get some referrers that are obstinate, stubborn. Or they might say to you, well look I have a specific question that can only be answered with this and you would say, now I can understand. So - but it does occasionally happens, but like all things it's I think if you have good people skills and you try and talk to people and you can talk to them. (ID08)

We still do lots of [the test], even though we tell them don't do it, it's useless, they still request, we still end up doing it. Resigned to my fate. What can you do? No, once you accept it it's not frustrating. It's only frustrating if you try to resist. Of course, but can you change it? I'm a realistic - I'm a pragmatist, it can't be changed, so don't bother even trying. (ID25)

When I try and suggest it to my peers that hey look, there are all these studies showing that we don't need to do this anymore, they still refuse to accept and still insist on it happening. (, ID25)

We'll have to rely on the referrers to be agreeable but on the other hand we're the gatekeepers. If you think of it, you are going to refer your patient to me, I'm going to look at - and we do that all day, every day. I'm going to look at it and you've written down that you want this and this and this, and I look at this and I say no, that's no longer indicated, we just do this. I will then pick up the phone and phone you and say it's not indicated, this is what we're going to do. So you can't send me - gone are the days where you send me your shopping list and then I just fulfil it. There's an active role to play. (ID21)

I know a few years ago I probably wouldn't have even considered consulting with others when I was doing radiology, because people just send the request along and that's it. Back when I was Director, they'd send a request and you'd go, well I don't really believe this is the right test. They'd go, I don't care. That's what I want. So over time I guess there's been a bit of an evolution. (ID16)

You do it. You might put up a little bit of a fight and point to the article or the literature or say something, but you wouldn't expect to win. Occasionally you do I suppose, occasionally you do. I had a win last week, but that's a rare event. Usually they will say - they have more - you're not arguing on a level playing field there. So they're coming at it from a different perspective. (ID22)

Because we're at arm's length for the referrals is a good thing in one way, because we're not self-referring. But it's bad, because we don't get to influence this. The referrers don't feel that radiology should be gatekeepers, because they know what tests they need on their patients. However, the government does feel that radiology should be capping the expenses on - for imaging, so making us gatekeepers. We are the experts in that area, so we should be trying to do that. (ID11)

It's a difficult thing to do, and even if you've got evidence-based, a lot of - or consensus guidelines, or whatever. A lot of people don't - no, no, it's my patient, I demand that we have this done. (ID11)

It's frustrating in a sense, because you know it's happening. I mean I've had clinical doctors tell me, yeah well we'll say whatever we need to, to get you to do the scan. We'll make a headache sound like a subarachnoid haemorrhage, we'll make chest pain sound like a possible aortic dissection, we'll make abdominal pain sound more sinister because we just want you to do the scan. And we know they do that; and they know that we know that they do that. And I've had one's even straight out admit to me. (ID02)

Well for the reasons I've said. With the diagnosis ones it's harder because you are then trying to change the behaviour of the referrer as much as the radiologist. And we don't get as much control over the imaging strategy as we should. The referrer has to come along with us, if you like. And that's hard. Because it's a funny relationship,

	we're sort of seen as a service provider. (ID02)
	We always have a discussion when we turn down a request. That's where it becomes an art ant. We take time when I really feel for it, but others won't, they just say just do it. So that 50 per cent of them will just do it, and 50 per cent of them we will have an argument. We are so busy it is easier - the path of least resistance. That happens when you are busy. But it may not be the right thing. (ID15)
	You try and educate the clinician, but I think in real practice you just do what they ask you to do, which is the expectation by the clinicians. (ID05)
	Unless it has an adverse effect on the patient outcome, generally I just do it because it's easier to do it than to argue and then they still go over your head and get it done. So unless it's, for example, you're radiating a pregnant woman or a child, if it's an older person and you think that's a low probability for risk then it's better to do it or easier to do it than to argue. (ID05)
	The joy of working in paediatrics is most of the people work as a team and everyone respects their specialties there. I can see that's the reason, for example, why I choose to do paediatrics, because I think I'm dealing with people more open, more gentle and less dogmatic in a way and in paediatrics in a way radiology or imaging plays a major field in a way, because you can't get the clinical side or history as easy as from the adults there. I think for getting a right diagnosis or you put on a new treatment, the right treatment there very much depends you established a disease, you know, making the diagnosis there, so I guess that's the joy of being a diagnostician in the paediatrics there. (ID24)
	See mammography is quite different because it's a multidisciplinary team so everyone gets together. But things like intervention, I don't think it's quite as multidisciplinary. It's more the referring physician or surgeon or whoever and you're at the end of that list and you just get the request and you just have to go off and do it. That's right. I think with that evidence-based medicine, I think it has to be more of a team approach. That's my thoughts on it. Yes. I think it might happen in oncology and radiology because oncology relies on radiology for the results. So I think they have a lot more meetings and get together and discuss things more. But basically, some of the other specialties just want the answer. They want their answer. (ID16)
	I do attend multidisciplinary meetings like lung cancer then you have to make a decision. To say whether - you have said this patient has lung cancer when the decision is multi-factorial because you have to decide whether the patient is fit enough for surgery or fit enough for radiotherapy or whatever. So it's not that difficult to judge on those ones where you are giving an opinion. Your opinion is taken as a part of a broad decision-making. So you feel that you not - still stressed but not much stress, do you know what I mean? Because it's part of a group decision rather than a single decision. (ID15)
	Those are evidence-based because it's a multidisciplinary meeting and everybody comes and everybody has their previous - not only previous experience but research has been done. (ID15)
	think in our department we like to share problem cases around a lot and so it's an open department where people can share without feeling they're going to be picked on or someone's going to make fun of them for making a mistake. So it's actually quite collaborative. We refer to journals and multidisciplinary teams to get the answers. (ID13)
Prevailing commercial interests	The other issue is that sometimes they think he's requested this but this patient actually needs this, so they'll come back and have the right test later and there'll be more revenue generated for my practice. It's kind of a financial incentive for them to do more tests. Some radiologists who are running private practices may just do as many tests - they encourage as many tests and when they report studies they'll suggest another test to confirm the diagnosis even though it may not be - it may or may not be strictly required. (ID25)
	The financial issues potentially could come before patient safety issues. (ID25)
	It's a money-making or it's - you have to generate revenue to keep the practice going. You're trying to encourage people to image, not necessarily inappropriately, but just you're trying to get as much throughput through the practice as possible, whereas in the public hospital there's such a demand already that we just have to try and prioritise a little bit. (ID25)
	I suppose my feeling is that evidence-based medicine will never ever work in an item for service based medical culture and that's the bottom line. The trouble with evidence-based medicine is that best practice doesn't always align itself with best ability to make money and there's going to be that tension. (ID18)
	Now the reason you have to be a little bit careful with some things, now whether it's endoscopy or radiology, is that if there's harm involved and with radiology you could say no we shouldn't do that because there's a potential downside. With MR you can say well look there doesn't appear to be any downside. With ultrasound well there's no downside, it won't harm the patient, let's do it. Now it may harm the patient's bank balance but we tend not to involve ourselves in that. (ID18)

*Quotations identified only by ID to protect anonymity

Supplementary File. COREQ Checklist

No.	Item	Comment
Domain 1: Research team and reflexivity		
1	Interview/facilitator	AT
2	Credentials	AT (PhD, MPH, MM)
3	Occupation	AT, Associate Professor in Public Health; SEM, Lecturer in Clinical Epidemiology; JCC, Professor of Clinical Epidemiology; GL, Radiologist; AJP, Professor of Medical Imaging; CL, Senior Lecturer in Clinical Epidemiology
4	Gender	AT (Female)
5	Experience and training	AT has conducted and published qualitative research and lectures in qualitative methods and methodology.
6	Relationship established	None
7	Participant knowledge of the interviewer	AT is conducting a study to elicit radiologists' perspectives on evidence-based medicine (EBM) to inform ways to improve EBM training.
8	Interviewer characteristics	AT is a qualitative health researcher.
Study design		
9	Theoretical framework	Grounded theory
10	Sampling	Purposive and snowballing
11	Method of approach	Email
12	Sample size	N=25 (refer to table 2)
13	Non-participation	N=6 due to travel and clinical committments
14	Setting of data collection	Clinic offices, hospital meeting rooms, conference venue
15	Presence of non-participants	None
16	Description of sample	Refer to Table 2
17	Interview guide	Provided in Supplementary File 2
18	Repeat interviews	Single interview conducted
19	Audio/visual recording	Interviews were audio recorded
20	Field notes	AT recorded field notes
21	Duration	Mean duration 35 minutes
22	Data saturation	Yes
23	Transcripts returned	No
Analysis and findings		
24	Number of data coders	AT/SM
25	Description of the coding tree	No
26	Derivation of themes	Inductively derived from data
27	Software	HyperRESEARCH
28	Participant checking	Yes, preliminary results were sent to all participants who were given two weeks to provide feedback for integration into the final analysis
29	Quotations presented	Refer to Table 2
30	Data and findings consistent	Quotations provided to illustrate each theme.
31	Clarity of major themes	Yes
32	Clarity of minor themes	Yes

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Radiologists' perspectives about evidence-based medicine and their clinical practice: semi-structured interview study

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Radiologists' perspectives about evidence-based medicine and their clinical practice: semi-structured interview study

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Abstract

Objectives: To describe radiologist's attitudes and perspectives on evidence-based medicine and their practice

Design: Face-to-face semi-structured interviews, thematic analysis

Setting: 24 institutions across six Australian states and New Zealand. Transcripts were imported into HyperRESEARCH software and thematically analysed.

Participants: 25 radiologists

Results: Six themes were identified: legitimising decisions (validated justification, prioritising patient preferences, reinforcing protocols), optimising outcomes (ensuring patient safety, maximising efficiency), availability of access (requiring immediacy, inadequacy of evidence, time constraints, proximity of peer networks, grasping information dispersion), overriding pragmatism (perceptibly applicability, preserving the art of medicine, technical demands), limited confidence (conceptual obscurity, reputation based trust, demands constant practice, suspicious and cynicism), and competing powers (hierarchical conflict, prevailing commercial interests).

Conclusions: Radiologists believe EBM can support clinical decision-making for optimal patient outcomes and service efficiency but feel limited in their capacities to assimilate and apply EBM in practice. Improving access to evidence, providing ongoing education and training supplemented with practical tools for appraising evidence; and developing evidence-based guidelines and protocols may enhance feasibility and promote the confidence and skills among radiologists in applying EBM in radiology practice for better patient care.

Article summary

Strengths and limitations of the study:

- Interviews were conducted until saturation and we recruited participants from a range of demographic characteristics, years of practice in radiology, and evidence-based medicine training.
- Participants were recruited from two countries and therefore transferability to other countries beyond Australia and New Zealand is uncertain.

Key messages:

- Radiologists believe EBM can support clinical decision-making for optimal patient outcomes and service efficiency.
- Capacities to assimilate and apply EBM were limited by barriers to accessing and appraising the evidence, perceived need for pragmatism and gaining practical experience, and contending with power hierarchies with referring physicians and commercial interests.
- Radiologists' perspectives on EBM are reflected in six major themes: legitimizing decisions, optimizing outcomes, availability of access, overriding pragmatism, limited confidence, and competing powers.

Introduction

Evidence-based medicine (EBM) is the "integration of best research evidence with clinical expertise and patient values[1 2]" and is widely promoted as a tool to improve patient care. EBM was originally designed to address clinical problems within internal medicine, but has been generalised and expanded to enable applicability to other medical specialties. Recognised barriers to the optimal use of EBM in a variety of specialties include competing priorities and lack of time, inability to cope with "information explosion[3]", misconceptions about what constitutes quality evidence[4], lack of awareness of EBM resources[3], threat to professional autonomy[5 6], concerns about the trustworthiness of the data[5], fear of conflict with colleagues[7], and institutional dynamics and culture[8-10]. However, there is little information on how EBM is regarded and practised by radiologists and whether barriers to optimal use may differ.

For example, technological innovation in imaging and interventional technologies has intensified the demand on radiologists to assimilate the proliferation of new information to deliver safe and cost-effective care[11 12], and the promotion of new tests may occur prior to published evidence supporting widespread use. EBM use within radiology has not been examined, but a survey of radiation oncologists found widespread support for EBM, although most had not undertaken formal EBM training and were unaware of integral resources such as the Cochrane Library[3].

We aimed to describe radiologist's attitudes and perspectives on learning and applying EBM in practice, and in doing so, inform strategies for improving EBM training, and assist development of resources to facilitate greater use of EBM. This may help to foster appropriate decisions regarding imaging and interventional procedures for improved patient outcomes.

Methods

Participant selection and practice setting

Radiologists in Australia and New Zealand were purposively selected to capture a range of age, gender, years of clinical experience, radiology sub-specialties, EBM training, and practice locations. Invitations were emailed to radiologists enrolled in the critical skills appraisal program at The University of Sydney (July 2013) or were attending an Annual Scientific Meeting (October 2013). Radiologists known to the investigators were also invited and participants could nominate other radiologists who could offer a different perspective about EBM. Interviews were conducted in meeting rooms, clinic offices, conference venue. The University of Sydney provided ethics approval and all participants provided informed consent.

Data collection

The interview guide was based on a review of the literature [3-8 13 14] and discussion among the research team (Box 1). AT conducted a face-to-face semi-structured interview with each participant from July to November 2013. Participant recruitment ceased when theoretical saturation was reached i.e. when little or no new concepts were being raised in subsequent interviews. All interviews were audio-recorded and transcribed.

Analysis

The transcripts were entered into HyperRESEARCH software (ResearchWare, US Version 3.0, Randolph MA, United States) for coding qualitative data. Based on the principles of grounded theory (to develop a theory or explanation that is grounded in the data collected) [15] and thematic analysis, AT read the transcripts, conceptualised and coded all sections relating to radiologists' perspectives on EBM into concepts identified inductively in the data; and created new codes when necessary. These were reviewed by SM who also read the transcripts. This can help to ensure that ensure data were captured in the preliminary codes. Similar concepts were grouped into themes and subthemes. Patterns and conceptual links between themes were mapped into a thematic schema. Member checking was conducted whereby participants were sent a copy of the preliminary analysis and given two weeks to suggest additional opinions. These were integrated into the final thematic analysis. This ensures that the findings reflect and captures the full breadth of data from the participants.

Results

Twenty-five radiologists from 24 institutions across 6 Australian states and New Zealand participated. Non-participation (n=6) was due to travel and clinical commitments. The mean duration of interviews was 35 minutes. Participant characteristics are provided in Table 1.

We identified six major themes: legitimising decisions, optimising outcomes, availability of access, overriding pragmatism, limited confidence, and competing powers. Illustrative quotations for each theme are provided in Table 2/Supplementary File 1. A thematic schema illustrating the conceptual links among themes is shown in Figure 1. EBM was believed to support clinical decision-making for optimal patient outcomes and service efficiency, but radiologists' capacities to assimilate and apply

EBM were limited by barriers to accessing and appraising the evidence, perceived need for pragmatism and gaining practical experience, and contending with power hierarchies with referring physicians and commercial interests. A description of the themes and subthemes are provided in the following section. Most of the themes apply to both interventional and diagnostic radiology; however results that were specific to either interventional (therapeutic) or diagnostic radiology will be indicated.

Legitimising decisions

Validated justification

EBM provided a framework to make clinical decisions based on science, rather than anecdotal data. EBM "added weight, added experience and evidence behind decisions". And some participants felt reassured when research "validated their own experiences", and EBM was regarded as an opportunity "to borrow information and techniques from other people who have been using them more."

Prioritising patient preferences

Shared-decision making was regarded as important though some felt that patient preferences contradicted EBM. For example, they felt unable to deny patients who wanted treatment even when the evidence suggested that the therapeutic intervention would not be cost-effective or beneficial.

Reinforcing protocols

EBM was regarded as useful for developing evidence-based protocols and guidelines. This was particularly relevant in directing decisional pathways for inexperienced referrers. Protocols were seen

to protect radiologist's decisions as "you get in trouble for missing something, you don't get in trouble for over-investigating something."

Optimising outcomes

Ensuring patient safety

Some were convinced that EBM had demonstrable impact on ensuring safe patient care. There was reference to studies assessing safe dosages of gadolinium in patients with renal impairment, reducing the incidence of nephrogenic systemic fibrosis. Participants remarked on the "increasing number of normal examinations which meant they were scanning more people, and that they were not selecting them correctly." They felt a burden of responsibility – "we definitely do cause the public harm, we just don't know how many [malignancies] is due to us yet" and believed that applying EBM in diagnostic radiology could reduce over-exposing patients to unnecessary ionizing radiation and risk of malignancies.

Maximising efficiency

Participants felt certain that the financial costs to public hospitals incurred by performing excessive radiologic tests and procedures could be minimised by applying EBM. Some suggested that evidence-based referral guidelines may reduce the number of unnecessary diagnostic tests ordered by referrers and improve economic and service efficiency.

Availability of access

Requiring immediacy

Simple and direct access to information was important. Most used Google or PubMed as their primary search engine. Some relied on email updates or review articles to keep up-to-date. Evidence summaries offered information that "had already been critically appraised, filtered out so most of the rubbish wasn't there." Being unable to access journals due to institutional restrictions "added an extra element of difficulty" however, some participants who had received EBM training felt confident about searching for high-quality scientific research using MEDLINE and the Cochrane Library.

Inadequacy of evidence

Radiological technologies often "progressed before the evidence could come out." Some observed that diagnostic procedures (for example, CT angiograms for vertebral artery dissection) were used without supporting evidence. In radiological research, some felt that relevant outcomes could not be feasibly measured, for example if it necessitated surgical or autopsy proof. Research in diagnostic imaging was unavailable particularly for rare clinical cases. They felt that, "there's no culture of [radiology] research except in little pockets and enclaves in different institutions few and far between."

Time constraints

The "fast-growing field" of radiology meant participants felt without capacity to be "a true academic," engage in research, and "to go through everything we do and find the evidence to prove that that's the best method or way of doing something." Instead of an appointment-based patient caseload,

radiologists had to manage a continuous inflow of patients, which was more difficult to keep manageable particularly if working in a smaller radiology department, or in the private sector. Some reviewed the literature only when required to, for example when preparing for presentations.

Proximity of peer networks

Participants relied on their colleagues to discuss and resolve cases. In larger radiology departments, participants could readily contact experienced colleagues for advice. One participant stated, "my approach to medicine is a very practical approach and based on my experience and the knowledge of others, my skill set is complementary to others so I use their skills." Interventional radiologists valued practical suggestions from colleagues about procedures and participants attended conferences to learn about new procedures and protocols, then turned to "selected articles on the nuts and bolts, assuming that somebody has looked at the utility of the procedure."

Grasping information dispersion

The field of radiology was described as broad, "dynamic," and all-encompassing of different sub-specialties which augmented the challenge of keeping up with the literature – "radiologists in most places are generalists, you have to be able to do neurology, gastroenterology, intervention, it's not actually possible to be at the top level of science in all those fields." They felt "confounded by the plethora of information that you can't filter anymore." Radiologists practising within a narrow sub-specialty felt better able to remain aware of the current literature in their area.

Overriding pragmatism

Perceptible applicability

From a practical perspective, some judged the clinical relevance of a research article rather than the methodology. One participant reflected, "I'm not an academic, I'm much more practical, I'm more operational." They would "look at what they do and the outcomes measures more than analysing the way they get the outcomes." Research results that were too broad or excluded relevant patient groups made it difficult to extrapolate or assess the transferability of the findings to their own patient population or to an individual patient – "like meta-analysis, you have to spend more energy on trying to pick out tiny fragments of useful data, so most of the time the article was justifying itself and talking about itself, I just want to get to the crux of the matter."

Preserving the art of medicine

There was anxiety that "if everything gets based on evidence based medicine, we lose the art of radiology." Participants with more years of experience believed in learning from practice, observing senior colleagues, and developing expert intuition, more so than "reading about things" as EBM could "never capture the whole story."

Technical demands

The technological advances in radiology placed demands on participants to prioritise their technical competence and knowledge of anatomy and pathology. They had to "keep on learning new tricks, as well as refine what they knew before" and studied textbooks and "didactic" articles rather than

scientific research publications – "What does such a condition look like on ultrasound? You don't need a research article."

Limited confidence

Conceptual obscurity

The perceived complexity of concepts, mainly relating to critical appraisal and statistical analysis, was overwhelming. Many described their judgment about study validity as "superficial" and felt they lacked a framework for critically appraising an article – "we all aspire to practice EBM but we don't necessarily know how to and I think there's a lot of quasi EBM going on." Some assessed articles based on sample size, participant characteristics, and blinding. Also, some believed a high-level understanding of statistics was required for EBM, perceived to be daunting, "we've come out of it with this monster that most of the radiologists don't know how to cope with, most of us left statistics behind in high school, we don't have this analysis in our brains."

Reputation-based trust

Participants trusted journals with high impact factors, and articles from reputable institutions with experienced authors. They placed confidence in editorial integrity and expertise to ensure that only high-quality and valid research articles were published.

Demands constant practice

EBM was a skill that required ongoing practice. Participants suggested regular EBM training, and journal clubs to maintain EBM proficiencies, such as conducting critical appraisal.

Suspicion and cynicism

Some were suspicious of authors who might be misusing research to push their own agenda, "People usually decide what they want the reality to be and then harness the appropriate evidence that they want to support it." For example, in diagnostic cardiac imaging, one participant observed nuclear physicians advocating for nuclear medicine while cardiologists were promoting stress echocardiogram, and both presented compelling arguments supported by research. Contradictory results also perpetuated cynicism of EBM, "I've seen a few cases where different meta-analyses will draw completely different conclusions from the same set of data analysing the same papers." Some were wary of academic competition, and the "politics of journals, and personal egos." However, multiple independent studies which demonstrated confirmatory findings, provided reassurance.

Competing powers

Hierarchical conflict

Disempowerment prevented the practice of EBM. Some radiologists felt that referring physicians perceived them as service providers rather than as consultants. They viewed that "referrers don't feel that radiology should be gate keepers." Being "secondary referrals" most radiologists did not control patient management and lacked clinical information about the patient. Some resigned themselves to

"defeat" and "dogmatism" as they continued to perform tests they regarded as unnecessary. At times, there was a palpable tension between keeping referrers satisfied and advocating for the patient's safety and preventing them from being "irradiated just for expediency rather than a clinical indication". Some tried to "battle" with referrers but withdrew from the "uneven playing field". More senior participants felt that referrers respected their recommendations.

In certain radiology sub-specialties including paediatrics, oncology, and obstetrics, radiologists participated in multi-disciplinary meetings and valued the active engagement in patient management where their expert opinion contributed to the broader decision-making. Participants appreciated this "cross-pollination" of information and clinical history.

Prevailing commercial interests

Private radiology centres faced the pressure of "generating revenue to keep the practice going", which was perceived to nullify any impetus to implement EBM. Some believed that "evidence-based medicine will never work in an item for service based medical culture" and there was "no real incentives for doctors to do the right thing" in referring patients for radiological diagnostics tests. To protect a thriving business, they kept referrers satisfied by fulfilling their radiologic requests, even when it was not evidence-based.

Discussion

Although radiologists appreciate the role of EBM in improving patient care, misperceptions of the definition of EBM, a lack of critical appraisal skills and an under appreciation of how EBM could help resolve common tensions within daily practice limited its optimal use. EBM is defined as the integration of best research evidence with clinical expertise and patient values however some participants thought that EBM supplanted clinical expertise and therefore rejected it as being exclusive of clinical wisdom. A common tension cited by many participants was the performance of unnecessary tests, contributing to excess cost and increased exposure to radiation, however many felt helpless to refuse the request. However, when evidence-based guidelines were available to support appropriate imaging pathways, radiologists felt more confident in negotiating referrals.

Some of the barriers to implementing EBM we identified have been reported in other areas of medicine and health. Studies conducted in internal medicine and surgery found that confusion about EBM terminology, team dynamics, staff disapproval, and time constraints prevented residents from practising EBM[7 8]. In primary care, EBM was perceived by some physicians as devaluing the "art" of medicine and a threat to their professional autonomy, and were concerned about industry influence[5]. Another study found that healthcare providers preferred tested, convenient and respected evidence sources including professional societies and expert colleagues[4]. There are unique features in radiological practice: the limitations of being perceived as a service provider rather than an "expert consultant", the demands of maintaining technical competence, the requirement for detailed but stable knowledge of anatomy and pathology, and the challenges of keeping up in a field of rapid technological advances.

While understanding and use of EBM is widely accepted as a core competency of clinical practice, this is the first study to explore understanding and barriers to use in radiology. We conducted interviews

until little or no new concepts were emerging from subsequent interviews (theoretical saturation), and included participants from a range of demographic characteristics, years of practice in radiology, and EBM training. Also, participants were asked to provide feedback on the preliminary findings (member checking). However, our study has potential limitations. Participants were recruited from Australia and New Zealand therefore the transferability of the findings to other regions may be limited, although similar barriers have been identified in studies conducted in different settings[16], suggesting broader applicability.

The acquisition and application of EBM skills including literature searching, critical appraisal of articles and interpretation of diagnostic tests and their limitations is essential to competent clinical care[12]. Several resources have been published in radiology literature[12 17]. However, barriers related to the availability and access to evidence, unmet education and training needs, pragmatic and structural difficulties that need to be addressed. Based on our findings, we suggest key target areas, strategies and actions for promoting EBM awareness and implementation (Table 3).

Moving EBM teaching from the classroom to clinical practice settings has been strongly advocated to improve knowledge, critical appraisal skills, attitudes and behavior[18]. The few strategies to clinically integrate EBM teaching which have been evaluated include daily EBM teaching rounds in which searches and study appraisals are based on cases presented at clinical rounds[19], journal clubs[20], and EBM ward round sessions led by a clinical specialist and epidemiologist to develop clinical questions, literature search, critical appraisal and development of evidence summaries[21]. While these teaching methods are effective, more specific evaluation of these strategies is needed in radiology.

It has been recognised that evidence-based practice should be taught from an early stage in medical and radiologic education[22 23]. Current models for educating evidence-based practice include having trained

epidemiologists to deliver regular teaching and interactive sessions which encompass theory, self-directed learning, and application to clinically relevant questions; or providing training workshops or teaching EBM in postgraduate meetings which cover the principles of EBM[22]. Our study has highlighted important implications for teaching EBM within radiology. Skills that require greater emphasis included literature searching and critical appraisal. A recent survey found that radiologists and trainees preferred Google, customised radiology-focussed produces and apps, and online resources to solve imaging questions[16]. Evidence summaries or EBM guidelines could be developed and disseminated via these channels. Confidence in appraisal skills could be improved with wider use of EBM tools[24]. For most EBM skills, a mix of educational strategies is likely to be most effective in increasing skills including interactive online courses, journal clubs and seminars[25].

While our findings are likely to have some commonality across geographic regions, further studies on barriers to EBM in different areas would be enlightening. Teaching strategies that are most helpful to radiologists should be clarified, as these may not be the same as those for bedside practitioners. Studies of implementation of evidence-based guidelines for imaging pathways and whether these improve patient important outcomes and cost are also needed.

Better access to evidence, ongoing education and training supplemented with practical tools for appraising evidence; and developing evidence-based guidelines and protocols may promote optimal use of EBM within radiology, and ultimately translate to better patient care.

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Contributions

AT participated in the design of the study, did the interviews, transcribed the interviews, carried out the thematic analysis and drafted the manuscript. SM, JCC, CL designed the study, participated in the thematic analysis, and provided critical review of manuscript drafts. GL, AJP participated in the design of the study, assisted with the analysis, and provided intellectural input into subsequent manuscript drafts. All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; drafting the article or revising it critically for important intellectual content; and provided final approval of the version to be published. All authors had full access to all of the data in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

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Declaration of competing interests

The authors do not have any competing interests of conflicts of interest to declare.

Ethics approval

All participant provided writte and voluntary informed consent. The study was approved by the University of Sydney Ethics Committee (20130616).

Data sharing

No additional data are available.

List of Supplementary Files

Supplementary File 1. Additional quotations

Supplementary File 2. COREQ criteria

Figure Legends

Figure 1. Thematic Schema

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Box 1. Interview guide

1. Role as a radiologist/radiology trainee
    a. What is your current position and how many years have you been working in that role or what year of training?
    b. Working as a radiologist/trainee, what are the some of the most difficult, common, or complex issues/decisions you have faced and how do you deal with them (e.g. when interpreting images)?
2. Knowledge about evidence-based medicine (EBM)
    a. How would you define evidence-based medicine or what is the first thing that comes to mind when thinking about EBM?
    b. How you rate your knowledge or understanding about EBM from 0 (lowest) to 10 (highest – most knowledgeable) – why?
    c. What educational sources do you use to inform your practice? What resources or how do you go about interpreting diagnostic tests? (STATdx, Up to date, guidelines and protocols, experience and intuition, other colleagues' opinions, decision aids or online resources such as calculators)
    d. Can you comment on the level of trust you have in these resources – what makes you trust it more/less? (journal reputation, authors, sample size)
    e. What aspect of EBM do you find most challenging or difficult – why? (asking answerable questions, searching, appraising, analysis or synthesis, interpreting the data, applicability to individual patients or applying EBM in your day to day practice)
    f. What EBM concepts of terms do you feel you understand the least/most?
3. Evidence-based medicine training
    a. What was the most/least interesting or valuable thing you learnt in EBM – why?
    b. How you rate the importance of EBM training to your - clinical practice from 0 (least) to 10 (most important) – why?
    c. How would you improve EBM teaching i.e. what teaching methods do you believe would be most effective in helping radiologists apply EBM in their practice – why? (journal club, study appraisal)
4. Applying EBM in practice
    a. Can you describe the role EBM has in your overall clinical decision making? Have you applied EBM in practice – how/give an example?
    b. Do you believe there are benefits in applying EBM in radiology practice - why? (service efficiency, costs, patient care, develop guidelines)
    c. What are the challenges or barriers in applying EBM in day-to-day practice? (service provision vs. consultative, not sure where to find resources to guide its use (access), unsure of the validity of a checklist compared with clinical reasoning, competing priorities, concern about the trustworthiness of the evidence, threat to clinical autonomy, financial interests, potential to cause conflict, contradictory data, information overload)
    d. What can you suggest would facilitate the application of EBM into day to day practice? (Evidence summaries, technology and tools)
    e. Do you think EBM is more relevant for the clinical aspects of radiology such as interventional radiology rather than diagnosis - why?
    f. Compared with other medical specialties, do you think radiology lags behind, is equal or, or is more advanced in terms of EBM knowledge and application – why? (research culture, limited research evidence)
    g. Does learning about EBM make you more or less likely to undertake research to answer clinical issues you have encountered - why?

Table 1. Participant characteristics

Participant characteristics (n=25)	No. of participants	%
Sex		
Men	20	80
Women	5	20
Age (years)		
30-39	3	12
40-49	11	44
50-59	5	20
60-69	6	24
Years of practice in radiology		
≤10	5	20
11-20	10	40
21-30	6	24
>30	4	16
Training in evidence-based medicine		
Yes*	12	48
No	13	52
Radiology subspecialty*		
Breast imaging	3	12
Cardiovascular	8	32
Chest	7	28
Emergency	9	36
Gastrointestinal	8	32
General radiology**	4	16
Genitourinary	8	32
Head and Neck	6	24
Interventional	11	44
Musculoskeletal	13	52
Neuroradiology	9	36
Nuclear radiology	3	12
Obstetrics and gynecology	1	4
Paediatric radiology	5	20
Vascular	1	4
Type of practice		
Public	23	92
Private	2	8

*Includes short courses, formal evidence-based medicine training during medical school; **Multiple subspecialties can be indicated by a participant; ***as identified by the participant and includes most subspecialties.

Table 2. Illustrative quotations

Theme	Illustrative quotations*
	Legitimising decisions
Validated justification	I suppose the antithesis would be anecdotal medicine, so you're getting away from what you perceive, or what you think is the correct way to behave, what you had thought before. What you're trying to do is be critical about what you do and see if there's scientific basis to support the way you practise medicine. (ID08) The most valuable is that if you can confront a clinician and say that a certain practice is the right practice. To do a certain test in a certain scenario, if you have evidence that shows that that's the best practice then it's easier to stand your ground and then say we shouldn't be doing this and we should be doing it the other way because there is research that suggests that's the best practice. If you don't have that sort of research it's very hard to back up your opinion. (ID05) So it's nice when research validates your own experiences. (ID17)
Prioritising patient preferences	How can I deny a patient treatment? That's the problem with it. Even if the evidence-based medicine says you shouldn't treat this patient. For example you are a patient, I can't say, this evidence says you shouldn't be treated but the patient still wants it, what do you do? That's the ethical dilemma. (ID15)
Reinforcing protocols	We have in the department guidelines to help people to request certain radiology procedures on the basis of what was published. This is the evidence that you should go down this pathway and don't ask for anything more. (ID21)
	Optimising outcomes
Ensuring patient safety	We would decrease the amount of ionisation radiation as we give to the public, which hopefully then would decrease the number of malignancies that we cause. We definitely do cause them, given on a population level, we just don't know how many is due to us, yet. (ID04) Perhaps one area where evidence-based medicine has had a benefit in paediatrics is the reduction in imaging for vesicoureteral reflux. There's been no improvement or change in the incidence of chronic renal disease in children as a consequence of treatment of urinary tract infection or treatment of reflux. So that has totally changed the management. Seven or eight years ago I was doing MCUs on children up to five years old and there were probably five or 10 on a list. Now it's down to less than one because of evidence-based medicine showing that the treatment doesn't - the investigation and treatment doesn't change outcome. (ID13) So the literature that appeared over that period of time has really changed the way that I think about using gadolinium in renal impairment. I'm not as scared to use it anymore providing I stick to guidelines with regard to the estimated GFR. (ID25)
Maximising efficiency	Service efficiency, there is a safety aspect in that they don't have to undergo other tests as well, more invasive tests, and economic from the point of view that they're not taking up further resources in the hospital which could be used for other people. (ID01)
	Availability of access
Requiring immediacy	If I really need an article that is not available I get the library to get it for me, but that adds an extra element of difficulty, so I tend to just ignore the ones - not ignore, but I tend to find a free access version if I can, not of the same study but as best I can. (ID04) MEDLINE - unfortunately a lot of the time you can't get in journals what you want and a lot of the time they only give you the abstracts there, so that's where the Google comes into it, because HighWire provides a lot of free journals there. You can actually go to the full journal rather than just the abstract. I guess I can always go to the university library and find out but it takes a long while to get in there. (ID24)
Inadequacy of evidence	The technology's there and you're playing catch up really. It jumps ahead, the lag is apparent. (ID07) Often the outcomes aren't measurable. So you may see certain findings but you'll never find out because that patient doesn't have the joint opened up or - so the outcome that you're measuring or the gold standard, there may not be a gold standard in a lot of the studies – where you have surgical proof or autopsy proof. (ID25)
Time constraints	It's a lot of time so sometimes it's obviously easier just to say it needs follow-up or repeat imaging rather than taking time out to consult a study. (ID13) I guess you can't be really a true academic because the clinical service is so demanding. You just don't get time to do it. (ID24)
Proximity of peer networks	Colleagues' opinions, because I'm doing some interventional stuff, and often, the interventional has much less research. If you get into trouble, try this, and, have you thought about doing this, and, here's another approach. They are not the stuff that gets written up. It's more just because it's a "doing" rather than a "thinking about" bit. So, for those things, talking to colleagues is much more important. (ID11) I haven't had any formal training in EBM. I don't actively practise EBM, I don't visit the Cochrane Institute. I'm aware of it but I don't actually regularly view it to see what's out there. My approach to medicine is a very practical approach and based on my experience and the knowledge of others. My skill set is complementary to others, so I

	use their skills. I'm not the sort of person who remembers detailed differential diagnoses or percentages but I know that that's not a good finding or a good finding or it requires this person to review and share their knowledge. We each have different skill sets. That's how I see my role.(ID13)
Grasping information dispersion	Because radiologists in most places are generalists, so you have to be able to do neuro, you have to be able to do gastro, you have to be able to do intervention, it's not actually possible to be at the top level of science in all those fields. (ID07) It's very hard to practice in a non-Google fashion in all of those fields. In some areas you'll be able to or if that's all you do you can, because you'd be up with the literature and you'll know about it otherwise you're kind of just going with a level of safety that's acceptable, but it's probably not the top end of care. (ID07)
Overriding pragmatism	
Perceptible applicability	[EBM] is completely foreign to my brain and I'm afraid that's why I haven't bothered to learn how to evaluate these things in a statistical analysis way…it's certainly not something I use for my day to day work. (ID14) I don't read journal articles to know about evidence based medicine per se, like meta-analyses I find less instantly useful. You have to spend a lot more energy on trying to pick out a tiny little fragment of useful data, so most of the time the article was justifying itself and talking about itself. I just sort of get to the crux of the matter, so yeah. (ID14) I look at their protocol in terms of what they do and then whether their outcome measures more than probably analysing the way they got the outcomes. (ID07) I'm not a boffin, I'm not an academic, I'm much more practical, and I'm not saying academics aren't practical…. I'm more operational. (ID23)
Preserving the art of medicine	They are probably more like spending time reading about things – learning from practice is more important than reading from it. You see a patient and if you make a mistake and know that you made a mistake you'll never do that again. But that is real medicine. That's real evidence-based medicine I tell you." (ID24) If everything gets based on evidence-based medicine we lost the art – this is my one piece of information you is that we lost the art of radiology...I don't think that is should be rigid. I think there needs to be room for the art of medicine. (ID14)
Technical demands	It's not looking for research articles, it's looking for information. As I said what does such and such a condition look like on ultrasound? You don't need a research article. (ID12) So I guess it's becoming more and more complex rather than just a film that you can read, but you have to go and find out how to do it and get the right sequences done and then on top of it you have to relearn your anatomy, because normally you don't see cartilage and soft tissues on other modality but the MR are coming on where you can see everything, so you have to know the tiny gritty bits there and capsules, the tendons and normally in old times you don't see it. So it's a fast-growing field that you have to keep on learning new tricks there, as well as refine what you knew before. (ID24)
Limited confidence	
Conceptual obscurity	I think we all aspire to practice it but we don't necessarily know how to and I think there's a lot of quasi - I'm not a victim and a perpetrator of it but there's a lot of quasi EBM going on. (ID07) if you asked me to list the different types of bias, I would have had great difficulty doing it. Just because I've never actually sat and thought through a framework. (ID03)
Reputation based trust	If it comes from a reputable journal within radiology… I would give more validity to or I tend to say oh well obviously if it's got through the editors it must be good. (ID08)
Demands constant practice	Certainly, going through critical assessment of particular papers, I think those sorts of exercises do develop our understanding and confidence in appraisal with more experience. I guess even in the department, having journal clubs and again, practising critical appraisal would help everyone in our department. (ID01)
Suspicion and cynicism	Lies, more lies, and statistics. You can make anything into anything when you know statistics. (ID 04) I've seen a few cases now where different meta-analyses will draw completely different conclusions from the same set of data analysing the same group of papers. (ID20) In my personal experience people usually decide what they want the reality to be and then harness the appropriate evidence that they want to support it, particularly in imaging. (ID20)
Competing powers	
Hierarchical conflict	We do not control the ultimate management of the patient because we are secondary referrals, so we are not the person that was in charge - that's the difficulty. (ID04) I mean there's a bit of a stigma in radiology, it's seen by some other specialties as being a bit of a service profession or service industry to the rest of medicine, in that we're just doing tests because the others decide that that test needs to be done that we do. (ID12)

	The doctors are covering their backside and being defensive; they're also being efficient. Right, you know it's quicker to get us to do a scan than it is to wait for the surgical registrar to get out of theatre and come and see the patient. And from their point of view it's probably also being of the patient's advocate in saying, I don't care if this only benefits one patient in a hundred; you do it for my patient. I'm just letting you know EBM to radiologists, it has that theme to it like it's all wonderful. But it's impossible for us to actually use. I shouldn't say impossible because that's an exaggeration, but it's difficult. (ID02)
Prevailing commercial interests	Radiology, cardiology, endoscopy, all the various other things where somebody gets paid for doing something, the temptation is to go and do it. You can always justify it to a certain extent. (ID18)

*Quotations identified only by ID to protect anonymity

Table 3. Suggested strategies for promoting evidence-based medicine in radiology

Key areas of improvement	Suggested strategies and action
Quality and quantity of evidence	• Fostering a research culture (e.g. clinician researcher interaction) • Link to academic institutions • Form multicentre research networks • Focus on the evidence base should be an integral part of multidisciplinary meetings
Access to evidence	• Mobile applications
Education and training	• Definition of EBM, emphasising the role of clinical expertise and patient preferences in EBM • Explain the pros and cons of Google and PubMed searches or other sources (STATdx) • Clarify the fundamentals of EBM being the evidence hierarchy • Demonstrate practice tips for using Cochrane to answer a clinical question • Provide a framework for critical appraisal • Setting EBM in context (not sacrificing clinical experience or the art of medicine) • Mandated training e.g. continuous medical education (CME) • Short courses in EBM (+ online support)
Applying EBM in practice	• Journal club meetings (include tools, feedback) – face to face or online • Ongoing training in using EBM, with assistance from experts such as clinical epidemiologists • Develop and disseminate evidence-based guidelines and protocols for referrers • Develop evidence summaries in clinical practice • Promote access to pre-appraised evidence based resources such as AJR guidelines
Empowerment	• Conduct audits of referral practices

CME, Continuous Medical Education, EBM, evidence-based medicine

Radiologists' perspectives about evidence-based medicine and their clinical practice: semi-structured interview study

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Abstract

Objectives: To describe radiologist's attitudes and perspectives on evidence-based medicine and their practice

Design: Face-to-face semi-structured interviews, thematic analysis

Setting: 24 institutions across six Australian states and New Zealand. Transcripts were imported into HyperRESEARCH software and thematically analysed.

Participants: 25 radiologists

Results: Six themes were identified: legitimising decisions (validated justification, prioritising patient preferences, reinforcing protocols), optimising outcomes (ensuring patient safety, maximising efficiency), availability of access (requiring immediacy, inadequacy of evidence, time constraints, proximity of peer networks, grasping information dispersion), overriding pragmatism (perceptibly applicability, preserving the art of medicine, technical demands), limited confidence (conceptual obscurity, reputation based trust, demands constant practice, suspicious and cynicism), and competing powers (hierarchical conflict, prevailing commercial interests).

Conclusions: Radiologists believe EBM can support clinical decision-making for optimal patient outcomes and service efficiency but feel limited in their capacities to assimilate and apply EBM in practice. Improving access to evidence, providing ongoing education and training supplemented with practical tools for appraising evidence; and developing evidence-based guidelines and protocols may enhance feasibility and promote the confidence and skills among radiologists in applying EBM in radiology practice for better patient care.

Article summary

Strengths and limitations of the study:

- Interviews were conducted until saturation and we recruited participants from a range of demographic characteristics, years of practice in radiology, and evidence-based medicine training.
- Participants were recruited from two countries and therefore transferability to other countries beyond Australia and New Zealand is uncertain.

Key messages:

- Radiologists believe EBM can support clinical decision-making for optimal patient outcomes and service efficiency.
- Capacities to assimilate and apply EBM were limited by barriers to accessing and appraising the evidence, perceived need for pragmatism and gaining practical experience, and contending with power hierarchies with referring physicians and commercial interests.
- Radiologists' perspectives on EBM are reflected in six major themes: legitimizing decisions, optimizing outcomes, availability of access, overriding pragmatism, limited confidence, and competing powers.

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Declaration of competing interests

The authors do not have any competing interests of conflicts of interest to declare.

Introduction

Evidence-based medicine (EBM) is the "integration of best research evidence with clinical expertise and patient values[1 2]" and is widely promoted as a tool to improve patient care. EBM was originally designed to address clinical problems within internal medicine, but has been generalised and expanded to enable applicability to other medical specialties. Recognised barriers to the optimal use of EBM in a variety of specialties include competing priorities and lack of time, inability to cope with "information explosion[3]", misconceptions about what constitutes quality evidence[4], lack of awareness of EBM resources[3], threat to professional autonomy[5 6], concerns about the trustworthiness of the data[5], fear of conflict with colleagues[7], and institutional dynamics and culture[8-10]. However, there is little information on how EBM is regarded and practised by radiologists and whether barriers to optimal use may differ.

For example, technological innovation in imaging and interventional technologies has intensified the demand on radiologists to assimilate the proliferation of new information to deliver safe and cost-effective care[11 12], and the promotion of new tests may occur prior to published evidence supporting widespread use. EBM use within radiology has not been examined, but a survey of radiation oncologists found widespread support for EBM, although most had not undertaken formal EBM training and were unaware of integral resources such as the Cochrane Library[3].

We aimed to describe radiologist's attitudes and perspectives on learning and applying EBM in practice, and in doing so, inform strategies for improving EBM training, and assist development of resources to facilitate greater use of EBM. This may help to foster appropriate decisions regarding imaging and interventional procedures for improved patient outcomes.

Methods

Participant selection and practice setting

Radiologists in Australia and New Zealand were purposively selected to capture a range of age, gender, years of clinical experience, radiology sub-specialties, EBM training, and practice locations. Invitations were emailed to radiologists enrolled in the critical skills appraisal program at The University of Sydney (July 2013) or were attending an Annual Scientific Meeting (October 2013). Radiologists known to the investigators were also invited and participants could nominate other radiologists who could offer a different perspective about EBM. Interviews were conducted in meeting rooms, clinic offices, conference venue. The University of Sydney provided ethics approval and all participants provided informed consent.

Data collection

The interview guide was based on a review of the literature [3-8 13 14] and discussion among the research team (Box 1). AT conducted a face-to-face semi-structured interview with each participant from July to November 2013. Participant recruitment ceased when theoretical saturation was reached i.e. when little or no new concepts were being raised in subsequent interviews. All interviews were audio-recorded and transcribed.

Analysis

The transcripts were entered into HyperRESEARCH software (ResearchWare, US Version 3.0, Randolph MA, United States) for coding qualitative data. Based on the principles of grounded theory (to develop a theory or explanation that is grounded in the data collected) [15] and thematic analysis, AT read the transcripts, conceptualised and coded all sections relating to radiologists' perspectives on EBM into concepts identified inductively in the data; and created new codes when necessary. These were reviewed by SM who also read the transcripts. This can help to ensure that ensure data were captured in the preliminary codes. Similar concepts were grouped into themes and subthemes. Patterns and conceptual links between themes were mapped into a thematic schema. Member checking was conducted whereby participants were sent a copy of the preliminary analysis and given two weeks to suggest additional opinions. These were integrated into the final thematic analysis. This ensures that the findings reflect and captures the full breadth of data from the participants.

Results

Twenty-five radiologists from 24 institutions across 6 Australian states and New Zealand participated. Non-participation (n=6) was due to travel and clinical commitments. The mean duration of interviews was 35 minutes. Participant characteristics are provided in Table 1.

We identified six major themes: legitimising decisions, optimising outcomes, availability of access, overriding pragmatism, limited confidence, and competing powers. Illustrative quotations for each theme are provided in Table 2/Supplementary File 1. A thematic schema illustrating the conceptual links among themes is shown in Figure 1. EBM was believed to support clinical decision-making for optimal patient outcomes and service efficiency, but radiologists' capacities to assimilate and apply

EBM were limited by barriers to accessing and appraising the evidence, perceived need for pragmatism and gaining practical experience, and contending with power hierarchies with referring physicians and commercial interests. A description of the themes and subthemes are provided in the following section. Most of the themes apply to both interventional and diagnostic radiology; however results that were specific to either interventional (therapeutic) or diagnostic radiology will be indicated.

Legitimising decisions

Validated justification

EBM provided a framework to make clinical decisions based on science, rather than anecdotal data. EBM "added weight, added experience and evidence behind decisions". And some participants felt reassured when research "validated their own experiences", and EBM was regarded as an opportunity "to borrow information and techniques from other people who have been using them more."

Prioritising patient preferences

Shared-decision making was regarded as important though some felt that patient preferences contradicted EBM. For example, they felt unable to deny patients who wanted treatment even when the evidence suggested that the therapeutic intervention~~it~~ would not be cost-effective or beneficial.

Reinforcing protocols

EBM was regarded as useful for developing evidence-based protocols and guidelines. This was particularly relevant in directing decisional pathways for inexperienced referrers. Protocols were seen

to protect radiologist's decisions as "you get in trouble for missing something, you don't get in trouble for over-investigating something."

Optimising outcomes

Ensuring patient safety

Some were convinced that EBM had demonstrable impact on ensuring safe patient care. There was reference to studies assessing safe dosages of gadolinium in patients with renal impairment, reducing the incidence of nephrogenic systemic fibrosis. Participants remarked on the "increasing number of normal examinations which meant they were scanning more people, and that they were not selecting them correctly." They felt a burden of responsibility – "we definitely do cause the public harm, we just don't know how many [malignancies] is due to us yet" and believed that applying EBM in diagnostic radiology could reduce over-exposing patients to unnecessary ionizing radiation and risk of malignancies.

Maximising efficiency

Participants felt certain that the financial costs to public hospitals incurred by performing excessive radiologic tests and procedures could be minimised by applying EBM. Some suggested that evidence-based referral guidelines may reduce the number of unnecessary diagnostic tests ordered by referrers and improve economic and service efficiency.

Availability of access

Requiring immediacy

Simple and direct access to information was important. Most used Google or PubMed as their primary search engine. Some relied on email updates or review articles to keep up-to-date. Evidence summaries offered information that "had already been critically appraised, filtered out so most of the rubbish wasn't there." Being unable to access journals due to institutional restrictions "added an extra element of difficulty" however, some participants who had received EBM training felt confident about searching for high-quality scientific research using MEDLINE and the Cochrane Library.

Inadequacy of evidence

Radiological technologies often "progressed before the evidence could come out." Some observed that diagnostic procedures (for example, CT angiograms for vertebral artery dissection) were used without supporting evidence. In radiological research, some felt that relevant outcomes could not be feasibly measured, for example if it necessitated surgical or autopsy proof. Research in diagnostic imaging was unavailable particularly for rare clinical cases. They felt that, "there's no culture of [radiology] research except in little pockets and enclaves in different institutions few and far between."

Time constraints

The "fast-growing field" of radiology meant participants felt without capacity to be "a true academic," engage in research, and "to go through everything we do and find the evidence to prove that that's the best method or way of doing something." Instead of an appointment-based patient caseload,

radiologists had to manage a continuous inflow of patients, which was more difficult to keep manageable particularly if working in a smaller radiology department, or in the private sector. Some reviewed the literature only when required to, for example when preparing for presentations.

Proximity of peer networks

Participants relied on their colleagues to discuss and resolve cases. In larger radiology departments, participants could readily contact experienced colleagues for advice. One participant stated, "my approach to medicine is a very practical approach and based on my experience and the knowledge of others, my skill set is complementary to others so I use their skills." Interventional radiologists valued practical suggestions from colleagues about procedures and participants attended conferences to learn about new procedures and protocols, then turned to "selected articles on the nuts and bolts, assuming that somebody has looked at the utility of the procedure."

Grasping information dispersion

The field of radiology was described as broad, "dynamic," and all-encompassing of different sub-specialties which augmented the challenge of keeping up with the literature – "radiologists in most places are generalists, you have to be able to do neurology, gastroenterology, intervention, it's not actually possible to be at the top level of science in all those fields." They felt "confounded by the plethora of information that you can't filter anymore." Radiologists practising within a narrow sub-specialty felt better able to remain aware of the current literature in their area.

Overriding pragmatism

Perceptible applicability

From a practical perspective, some judged the clinical relevance of a research article rather than the methodology. One participant reflected, "I'm not an academic, I'm much more practical, I'm more operational." They would "look at what they do and the outcomes measures more than analysing the way they get the outcomes." Research results that were too broad or excluded relevant patient groups made it difficult to extrapolate or assess the transferability of the findings to their own patient population or to an individual patient – "like meta-analysis, you have to spend more energy on trying to pick out tiny fragments of useful data, so most of the time the article was justifying itself and talking about itself, I just want to get to the crux of the matter."

Preserving the art of medicine

There was anxiety that "if everything gets based on evidence based medicine, we lose the art of radiology." Participants with more years of experience believed in learning from practice, observing senior colleagues, and developing expert intuition, more so than "reading about things" as EBM could "never capture the whole story."

Technical demands

The technological advances in radiology placed demands on participants to prioritise their technical competence and knowledge of anatomy and pathology. They had to "keep on learning new tricks, as well as refine what they knew before" and studied textbooks and "didactic" articles rather than

scientific research publications – "What does such a condition look like on ultrasound? You don't need a research article."

Limited confidence

Conceptual obscurity

The perceived complexity of concepts, mainly relating to critical appraisal and statistical analysis, was overwhelming. Many described their judgment about study validity as "superficial" and felt they lacked a framework for critically appraising an article – "we all aspire to practice EBM but we don't necessarily know how to and I think there's a lot of quasi EBM going on." Some assessed articles based on sample size, participant characteristics, and blinding. Also, some believed a high-level understanding of statistics was required for EBM, perceived to be daunting, "we've come out of it with this monster that most of the radiologists don't know how to cope with, most of us left statistics behind in high school, we don't have this analysis in our brains."

Reputation-based trust

Participants trusted journals with high impact factors, and articles from reputable institutions with experienced authors. They placed confidence in editorial integrity and expertise to ensure that only high-quality and valid research articles were published.

Demands constant practice

EBM was a skill that required ongoing practice. Participants suggested regular EBM training, and journal clubs to maintain EBM proficiencies, such as conducting critical appraisal.

Suspicion and cynicism

Some were suspicious of authors who might be misusing research to push their own agenda, "People usually decide what they want the reality to be and then harness the appropriate evidence that they want to support it." For example, in diagnostic cardiac imaging, one participant observed nuclear physicians advocating for nuclear medicine while cardiologists were promoting stress echocardiogram, and both presented compelling arguments supported by research. Contradictory results also perpetuated cynicism of EBM, "I've seen a few cases where different meta-analyses will draw completely different conclusions from the same set of data analysing the same papers." Some were wary of academic competition, and the "politics of journals, and personal egos." However, multiple independent studies which demonstrated confirmatory findings, provided reassurance.

Competing powers

Hierarchical conflict

Disempowerment prevented the practice of EBM. Some radiologists felt that referring physicians perceived them as service providers rather than as consultants. They viewed that "referrers don't feel that radiology should be gate keepers." Being "secondary referrals" most radiologists did not control patient management and lacked clinical information about the patient. Some resigned themselves to

"defeat" and "dogmatism" as they continued to perform tests they regarded as unnecessary. At times, there was a palpable tension between keeping referrers satisfied and advocating for the patient's safety and preventing them from being "irradiated just for expediency rather than a clinical indication". Some tried to "battle" with referrers but withdrew from the "uneven playing field". More senior participants felt that referrers respected their recommendations.

In certain radiology sub-specialties including paediatrics, oncology, and obstetrics, radiologists participated in multi-disciplinary meetings and valued the active engagement in patient management where their expert opinion contributed to the broader decision-making. Participants appreciated this "cross-pollination" of information and clinical history.

Prevailing commercial interests

Private radiology centres faced the pressure of "generating revenue to keep the practice going", which was perceived to nullify any impetus to implement EBM. Some believed that "evidence-based medicine will never work in an item for service based medical culture" and there was "no real incentives for doctors to do the right thing" in referring patients for radiological diagnostics tests. To protect a thriving business, they kept referrers satisfied by fulfilling their radiologic requests, even when it was not evidence-based.

Discussion

Although radiologists appreciate the role of EBM in improving patient care, misperceptions of the definition of EBM, a lack of critical appraisal skills and an under appreciation of how EBM could help resolve common tensions within daily practice limited its optimal use. EBM is defined as the integration of best research evidence with clinical expertise and patient values however some participants thought that EBM supplanted clinical expertise and therefore rejected it as being exclusive of clinical wisdom. A common tension cited by many participants was the performance of unnecessary tests, contributing to excess cost and increased exposure to radiation, however many felt helpless to refuse the request. However, when evidence-based guidelines were available to support appropriate imaging pathways, radiologists felt more confident in negotiating referrals.

Some of the barriers to implementing EBM we identified have been reported in other areas of medicine and health. Studies conducted in internal medicine and surgery found that confusion about EBM terminology, team dynamics, staff disapproval, and time constraints prevented residents from practising EBM[7 8]. In primary care, EBM was perceived by some physicians as devaluing the "art" of medicine and a threat to their professional autonomy, and were concerned about industry influence[5]. Another study found that healthcare providers preferred tested, convenient and respected evidence sources including professional societies and expert colleagues[4]. There are unique features in radiological practice: the limitations of being perceived as a service provider rather than an "expert consultant", the demands of maintaining technical competence, the requirement for detailed but stable knowledge of anatomy and pathology, and the challenges of keeping up in a field of rapid technological advances.

While understanding and use of EBM is widely accepted as a core competency of clinical practice, this is the first study to explore understanding and barriers to use in radiology. We conducted interviews

until little or no new concepts were emerging from subsequent interviews (theoretical saturation), and included participants from a range of demographic characteristics, years of practice in radiology, and EBM training. Also, participants were asked to provide feedback on the preliminary findings (member checking). However, our study has potential limitations. Participants were recruited from Australia and New Zealand therefore the transferability of the findings to other regions may be limited, although similar barriers have been identified in studies conducted in different settings[16], suggesting broader applicability.

The acquisition and application of EBM skills including literature searching, critical appraisal of articles and interpretation of diagnostic tests and their limitations is essential to competent clinical care[12]. Several resources have been published in radiology literature[12 17]. However, barriers related to the availability and access to evidence, unmet education and training needs, pragmatic and structural difficulties that need to be addressed. Based on our findings, we suggest key target areas, strategies and actions for promoting EBM awareness and implementation (Table 3).

Moving EBM teaching from the classroom to clinical practice settings has been strongly advocated to improve knowledge, critical appraisal skills, attitudes and behavior[18]. The few strategies to clinically integrate EBM teaching which have been evaluated include daily EBM teaching rounds in which searches and study appraisals are based on cases presented at clinical rounds[19], journal clubs[20], and EBM ward round sessions led by a clinical specialist and epidemiologist to develop clinical questions, literature search, critical appraisal and development of evidence summaries[21]. While these teaching methods are effective, more specific evaluation of these strategies is needed in radiology.

It has been recognised that evidence-based practice should be taught from an early stage in medical and radiologic education[22 23]. Current models for educating evidence-based practice include having trained

epidemiologists to deliver regular teaching and interactive sessions which encompass theory, self-directed learning, and application to clinically relevant questions; or providing training workshops or teaching EBM in postgraduate meetings which cover the principles of EBM[22]. Our study has highlighted important implications for teaching EBM within radiology. Skills that require greater emphasis included literature searching and critical appraisal. A recent survey found that radiologists and trainees preferred Google, customised radiology-focussed produces and apps, and online resources to solve imaging questions[16]. Evidence summaries or EBM guidelines could be developed and disseminated via these channels. Confidence in appraisal skills could be improved with wider use of EBM tools[24]. For most EBM skills, a mix of educational strategies is likely to be most effective in increasing skills including interactive online courses, journal clubs and seminars[25].

While our findings are likely to have some commonality across geographic regions, further studies on barriers to EBM in different areas would be enlightening. Teaching strategies that are most helpful to radiologists should be clarified, as these may not be the same as those for bedside practitioners. Studies of implementation of evidence-based guidelines for imaging pathways and whether these improve patient important outcomes and cost are also needed.

Better access to evidence, ongoing education and training supplemented with practical tools for appraising evidence; and developing evidence-based guidelines and protocols may promote optimal use of EBM within radiology, and ultimately translate to better patient care.

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Contributions

AT participated in the design of the study, did the interviews, transcribed the interviews, carried out the thematic analysis and drafted the manuscript. SM, JCC, CL designed the study, participated in the thematic analysis, and provided critical review of manuscript drafts. GL, AJP participated in the design of the study, assisted with the analysis, and provided intellectural input into subsequent manuscript drafts. All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; drafting the article or revising it critically for important intellectual content; and provided final approval of the version to be published. All authors had full access to all of the data in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

Ethics approval

All participant provided writte and voluntary informed consent. The study was approved by the University of Sydney Ethics Committee (20130616).

Data sharing

No additional data are available.

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Box 1. Interview guide

1. Role as a radiologist/radiology trainee
    a. What is your current position and how many years have you been working in that role or what year of training?
    b. Working as a radiologist/trainee, what are the some of the most difficult, common, or complex issues/decisions you have faced and how do you deal with them (e.g. when interpreting images)?
2. Knowledge about evidence-based medicine (EBM)
    a. How would you define evidence-based medicine or what is the first thing that comes to mind when thinking about EBM?
    b. How you rate your knowledge or understanding about EBM from 0 (lowest) to 10 (highest – most knowledgeable) – why?
    c. What educational sources do you use to inform your practice? What resources or how do you go about interpreting diagnostic tests? (STATdx, Up to date, guidelines and protocols, experience and intuition, other colleagues' opinions, decision aids or online resources such as calculators)
    d. Can you comment on the level of trust you have in these resources – what makes you trust it more/less? (journal reputation, authors, sample size)
    e. What aspect of EBM do you find most challenging or difficult – why? (asking answerable questions, searching, appraising, analysis or synthesis, interpreting the data, applicability to individual patients or applying EBM in your day to day practice)
    f. What EBM concepts of terms do you feel you understand the least/most?
3. Evidence-based medicine training
    a. What was the most/least interesting or valuable thing you learnt in EBM – why?
    b. How you rate the importance of EBM training to your - clinical practice from 0 (least) to 10 (most important) – why?
    c. How would you improve EBM teaching i.e. what teaching methods do you believe would be most effective in helping radiologists apply EBM in their practice – why? (journal club, study appraisal)
4. Applying EBM in practice
    a. Can you describe the role EBM has in your overall clinical decision making? Have you applied EBM in practice – how/give an example?
    b. Do you believe there are benefits in applying EBM in radiology practice - why? (service efficiency, costs, patient care, develop guidelines)
    c. What are the challenges or barriers in applying EBM in day-to-day practice? (service provision vs. consultative, not sure where to find resources to guide its use (access), unsure of the validity of a checklist compared with clinical reasoning, competing priorities, concern about the trustworthiness of the evidence, threat to clinical autonomy, financial interests, potential to cause conflict, contradictory data, information overload)
    d. What can you suggest would facilitate the application of EBM into day to day practice? (Evidence summaries, technology and tools)
    e. Do you think EBM is more relevant for the clinical aspects of radiology such as interventional radiology rather than diagnosis - why?
    f. Compared with other medical specialties, do you think radiology lags behind, is equal or, or is more advanced in terms of EBM knowledge and application – why? (research culture, limited research evidence)
    g. Does learning about EBM make you more or less likely to undertake research to answer clinical issues you have encountered - why?

Figure Legends

Figure 1. Thematic Schema

Table 1. Participant characteristics

Participant characteristics (n=25)	No. of participants	%
Sex		
Men	20	80
Women	5	20
Age (years)		
30-39	3	12
40-49	11	44
50-59	5	20
60-69	6	24
Years of practice in radiology		
≤10	5	20
11-20	10	40
21-30	6	24
>30	4	16
Training in evidence-based medicine		
Yes*	12	48
No	13	52
Radiology subspecialty*		
Breast imaging	3	12
Cardiovascular	8	32
Chest	7	28
Emergency	9	36
Gastrointestinal	8	32
General radiology**	4	16
Genitourinary	8	32
Head and Neck	6	24
Interventional	11	44
Musculoskeletal	13	52
Neuroradiology	9	36
Nuclear radiology	3	12
Obstetrics and gynecology	1	4
Paediatric radiology	5	20
Vascular	1	4
Type of practice		
Public	23	92
Private	2	8

*Includes short courses, formal evidence-based medicine training during medical school; **Multiple subspecialties can be indicated by a participant; ***as identified by the participant and includes most subspecialties.

Table 2. Illustrative quotations

Theme	Illustrative quotations*
	Legitimising decisions
Validated justification	I suppose the antithesis would be anecdotal medicine, so you're getting away from what you perceive, or what you think is the correct way to behave, what you had thought before. What you're trying to do is be critical about what you do and see if there's scientific basis to support the way you practise medicine. (ID08) The most valuable is that if you can confront a clinician and say that a certain practice is the right practice. To do a certain test in a certain scenario, if you have evidence that shows that that's the best practice then it's easier to stand your ground and then say we shouldn't be doing this and we should be doing it the other way because there is research that suggests that's the best practice. If you don't have that sort of research it's very hard to back up your opinion. (ID05) So it's nice when research validates your own experiences. (ID17)
Prioritising patient preferences	How can I deny a patient treatment? That's the problem with it. Even if the evidence-based medicine says you shouldn't treat this patient. For example you are a patient, I can't say, this evidence says you shouldn't be treated but the patient still wants it, what do you do? That's the ethical dilemma. (ID15)
Reinforcing protocols	We have in the department guidelines to help people to request certain radiology procedures on the basis of what was published. This is the evidence that you should go down this pathway and don't ask for anything more. (ID21)
	Optimising outcomes
Ensuring patient safety	We would decrease the amount of ionisation radiation as we give to the public, which hopefully then would decrease the number of malignancies that we cause. We definitely do cause them, given on a population level, we just don't know how many is due to us, yet. (ID04) Perhaps one area where evidence-based medicine has had a benefit in paediatrics is the reduction in imaging for vesicoureteral reflux. There's been no improvement or change in the incidence of chronic renal disease in children as a consequence of treatment of urinary tract infection or treatment of reflux. So that has totally changed the management. Seven or eight years ago I was doing MCUs on children up to five years old and there were probably five or 10 on a list. Now it's down to less than one because of evidence-based medicine showing that the treatment doesn't - the investigation and treatment doesn't change outcome. (ID13) So the literature that appeared over that period of time has really changed the way that I think about using gadolinium in renal impairment. I'm not as scared to use it anymore providing I stick to guidelines with regard to the estimated GFR. (ID25)
Maximising efficiency	Service efficiency, there is a safety aspect in that they don't have to undergo other tests as well, more invasive tests, and economic from the point of view that they're not taking up further resources in the hospital which could be used for other people. (ID01)
	Availability of access
Requiring immediacy	If I really need an article that is not available I get the library to get it for me, but that adds an extra element of difficulty, so I tend to just ignore the ones - not ignore, but I tend to find a free access version if I can, not of the same study but as best I can. (ID04) MEDLINE - unfortunately a lot of the time you can't get in journals what you want and a lot of the time they only give you the abstracts there, so that's where the Google comes into it, because HighWire provides a lot of free journals there. You can actually go to the full journal rather than just the abstract. I guess I can always go to the university library and find out but it takes a long while to get in there. (ID24)
Inadequacy of evidence	The technology's there and you're playing catch up really. It jumps ahead, the lag is apparent. (ID07) Often the outcomes aren't measurable. So you may see certain findings but you'll never find out because that patient doesn't have the joint opened up or - so the outcome that you're measuring or the gold standard, there may not be a gold standard in a lot of the studies – where you have surgical proof or autopsy proof. (ID25)
Time constraints	It's a lot of time so sometimes it's obviously easier just to say it needs follow-up or repeat imaging rather than taking time out to consult a study. (ID13) I guess you can't be really a true academic because the clinical service is so demanding. You just don't get time to do it. (ID24)
Proximity of peer networks	Colleagues' opinions, because I'm doing some interventional stuff, and often, the interventional has much less research. If you get into trouble, try this, and, have you thought about doing this, and, here's another approach. They are not the stuff that gets written up. It's more just because it's a "doing" rather than a "thinking about" bit. So, for those things, talking to colleagues is much more important. (ID11) I haven't had any formal training in EBM. I don't actively practise EBM, I don't visit the Cochrane Institute. I'm aware of it but I don't actually regularly view it to see what's out there. My approach to medicine is a very practical approach and based on my experience and the knowledge of others. My skill set is complementary to others, so I

	use their skills. I'm not the sort of person who remembers detailed differential diagnoses or percentages but I know that that's not a good finding or a good finding or it requires this person to review and share their knowledge. We each have different skill sets. That's how I see my role.(ID13)
Grasping information dispersion	Because radiologists in most places are generalists, so you have to be able to do neuro, you have to be able to do gastro, you have to be able to do intervention, it's not actually possible to be at the top level of science in all those fields. (ID07) It's very hard to practice in a non-Google fashion in all of those fields. In some areas you'll be able to or if that's all you do you can, because you'd be up with the literature and you'll know about it otherwise you're kind of just going with a level of safety that's acceptable, but it's probably not the top end of care. (ID07)
Overriding pragmatism	
Perceptible applicability	[EBM] is completely foreign to my brain and I'm afraid that's why I haven't bothered to learn how to evaluate these things in a statistical analysis way…it's certainly not something I use for my day to day work. (ID14) I don't read journal articles to know about evidence based medicine per se, like meta-analyses I find less instantly useful. You have to spend a lot more energy on trying to pick out a tiny little fragment of useful data, so most of the time the article was justifying itself and talking about itself. I just sort of get to the crux of the matter, so yeah. (ID14) I look at their protocol in terms of what they do and then whether their outcome measures more than probably analysing the way they got the outcomes. (ID07) I'm not a boffin, I'm not an academic, I'm much more practical, and I'm not saying academics aren't practical…. I'm more operational. (ID23)
Preserving the art of medicine	They are probably more like spending time reading about things – learning from practice is more important than reading from it. You see a patient and if you make a mistake and know that you made a mistake you'll never do that again. But that is real medicine. That's real evidence-based medicine I tell you." (ID24) If everything gets based on evidence-based medicine we lost the art – this is my one piece of information you is that we lost the art of radiology...I don't think that is should be rigid. I think there needs to be room for the art of medicine. (ID14)
Technical demands	It's not looking for research articles, it's looking for information. As I said what does such and such a condition look like on ultrasound? You don't need a research article. (ID12) So I guess it's becoming more and more complex rather than just a film that you can read, but you have to go and find out how to do it and get the right sequences done and then on top of it you have to relearn your anatomy, because normally you don't see cartilage and soft tissues on other modality but the MR are coming on where you can see everything, so you have to know the tiny gritty bits there and capsules, the tendons and normally in old times you don't see it. So it's a fast-growing field that you have to keep on learning new tricks there, as well as refine what you knew before. (ID24)
Limited confidence	
Conceptual obscurity	I think we all aspire to practice it but we don't necessarily know how to and I think there's a lot of quasi - I'm not a victim and a perpetrator of it but there's a lot of quasi EBM going on. (ID07) if you asked me to list the different types of bias, I would have had great difficulty doing it. Just because I've never actually sat and thought through a framework. (ID03)
Reputation based trust	If it comes from a reputable journal within radiology… I would give more validity to or I tend to say oh well obviously if it's got through the editors it must be good. (ID08)
Demands constant practice	Certainly, going through critical assessment of particular papers, I think those sorts of exercises do develop our understanding and confidence in appraisal with more experience. I guess even in the department, having journal clubs and again, practising critical appraisal would help everyone in our department. (ID01)
Suspicion and cynicism	Lies, more lies, and statistics. You can make anything into anything when you know statistics. (ID 04) I've seen a few cases now where different meta-analyses will draw completely different conclusions from the same set of data analysing the same group of papers. (ID20) In my personal experience people usually decide what they want the reality to be and then harness the appropriate evidence that they want to support it, particularly in imaging. (ID20)
Competing powers	
Hierarchical conflict	We do not control the ultimate management of the patient because we are secondary referrals, so we are not the person that was in charge - that's the difficulty. (ID04) I mean there's a bit of a stigma in radiology, it's seen by some other specialties as being a bit of a service profession or service industry to the rest of medicine, in that we're just doing tests because the others decide that that test needs to be done that we do. (ID12)

	The doctors are covering their backside and being defensive; they're also being efficient. Right, you know it's quicker to get us to do a scan than it is to wait for the surgical registrar to get out of theatre and come and see the patient. And from their point of view it's probably also being of the patient's advocate in saying, I don't care if this only benefits one patient in a hundred; you do it for my patient. I'm just letting you know EBM to radiologists, it has that theme to it like it's all wonderful. But it's impossible for us to actually use. I shouldn't say impossible because that's an exaggeration, but it's difficult. (ID02)
Prevailing commercial interests	Radiology, cardiology, endoscopy, all the various other things where somebody gets paid for doing something, the temptation is to go and do it. You can always justify it to a certain extent. (ID18)

*Quotations identified only by ID to protect anonymity

Table 3. Suggested strategies for promoting evidence-based medicine in radiology

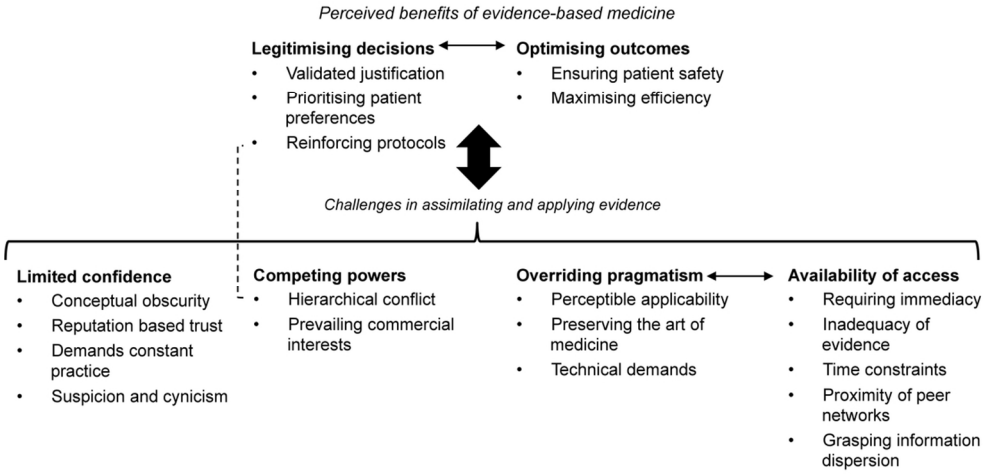
Key areas of improvement	Suggested strategies and action
Quality and quantity of evidence	• Fostering a research culture (e.g. clinician researcher interaction) • Link to academic institutions • Form multicentre research networks • Focus on the evidence base should be an integral part of multidisciplinary meetings
Access to evidence	• Mobile applications
Education and training	• Definition of EBM, emphasising the role of clinical expertise and patient preferences in EBM • Explain the pros and cons of Google and PubMed searches or other sources (STATdx) • Clarify the fundamentals of EBM being the evidence hierarchy • Demonstrate practice tips for using Cochrane to answer a clinical question • Provide a framework for critical appraisal • Setting EBM in context (not sacrificing clinical experience or the art of medicine) • Mandated training e.g. continuous medical education (CME) • Short courses in EBM (+ online support)
Applying EBM in practice	• Journal club meetings (include tools, feedback) – face to face or online • Ongoing training in using EBM, with assistance from experts such as clinical epidemiologists • Develop and disseminate evidence-based guidelines and protocols for referrers • Develop evidence summaries in clinical practice • Promote access to pre-appraised evidence based resources such as AJR guidelines
Empowerment	• Conduct audits of referral practices

CME, Continuous Medical Education, EBM, evidence-based medicine

List of Supplementary Files

Supplementary File 1. Additional quotations

Supplementary File 2. COREQ criteria



110x53mm (300 x 300 DPI)

Supplementary File 1. Additional quotations

Theme	Illustrative quotaions
Legitimizing decisions	
Validated justification	That's an exciting way of doing medicine, rather than postulate what is going to be good for the patient or not. With this you've got a result to back you up that you're doing the right thing. (ID01)
	We're now looking at how the blood flows in the brain for all the sickle cell anaemia children. They are more prone for strokes there and the Americans experience more than us because they have more blacks than our population, so there are more sickle cell disease there and they publish their data there, then we have to use their techniques there and see whether - of course, we're getting more and more Africans coming to the country and in haematology one has to provide similar services there, then we have to borrow the information and techniques from other people who have been using them more than us. (ID07)
	I think we're sort of leaning the side that we think that there's enough evidence that it's reasonable to do in most patients, but then we have had some complications and so it's made us relook at that evidence. (ID07)
	It's a framework to make clinical decisions and actions which is supported by science effectively. It's a support for your day to day work based on what's known. (ID07)
	Everyone strives to best practice but we also are a bit defensive in terms of legalities of practice. So if you can have support from the academic - well the scientific knowledge base, if you're working on that principle obviously things go wrong but if your principles are based in that then you probably are on a more solid ground legally, but also in terms of giving adequate and safe patient care. (ID07)
	You would make a diagnosis or you would institute a certain type of treatment based on proper researched data, using control groups, so that you have data that really reflects what actually is happening rather than anecdotal data. A lot of the therapies like musculoskeletal injections that are done, a lot of that is anecdotal evidence. There's no good quality research where you have control groups that are given an injection of saline instead of cortisone. (ID25)
	That's what makes our profession stand out, is that we do by and large strive to have evidence-based practice. So rather than rely on anecdotal evidence like some of the allied - or some of these alternative medical practices do, we try and run proper scientific studies. I think that's one major thing that stands out. (ID25)
	I guess you're referring to the build-up of knowledge and nowadays that's usually in journals on the internet, so you're talking about the weight of knowledge up to the present that supports a particular viewpoint in decision-making. (ID14)
	EBM is forming clinical decisions, performing your job as a clinician basing your decisions on precedent. What's happened before us that has been proved or experience that has been gained and backed by evidence. If you have a case and you want to know a bit more about it you search the internet, you see that papers have been written that have been very well researched and have had really strong peer review and then those opinions are gold. They replace case based reports and anecdotes from people. So, it's kind of adding weight, adding experience and evidence behind your decisions. (ID17)
	I've tried to convince the clinicians that doing a CT scan before a lumbar puncture is not indicated, by giving them five or six very good articles on why it's useless and had no success. So that is a good example of how successful or unsuccessful we have been. I do a lot of intervention, I'm an interventional radiologist. A couple of interventions they have shown to be of benefit or of no benefit that I'm asked to do or not to do, and everyone still ignores it and does what they want anyway, even the clinicians. (ID04)
	Well I did this, because this is what our peers are suggesting should happen. If it went horribly wrong, I did my best. So there is protection for the practitioners by following the rules. (ID23)
	Especially cases with higher complication rate, the more evidence I want that I'm on the right track and I'm doing the right thing and that I'm not doing harm, other than also protecting myself against litigation of course. (ID21)
	[EBM is] a process whereby medicine is evolved based previous empirical data, and created a format for treatment and management and patients. So, there will be a question, then there'll be a patient population and then there will be either an intervention of some sort of understanding what to do with this patient - or what the problem is, and then working out what is most effective, and then finding out whether it actually is real or not real. (ID10)
	It's the processes and decisions are made - what we do has some sort of scientific basis to it. It's proven and not just assumed, just what people generally do, what's the habit. So I suppose it's that there is good evidence for what you're doing. (ID16)
	So because those researchers have done some evidence-based research work although it may not be the perfect, at least it's some evidence to direct me to yes or no to treat the patient. (ID15)
	Well it's using collective knowledge to actually ensure best practice rather than just using gut feeling or just a simple protocol, you're actually using the evidence of multi-institutional or multiple studies combined to give guidelines to that what is best practice or what works in the most number of patients. (ID13)

	Then if you have to change [the decision of referrers], you have to really - they have to undergo this evidence-based medicine to disprove them. (ID09)
	think after all you want results there, especially at this time where everyone wants to see whether they're justified or not. You can't do fancy things without anything backing it up. (ID24)
	It was a prospective paper where they changed a protocol and analysed the results after and before. It was of substantial size, there were enough to make it statistically significant, and it had enough power in it. I thought it was well designed. It was a simple paper that answered a simple question. I love research that does that, I don't like complexity. I've got one question, how do I answer it? There's the answer, move on. It came from a big centre, so there were a whole bunch of reasons why I liked it. I kind of liked it because it was agreeing with what I've always thought, but just hadn't been able to prove. So it's nice when research validates your own experiences. (ID17)
	EBM to me is current clinical practice that has been proven - I don't know whether proven is the right word - that that's the best practice or application for that particular problem in this point in time. Obviously that might change with new research coming out, but whatever is supposed to be best practice right now. (ID05)
Prioritizing patient preferences	But then you have a patient in front of you and how do you deny treatment? It's easy to deny when the patient is moribund, you can say you're not going to live for more than a few weeks, there's no point treating you and they accept it. But you can't tell the patient in front of you you're going to die in two years because you don't know. So how do you make a decision? (ID24)
	Shall we say for instance they come with an aneurism, so do you want to treat them or not because at that age their lifespan, they're crossing the - their expected lifespan has been crossed and do we want to treat them or not. There is no real clinical evidence such as we should treat them or not or we should - we don't know. So we treat them, but that's a money - usefully spent is a question that I always have to deal with in my work. Because each of these procedures costs $40,000 to $50,000. (ID15)
	The other difficulty I also face is a patient has a lot of vascular disease and therefore the foot is falling off it's very diseased. So whether you treat them or not - you are - true we spend a couple of about two hours three hours spent on them with a lot of catheters and vials and all that stuff you have to use. Then of course will the money, not as much as the other ones but it does cost a lot of money and your time which you can sometimes employ somewhere else. But we know by experience again not truly evidence-based but the evidence is still coming out they don't respond that well. So because in about six months and they lose their leg anyway. So my other question is, is a patient worth having their leg for six months before they go? (ID15)
	The patients do get a say. It is mainly patient dominated rather than doctor dominated so that's a bit difficult. Because even if you tell the patient it's going to recur but they always cling to the last rope like everybody does so that's difficult. (ID15)
Reinforcing protocols	What we need to do is to put some guidelines in place and then with regard to that we've looked for, we've done some research and looked in other guidelines and tried to bring in some direction for the departments which is obviously evidence-based. (ID08)
	Through my training, I've always questioned why we routinely give oral contrast. Some people do, some people don't, and I found that through my training I was using it less and less, because I didn't think it was as beneficial. The detriment is it takes about two hours for prep, for the patient to drink the contrast. So there's a two-hour delay before you can do the scan. So based on that paper, the paper basically said there was no need, and I changed our emergency protocol and I made it official through our whole department and I got emergency involved. They loved it because it meant that patients weren't waiting. So, I've used the paper to change a protocol and actually, a registrar and I are about to go through the statistics of 1000 cases; 500 before and 500 after the protocol changed to see if it did change turnaround times. (ID17)
	So, yeah, there has been - oh, another example, in subarachnoid haemorrhage, CT for subarachnoid haemorrhage in emergency patients. We found that we're being asked more and more to do CTA, CT angiography, after the initial non-contrast CT head was negative. There wasn't much support in the literature and we got a whole bunch of papers together and then I kind of coordinated a group led by a couple of neurosurgeons and a couple of emergency physicians, and I was the radiology representative. We formed a tri-departmental protocol that we use now in emergency so we're not over scanning patients. We haven't done any validation audits yet, but we plan to. But that was quite good because we were saving radiation for patients when there was no clear indication in the literature to support it. So those two are actually quite big, we should - amazing, I'd almost forgot about them. (ID17)
	I think it helps drive protocol. Protocol in a big department where you have lots of inexperienced people referring is quite important. A lot of people don't like protocol driven radiology because it means you don't really have to think, you just tick boxes and then if you meet a criteria, then you get a scan. But I think it's good to have protocols to fall back on. I think every case is an individual case and requires discussion. But forming protocols that allow junior doctors in the middle of the night to have a piece of paper to say, actually no, as a department we don't do that routinely, we do this. I think it offers good guidance for juniors… Oh, some people can treat them as gospel. You know if it's in the protocol and then doesn't require thinking and then you move on and I think you've got to - all protocols require some kind of individual thought, so that you're not so rigid in your thought processes. But that's probably more of a personality thing. We don't get that too much in radiology because radiology is a speciality of grey. We like to say, yes, that's that disease. But there's a whole bunch of processes and thoughts that we have where we can't absolutely rule something in, or rule something out. So there's a lot of grey in radiology. I'm not sure if you understand that as a non-radiologist. (ID17)
	For them now I'm trying to develop a guideline on anti-coagulation procedures for my department, so I need to go and find out all the evidence, what is the safe cut-offs

	for platelets clotting and take it from there. (ID4)
	One of the problems with using EBM in radiology is one of the ways it's often used is to make protocols. And to say, this set of patients you know should or shouldn't have this type of study because it's rarely of use. So say there are studies that show that quite a few people that turn up to ED departments with a head injury should not have a CT scan of their brain. Because if they don't have a period of unconsciousness or vomiting or whatever, then the chances of them having a significant brain injury are very low. And therefore it's not worth if you like, the expense and the very small risk of doing a CT scan. So they shouldn't have it. And that kind of work is obviously very laudable, but it's impossible to apply in real life. And the reason for that is it studies a population and it comes to a valid conclusion, but if an ED doctor comes round and says I want to do a scan on my patient, and you say well it doesn't fit the criteria for this to be very likely useful. He'd just say no but this is my patient, and this individual could have a significant head injury. And so they end up just fudging the thing and telling us that they've got more worrying features than they do. And we end up scanning them. And I'm pulling that example out, but with various things that happens all day every day. If EBM was strictly applied to the patients getting scans in our community, a lot less scans would be done. But as radiologists we're in absolutely no position to be gatekeepers of that because doctors to look after their patients, or even to look after themselves, will insist on the scan. (ID02)
	Having a written protocol is somewhat protective. Because one of the reasons people over-investigate is of course to cover their backside. And to not miss something. You know, you get in trouble for missing something, you don't get in trouble for over-investigating something. That's one of the factors in radiology. I mean, it makes us all very safe. (ID02)
	We regularly contact the referrers who ask for investigations on children that we don't think are necessary. So if they had a normal ultrasound, we say that we don't need to do the MCU. So we do contact patients on the basis of current practice. We don't just do it because it's been asked. We're in a public hospital, we have imaging protocols and we just know we don't need to do it unless there are special indications coming from a urologist for different reasons. So that has changed practice but that's over a period of time. That's probably the biggest one in our institution in terms of evidence-based medicine changing clinical practice. (ID13)
Optimizing outcomes	
Enduring patient safety	I think the only way we're going to improve our particular specialties that you have good quality evidence as to when to do a test, (ID01)
	What we're doing is, to the best of our ability then, making sure that the patient is getting the appropriate investigation - appropriate to diagnosis, based on what we know at the moment. Now, I think there's still a role for variation from the evidence base, and part of what we do is not just treating the patient, part of it is treating the referring doctor as well. So, we've got to sit there and think about what it is that will make them happy as well. But for areas where we think we're putting the patient particularly at risk - so, renal failure or children or pregnant women, with the radiation dose and things like that - I think that's much more of a time to be making sure that we're doing no harm and getting the diagnosis. (ID11)
	Because those researchers have done some evidence-based research work although it may not be the perfect, at least it's some evidence to direct me to yes or no to treat the patient. (ID15)
Maximizing efficiency	Well it's obviously clinical practice based on research and studies that have been performed and validated in literature, or obviously you can do your own research to help you implement the most effective and efficient clinical practice. (ID12)
	Let's say from a CT coronary angiography point of view, if you can rule out significant coronary artery disease on a CT angiogram then it means that they don't have to undergo other further more invasive tests like invasive coronary angiography. It also has economic benefits, not that we are applying it at the moment, but I think there is a trend now that we get a lot of chest pain, acute chest pain patients in emergency, a lot of them atypical. Often they need to be admitted and undergo a variety of tests and I think some institutions are doing CT coronary angiograms to help expedite discharge of these patients. So I guess they're economic benefits from that point of view; these patients aren't being admitted. If they've got no evidence of plaque at all on the coronary CTA they get discharged and then that saves hospital cost. (ID01)
	I think it's relevant to both aspects of radiology. Certainly in intervention it may be potentially easier to, I guess, extrapolate the benefits of certain endpoints, doing a particular test and whether they get different benefits out of it, but I think even in diagnostic radiology, those points that I outlined before, economics and safety, accurate diagnosis I think is still equally relevant to diagnostic radiology. (ID01)
Availability of access	
Requiring immediacy	I think Google is pretty good. I think you don't really need to go into details just searching for literature any more. I think they've really done a very good job. (ID24)
	More or less you can Google more of the information. Then, of course, if you're not satisfied with Google then you really have to go into journals and looking for special areas and talk to your peers and see how you can get more information about something I think. (ID24)
	I mean surely a lot of people practice Google-based medicine but I guess we're sitting in the front of a computer a lot of the time so you have direct access to it. (ID7)
	Well I'll Google and look for anatomical information, so for instance someone - just the other day, just as an example, there was a patient who had symptoms in the distribution of the saphenous nerve. So that's a small nerve that runs on the medial part of the thigh and it causes pain or numbness on the - just above the knee. Now

	that's a nerve that we don't - it's not a common nerve to image and it's not something that you retain in your mind as anatomical information. So when I read that on the request and was looking at the images, I Googled to get the anatomy of that nerve. I looked at the images that come up and cross-sectional images that came up with the nerve labelled so that I knew where to look on the MR images. (ID25)
	Generally I use Google. I find that that gives me the widest range of results. The other thing I do is I'll use PubMed. (ID25)
	There are a lot of papers out there but a lot of them are behind paywalls. My institution doesn't have access to all of them and I think this is pervasive to every other institution I've been with, there will always be some article somewhere that you can't get even though - you can't even see the abstract or parts of it, some of them don't have abstracts at all. So sometimes it's difficult. (ID04)
	It's a reference tool, like a mega online textbook where if you're scratching your head on a particular diagnosis or findings in a particular diagnosis using a different radiological modality, you just look it up and there it is in STATdx. So the internet and even Google, I mean you sit there at work and you just think oh, what's that such and such? I can't remember. You just Google it and usually you can find the information you want. (ID12)
	I don't read a lot of scientific articles I have to say, but it would be probably which journal it was published in. So obviously you go to the big journals, you go to *Radiology*. I use a lot of review type articles which are not the latest basic research, but like *RadioGraphics* which has got a lot of review articles again with the same sort of knowledge that you would get from STATdx, updates on particular imaging modalities or particular imaging of particular clinical problems. So just go to the major big name journals and I rarely have cause to go to the high level basic research that's been done. Some of it filters through in emails and from different - like I'm in the Breast Interest Group so they would send on articles from the latest research and different aspects of breast imaging and breast screening for example. So I see those but I have to say I haven't got time to go seeking them out most of the time. (ID12)
	And so the thing is day-to-day you need something very quick and fast, so you need to - you do rely on what's often said from the reputable journals. Although you make your own assessment about what you see. But a lot of it is actually appearances, it's not necessarily - for us in radiology - it's appearances, and then (ID10)
	I mean Medline, Cochrane all that - use those every now and then. I suppose a key on the weekend was that Google is just a broad - it doesn't tell you, doesn't analyse, doesn't put it in any order here, as these other websites seem to order things and make things more useful. That was the impression I got. NK (ID10)
	Actually, now I'm getting a bit lazy. Sometimes I used to use, after that course I was going onto Clinical Queries in PubMed, and searching there. I did search there a little bit, but now I must say I tend to just go to Google. There are some resources we have but often they have logins and stuff. Sometimes I go to, if I find in Google a journal article, I go back and look - because I can get access through the University of Melbourne to an awful lot of journals. I'll go and look up an original article for something. But often now I just Google it and see what comes up. (ID19)
	Or resources, like evidence summaries or something. Yeah. I mean I suppose the easiest thing would be if you could look up stuff that had already been critically appraised, it was already filtered out so that most of the rubbish wasn't there, that would be good. (ID06)
	Yes, Google is usually the most common. We also have - our department has access to STATdx, which is an online radiology resource. Our registrars all have access subscriptions to that so we all can access that. (ID01)
	In the hospitals I'll still use Medline or basically those searchers although I think most people, it's sad but true but probably the most commonly used medical research tool is Google. Things come up on it that at least lead you at other places, but yeah probably those two would be the ones you'd use the most or Google Scholar, just because also your access - the access to - funded access to medical journals is getting harder and harder now as well. As least if you work in a public hospital you'll get access to a decent amount, but I know they're trying to organise like say our access in private practice it costs an absolute fortune to get access to them and it's becoming harder and harder to get. Yeah it's part of the - one of the reasons a lot of us will keep an appointment in a public hospital. It's just you can actually use the online library even though strictly speaking it's all taxpayer funded so it should really be available to anyone who's servicing patients, but we won't get into that. (ID20)
	Reading the abstract and then I guess skimming over the more detailed sections and trying to make sense of it. (ID02)
	You do not have the time to read - I mean look at just something like radiographics. It's like a telephone directory comes out each month and you're not going to read that. You struggle to find the time - I mean we're getting busier and busier and busier. There's no - if there was some way to have condensed reviewed - peer reviewed articles and there's a basic little summary that came out once a month and you could read it and trust it, it would be great but I don't think we're going to get that. (ID 20)
	It would be very time consuming that you have to come up with a clinical problem to sit down and then to actually try and find the information quickly. (ID05)
Inadequacy of evidence	Things have progressed before the evidence can come out, often. (ID07)
	When we first starting doing CTA, which is when I was training for carotid dissection and vertebral dissection, we used to do a lot of angiography previously, but one of my consultants at the time said you know, we should do this study on vertebral artery dissection because no one's done it, and that's not that long ago - and I don't think anyone ever needed to do it. They didn't even really do it in the end, it should have been done and then we'll do it - but everyone just went ahead and started doing CTAs and that was the diagnostic tool, even though no one actually did the study. (ID07)
	There are a few. There are a few but not as much as in clinical medicine where you're looking at different types of treatment regimes. In radiology it's a little bit different

	because we're a diagnostic specialty. So we're not offering any specific treatments, we're making diagnoses so we're looking at pictures and different modalities. (ID25)
	Often the outcomes aren't measurable. So you may see certain findings but you'll never find out because that patient doesn't have the joint opened up or - so the outcome that you're measuring or the gold standard, there may not be a gold standard in a lot of the studies. Yeah, where you have surgical proof or autopsy proof. (ID25)
	These lesions are called incidentalomas, and everyone struggles with them. ARGANZ, which is the abdominal imaging group within the college have an annual meeting, and the last meeting was in Brisbane a few months ago, extensively on incidentalomas. So I thought, I'll go to this. I got about an hour lecture in the middle of this two and a half day conference, and I thought, well that wasn't very helpful. So there is no real evidence based, if you like - so if I do this, I'm going to capture 75% of the things which are going to really worry patients, I'll grab some more stuff which doesn't really worry them, but that's just collateral language if you were. So that's the hardest thing that I find at the moment. (ID23)
	There's no culture of research except in little pockets and enclaves in different institutions. There's always going to be individuals who are keen on it in any area of life, any profession really. There'll be people who are keen to do some research, not just in medicine. But in radiology I think they're fewer and further between so I think that's obviously what the college is trying to change slowly. I think I've seen it written that it's not going to happen overnight. (ID12)
	I think I'm reasonably efficient at reading, this is again mostly returning to high-level obstetric stuff, because that's what I would most commonly search, and that's all the weird and wonderful rare things. So, in practice actually, what I'm looking up more commonly would probably be studies which are not particularly robust, because the numbers are not great. And that's by virtue of the work that I do, I think, because it's all rare. (ID03)
	A lot of studies aren't evidence based, and there's a bias in the literature as well. There are many biases I suppose in the literature, but the main one is that the negative studies are much less likely to be reported than the positive studies. (ID22)
	Meta-analysis and systematic reviews are the evidence, and then we go into the PICO - looking at the Population Intervention Comparator and Outcome. But particularly, the population - make sure of the replies to population you've got at your hospital, because often the literature is a bit sketchy, and it talks about things that may be referring to either a very specialist hospital, or else unnecessary in the same population you've got. They exclude lots of patients, which don't necessarily go there. So, that's the thing - I mean, it's basically trying to work out, based on the research that's available, what the best thing to do is. (ID11)
	Obviously you can't have every disease in the evidence-based medicine guidelines because there just isn't enough data out there or it's changing so fast that you can't include old data with new data because the treatments often are different. (ID13)
Time constraints	We're really flat out. I think as far as we were doing the right thing, I don't think we have the luxury to sit down and go through medical school once more. You know, just to catch up with what you need to know is already exhausting I think. I think it's good to know, but I guess - there are so many things you need to know at the moment, I think, in our specialty there because it's such a fast-growing field. There are new things coming out all the time and I guess my time is running out too. I think I'm looking more like retirement in a few years' time rather than a punch at doing anything special. (ID24)
	I guess I'm a more practical man. I don't have time to sit down and read all the journals that much. (ID24)
	Giving presentations about topics forces you to at least try and analyse the literature. (ID07)
	Occasionally, like if I'm giving a talk, that's kind of the time that I'll look for that type of information. Not generally like when I'm doing my work, I don't tend to look for that type of information. But if I'm talking to a group of people about certain things then I'll look at the evidence for - to support what I'm saying. (ID25)
	You don't leave until the work's done. So if you spend 20 minutes, 30 minutes reading about a case the work is backing up and you don't go until it's gone. So, having a big department at a big tertiary centre where I work four days a week, you have the flexibility to - that's a really interesting case - you go around and ask opinions and look up the research and look up the web and try and work it out. Because there's a lot of other people who are reporting and pulling the weight. (ID17)
	I've got enough on my plate. We need people in our network who are interested and skilled. (ID12)
	Most of it is culture, and - but the other thing that we've got is, okay, say you're a respiratory physician. You might have, say, 20 patients, in-patients, and a certain number in the outpatient clinic. If I'm doing plain films, I'll be doing 120 cases a day. Right? So that gives me 120 patients, different patients, as opposed to that - and that's in one day, as opposed to over the week that you've got your busy respiratory unit. So, it tends - there's that. Also, particularly in the public - well, no, both public and private hospital systems, there's not the time allocated. Like with, say, a physician - I'm just using the example, or a surgeon - they've got their operating lists, they've got their outpatient clinic times, they've got their ward round times. But it doesn't normally fill up all that time, so you've got your ward round; you've only got five patients and you've got the rest of the morning to do something. If you've got your outpatient clinic, okay, that's probably going to fill up the time, but people might cancel, so there might be a bit of time in there. Whereas, in radiology, you know you've got a pile of things like this. Even if you go off to do a meeting - so, if they have a respiratory meeting, the respiratory guys aren't having work piling up for them, because they know that they're at that meeting, so they don't put patients in. Whereas, I'm doing the respiratory meeting and they're still scanning. So, when I finish, it's not like you go, okay, now we're starting from - now we're starting behind the eight ball. When you say, okay, we want to do some research on things - yes. (ID11)
Proximity of peer	When you make a mistake everybody will tell you. There's nothing better than to learn from your mistakes, as far as I can see. (ID24)

networks	Well, luckily in a big department there are lots of opinions, so I sought the opinion of more experienced colleagues. (ID17) Occasionally there are features about a lesion which make you think, well this might be a cyst but I don't think it will be, and you might organise a patient to have a contrast injection at the time because they're already there maybe, or even an MRI. Or you might just ask the person next to you, what would you do with this? Which happens quite a lot because we practice in that environment, it's quite handy. (ID24) You don't practice in isolation. So you don't just have the information that you started out with when you got your fellowship. You do come across things, but often the papers that you read and the information that you get is slightly contradictory, and there's a lot of parochialism in medicine; well this is the way we do it in our institution, as if to say, this is the only way to do it, and it isn't. (ID23) Fortunately working in a hospital like that you've got other people around and if you have a difficult case you can just ask people. (Man, 40s, ID06) So it's just a case of word of mouth, people pass onto you what is relevant to your specialty. (ID20) Because a lot of what we do I assume is not evidence-based. A lot of how we practise is handed down supposedly through experience, which does not necessarily mean that there is documented evidence that that's the best practice, but it's whatever you've been taught by more senior clinicians that this is how something is done and you just do that. I don't have the time to go through everything we do to prove or find the evidence to prove that that's the best thing - best method or the best way of doing something at a particular point in time, because you just don't have time to do that. (ID05)
Grasping information dispersion	We have to keep up-to-date. There are new tricks coming out and there's a proliferation. In fact, it's getting unmanageable in a way. There's too much clinical information coming out. The progress there - and it's so fast growing, you know. But luckily we're in a subspecialty. It's easier to narrow down our scope there. You don't need to learn everything. You know, it's amazing some of the general people working in the private health side, how do they cope, but anyway I think it's good to work in a hospital. At least you can stick to what you're supposed to know, rather than have to cover everything and the society requires you to know everything nowadays with the Internet coming up and all of the parents coming in know more than what you know about rare diseases there, so I guess that's very challenging as well. (ID24) I think it's good to know, but I guess - there are so many things you need to know at the moment, I think, in our specialty there because it's such a fast-growing field. (ID24) And it's very common for clinicians to come up - well, when they talk to us because their often talking about one or in sub-specialty areas that's their focus. We're supposed to be sub-specialty radiologists yet do everything general whereas they can sub-specialise. So they know a lot more, often, about the literature in their own area. (ID07) Well, I think most radiology can be difficult if you're not switched on and with the volume of work that we do, it's hard to stay switched on for everything. So, there are times where you kind of zone out a little bit or knowing when to concentrate for the important cases is difficult. I also struggle, and I suppose this is just because I finished my fellowship last year, so I've only been a qualified radiologist for a year. But the level of detail now for most scans is getting to subspecialty level. So, if you've done a year subspecialty fellowship in neuro then you really should be on top of neuro, head and neck reporting. For someone general like me it's difficult to stay on top and be good at everything. So I find I struggle a bit with certain cases that require more subspecialty input and involvement. (ID17) I think a lot of us probably keep an archive of the recent publications and stuff that we think are quality and relevant to our area, but other than that I think probably it's getting confounded by a plethora of information that you can't filter anymore. (ID20)
Overriding pragmatism	
Perceptible applicability	I think methodology, of course, is probably not the first one I would look at. I would look at what they're talking about, the clinical relevance and everything and then if I had any doubt I would look for the methodologies, the number of patients they looked through and everything, you know. I think there's so much to read out nowadays, you just can't afford to chew a paper very slowly and pick up every bit of it. In fact, a lot of the time I just read the abstracts and see whether I need to go into details of that. (ID24) I look at their protocol in terms of what they do and then whether their outcome measures more than probably analysing the way they got the outcomes, which I think I'll probably change a bit more now after this EBM course. So I kind of look at what they've reported as their outcomes versus their - be it their positive or negative and see whether it might fit into our population so they're characteristics of their population as well. (ID07) I do think from a practical point of view, that's something that you know when I go to work on Monday, that's something I can implement straight away that I can do differently and it's interesting. There was some of the applications with regards to searching that you need to get universities involved or college and I was thinking well when I get back that's something that I'm going to address. So I think that that was to me that was probably one of the biggest things that will probably change my practice the way towards evidence-based medicine. (ID08) Well something that would change your management of how you report. Something that would change how you approach a film, how useful a certain sign is. Is this a useful sign? Is it not a useful sign? Is it something you should actually just ignore and not pay so much weight on? That's the sort of really nitty gritty information we use. I mean a simple thing like CTR, it's taken for granted that an adult CTR of 50 per cent is normal but that's not true. What I'm really afraid of is that if everything gets based

	on evidence based medicine we lose the art - this is my one piece of information for you is that we lose the art of radiology. (ID14)
	I understand what it is, it's the difference of the two risk reductions but I don't see how they translate to clinical practice, personally. (ID04)
	To be able to look at these articles and actually read them, and analyse whether they are useful or not useful, in wider, broader stage. I think that's probably a good thing. (ID10)
	A lot of the studies out of the States have techniques and contraptions that we can't afford and don't use within our system. So then by learning the concept I guess from a conference you then research other articles and what not, and then again, some of that's come out of conferences in Europe. We tend to do things slightly differently to the U.S. so we've followed a particular type of protocol that they've set out. (ID07)
	The guidelines are often they are written with big centres in mind. Because you're in a smaller centre, it can be a little bit more problematic. (ID11)
	Often then when they say come up with the final idea of the evidence says we should do this, in reality you've got to do what's practical in your area and in your place. I mean we live in Australia and what would be ideal even if you look at the evidence and say this is the best way to investigate this, this is the best way to do that, the money and resources and access may not be there in which case you can't necessarily do the best evidence-based option. You've just got to do the best option that's available to you or that's available to your patient. (ID20)
	You end up doing what you know is not the best but that's the best that you can get for that patient or that's the best you can get within the funding constraints that you have there. (ID20)
Preserving the art of medicine	Not from the journals you're reading trying to analyse these people, whether they got enough samples or they're whatever, you know, and use what they talk about and test on your patient and then - whether the science they talk about is just particularly applicable for their locality or their disease pattern is especially in the ethnic groups or not. You have to apply to our own patients there. So those are the real evidence medicines, as far as I can go. In practice, you get a few rather than in the books. (ID24)
	I know you have to be able to appraise whether what the people are talking about is real or not real and if with evidence-based medicine they're very basic steps of it, but you really need to know what they're talking about is actually truly effective in handling patients or not. You should be in the result that you get from treating the patients. (ID24)
	I'll go to the echo and the heart is big and there's something I'm referring to in my brain which is completely non-scientific. You can't put in words - I mean for a descriptive purpose it looks a bit tense and you just think oh, that heart's a big, CTR's normal. You go to the echo and it is abnormal and so that's where I think evidence based medicine will never capture the whole story. So I don't think that it should be rigid. I think there needs to be room for the art of medicine and I'm afraid that's the only point I've got to offer you. (ID14)
	Beyond the measurement there's an art and that's what we should actually be concentrating on. It's beyond the scientific evidence. (ID14)
	There's a whole bunch of processes and thoughts that we have where we can't absolutely rule something in, or rule something out. So there's a lot of grey in radiology. (ID17)
	Lots of grey in radiology. A lot of us do intrinsically do this, but we may not do it so effectively, and part of our experiences will tell us what the paper's trying to say as well without actually going into and dicing it up. Some of it is an art form. You can't actually put numbers and things into it and there'll be an experience related understanding of what's going on." (ID10)
	People don't necessarily like to justify an art form. (ID10)
	To some extent. It's hard to know just how much of an extent. I suppose a lot of what one does is you're looking at images, you're trying to work out is that an abnormality or not. That's the biggest step and that's based on experience and other reading and stuff that you do. Then I suppose in the interpretive part of it when you're actually giving recommendations, that's when it can alter it if you have a better understanding of the condition and the science behind it. But there's a lot of times when you don't actually have to do that, you've really got to just know what the diagnosis is and is it lung cancer or not? It's not going to make too much difference to that, but certainly in terms of what you might recommend potentially. (ID06)
Technical demands	The images are getting more and more well defined in detailed anatomies. You really need to relearn your anatomies altogether. Like the brains for the MRI coming in, you normally don't see different layers of the brain. Then now you see it and it's probably much more than what pathologist can see in a gross specimen state and it's so much detail there you just have to relearn your anatomy altogether and also there's a challenge how to get the best images up; all the new modalities there, you know, because there are so many more parameters that you can play with. (ID24)
	Main - well I'll Google and look for anatomical information, so for instance someone - just the other day, just as an example, there was a patient who had symptoms in the distribution of the saphenous nerve. So that's a small nerve that runs on the medial part of the thigh and it causes pain or numbness on the - just above the knee. Now that's a nerve that we don't - it's not a common nerve to image and it's not something that you retain in your mind as anatomical information. So when I read that on the request and was looking at the images, I Googled to get the anatomy of that nerve. I looked at the images that come up and cross-sectional images that came up with the

	nerve labelled so that I knew where to look on the MR images. I do that quite often to try and work out the anatomy, particularly when they're neurological cases, when they're a nerve problem, to work out what that nerve innervates, which muscles. (ID25)
	Well, I just had a difficult case yesterday where basically it was an MRI of a hand and there was some abnormal signal in some of the muscles but they were patchy everywhere and I couldn't quite put it all together, so I had to go back to my basic anatomy and review things like nerve supply to various muscles and whether there's a certain pattern. So I started Googling that and started looking up some textbooks and I think I got to fairly reasonable sort of differential diagnosis for that particular case. I realise there are some particular syndromes not quite completely fitting with that diagnosis but it was pretty close. (ID01)
	I've used *STATdx*. We've got it for all the registrars. But I mean, what you've got with that is a textbook like any other textbook. So I wouldn't say that it's necessarily kept up to date. It's the Amyrsis books. I still like books. I've got lots of books in my office, and I've got quite a few of the Amyrsis books, and I read through those. They are good, but the - it's not - I wouldn't say that's evidence-based. I would say that's just background knowledge. It may give you the answer of what it is and what's going on, but if it's a dilemma as to, what's the most recent stuff on that, that's not going to give you that. (ID11)
Limited confidence	
Conceptual obscurity	But I don't think I've really had a structure to critically analyse a lot of these type of papers and know that - I try to - I guess in basic terms looking at p-values and sensitivities and specificities, but I don't think I have a good structure. (ID07)
	I want to know how to approach different articles and recognise their strengths and weaknesses, and then have a slightly better approach to analysing the actual results section. (ID07)
	Yeah, I look at the methods too, how many patients they've studied, whether they've had a control group. If it's some sort of intervention - is it just an observational type of study, is it a study where they've eliminated biases? Are the observers blinded to - in a lot of imaging literature, the observers aren't blinded to certain things because of the nature of imaging. Those sorts of things I'll look at as well. (ID25)
	I think what would be good is to be able to analyse and critique papers more effectively, to actually know - the things that I look for may not be the most appropriate things in a paper. Just to learn what I should be looking at and focusing on rather than what I think I should be looking at. (ID25)
	Our worry is that a couple of weeks into a journal club, we'll stumble across one of these papers and we'll hit a rock of something like that, so it would be good to have that support and say well look, you've had a meeting now, we've maybe had a teleconference or something like you're all radiologists, what we'll do is we'll send out a paper to you once a month, you'll discuss it in your department, get some feedback and here's the answer sheet the next month. It would be good to have that support so you're not left floundering. (ID08)
	I don't know if I actively involve myself in it. I think having just gone through medical school in the last 10 years, I think the medical schools now have it so engrained in their curriculum that it's second nature and I don't know any different. So, I probably am of a generation that has always been okay with it. But I could imagine if I was 20 years older and going through medical school without knowing what EBM is, and then to have put in front of you it would be a bit daunting. (ID14)
	Well, I read it. It was a prospective paper where they changed a protocol and analysed the results after and before. It was of substantial size, there were enough to make it statistically significant, and it had enough power in it. I thought it was well designed. It was a simple paper that answered a simple question. I love research that does that, I don't like complexity. I like, I've got one question, how do I answer it? There's the answer, move on. It came from a big centre, so there were a whole bunch of reasons why I liked it. I kind of liked it because it was agreeing with what I've always thought, but just hadn't been able to prove. So it's nice when research validates your own experiences. (ID14)
	Kaplan-Meier curves I have a basic understanding, I think I do. I'm sure if I truly do so that one I'll put under don't know or very little. Multivariate analysis, a bit shaky in there. I roughly know what it is but again, I assume I know what it is but I'm not very sure if I do. (ID04)
	Very important, because I think I understand how all these studies are designed and I can read and know how they have arrived at what they have arrived and I can either look through the study and decide how reliable it is or not. (ID04)
	I'm not good at that. That's what I'm saying. I'm really not good at levelling. I basically just look at what the definitions say. It's got to be retro - not retrospective, prospective and it's got to be analysed, it's got to be blind or maybe open. (ID21)
	I have to say I struggled with the [EBM] course… in terms of the complexity of doing a proper literature search and things like that. It's just difficult to get my head around it without being able to dedicate myself to doing that fully, without actually putting it into practice. (ID12)
	I haven't been able to critically appraise their work very well just because of my own lack of in depth knowledge on the topic. (ID12)
	I think in first year we did a little booklet which was a biostatistics type of handbook, which to be honest went in one ear or in one eye and out the other because as I said I don't have much of a brain for it, never have. I don't think I retained too much of that knowledge. As I said I'm not that interested in doing research and I never really put it into practice. (ID12)

	I think it's more kind of the concepts. I mean, I think in practice it's something that we do every day, but it's the concepts behind it that I have a very poor knowledge of. You know, I read papers and studies all the time. Do I have the concrete knowledge behind it to be able to assess them in a proper way? Probably not. (ID03)
	I must admit, I do get lost in the statistics, but I'm not sure that it's probably necessary for me to know all about the statistics. So I don't know whether we're going through that or not. (ID03)
	I just have to get my head - I suppose just looking at the papers and then trying to - what sort of study is this? Just trying to sort out to have it clear in my mind the type of study and just doing the numbers and things that at the moment I'm a bit rusty on. (ID19)
	I suppose if we can find better articles more efficiently then that might help in terms of just trying to sort out which are the better ways of looking at things, and perhaps understanding the hierarchy of the different types of articles that there are would make it better, possibly. (ID19)
	Not particularly, no. I feel though my medical training I haven't developed all those skills, all the biostatistics. As I said, I did do a little bit of epidemiology at one stage for a couple of terms but that was quite a long time ago and all of that; statistics have filtered out of your brain after a while, you tune out. (ID01)
	I think it's the statistics because often when they start quoting statistics and where they've got those - why they use those particular tests to determine how relevant the findings are. I find it can be a little bit overwhelming trying to understand what it all means. (ID01)
	Yeah, I guess I would never have really had the proper training in terms of how to do a proper search, particularly if you want to do a paper yourself, trying to set up a trial. We've never really - I don't think I've ever felt comfortable having the skills to know how to go about even setting up a particular trial or study. So I think overall I just feel a little bit inadequate from that point of view. (ID01)
	Sensitivity, specificity, those sort of basic concepts are relatively easy to understand, and your positive predictive value, your negative predictive value, and a little bit about the confidence intervals. But things like how do they determine how many patients need to be recruited to get adequate power for a study. (ID01)
	Basically, it wasn't something that came up much through my medical school or medical career, so I don't have that background in it. Because we don't have that area of - that culture of evidence-based in radiology, it tends to be not played up as much. So, you feel that you're - you have to make an effort to do it, and you feel that you're sifting through a lot of stuff, and it's difficult to do, rather than easy and straightforward. (ID11)
	How to make sense of studies, and how to judge whether a study's good or not. I guess that's a real time saver if you can just dismiss studies as being not of high quality. (ID20)
	We don't have the statistical knowledge or ability or then in the end the staying power to actually do a proper trial. So that it's getting evidence-based medicine is very difficult and often you end up with possibly wrong conclusions because something which appears to be statistically acceptable when properly analysed isn't. (ID18)
	Well I haven't had any formal training in it. I don't actively practice EBM, I don't visit the Cochrane Institute or use - I'm aware of it but I don't actually regularly view it to see what's out there. (ID13)
	Understanding the methodology - that's very important in how research is done or how a paper is written, to know whether that is a well-constructed study and therefore the conclusions are robust. I think that's the hardest to do, which is part of why we do this course. (ID05)
Reputation based trust	Well, I guess your experience of what they say and I also look at where it came from; which research centre they come from. (ID25)
	Some of the things that I'd look for are the journal that it appears in. So if it's a journal that I know and trust, that is a high quality journal, I'll consider that a more relevant paper. If it's in one of the throwaway-type journals or if it's on a website without any peer review, like someone's own personal website, then that information is always - you view that with a lot of scepticism. (ID25)
	It's not a strong suit of mine, so that's why it comes down to what journal the stuff is printed in. If it's the yellow or the grey journal, the American ones, I'm confident that it's been peer reviewed meticulously, that the results are acceptable and the methodology is sound. That's not always the case, I know that. Things slip through, but I trust the experts who have reviewed and given me the information that actually - the assurance that this is a good study. That's what I do. (ID23)
	So you need to be able to understand how the statistics are done and question - work out whether it's been done correctly or not correctly - but you'd hope the editors of these magazines would be doing these things. (ID10)
	If it comes from one of the well-known Radiology journals, or in musculoskeletal imaging if it comes from some of the well-known orthopaedic journals, then I'll trust that. Or some websites that I know quite well, or names that I know. (ID19)
	STATdx I think is well refereed, so I put quite a bit of trust in that. (ID 22)
	A lot of the people who are big names will present there and a lot of them that are big names aren't necessarily that great. They're people who are on the speaker circuit and realise their publications are all by their underlings and when you go and see their presentation and the quality of the presentation you get an idea of whether or not you should be trusting their research. (ID20)
	Oh different experience of the authors. What they have done. First the authors, how much experience they have. (ID15)

	Yes I do because each author has certain experience, so that shows the bias to me straightaway. You see because it's a veteran radiologist who is doing it and he will say what he has done. So that gives me the bias and some of them also say they are industry-based. (ID15)
	I hold the editors of journals to task for that because they should be up-to-date with what's current nomenclature. If someone submits a paper using out-dated or non-preferred nomenclature then it should go back for revision. (ID13)
Demands constant practice	Like one of those things like use it or lose it. So I think that if you can implement the journal club, well then two things. What it means that you'll share it, which you have and then it keeps up those skills or hopefully it will keep those skills and obviously people will ask you difficult questions and then you'll have to go back and reread the information that you have. (ID08)
	So we're constantly being pushed to update, hearing papers presented, and so thinking about things like that. (ID19)
Suspicion and cynicism	There's always the risk of if [industry] fund a study then they're kind of trying to get a result that they want, so that you have to look at that data carefully. That's why it took several years for - more data from different sources - like it wasn't just one study, there were several studies done. Some of them were independent studies, non-funded by drug companies. (ID25)
	I've learnt there's a lot of publication bias in every aspect of research out there, every single one is publication bias, as in the bad results don't get published, the bad trials get buried somewhere in someone's drawer and filed into oblivion. That's why I hold a slight degree of scepticism. (ID04)
	I'd probably want to see another bigger study or somebody else doing it as well. I think there might be some - possibly, they were better at doing ultrasound or they had a particular type of patient. (ID19)
	That doesn't concern me so much, but there's a bias with pharmaceutical literature reports, because the pharmaceutical companies - as you know - maintain control over whether a paper is published or not. (ID22)
	So for instance, in cardiac imaging you're only looking at how should we be investigating chest pain and you can go to a session at a college meeting and see the nuclear physicians have their say in why you should do it starting with nuclear medicine. You have the cardiologists saying you should do it this way, you have the stress echo. people saying do it this way and you have the cardiac CT people doing it this way and they've all got plenty of good research that makes it very compelling that their argument is true, but the fact is if you look between them all and there's very - you can say yeah this is all evidence-based and in reality you can be blinded by what people call evidence-based anyway. So in theory yes it's great to have what you practice based on evidence but traditional practice hasn't been for a long time and similarly, even how we investigate things or things like people have got decision pathways and things which are a double-edged sword as you're probably aware as well and a lot of them may be based on various evidence that's been created to - a lot of the evidence gets created to support a particular agenda and it's used to support a particular agenda or preconceived notion of what you should actually be doing. (ID20)
	To be honest it's been a bit disillusioning because dealing with the whole academic side of it. You get into the politics of journals and egos and it's much worse when you deal with Americans as well because getting publications and stuff is such a big part of how they get their positions and get their funding and so on. You'll see people actively try to discredit each other's research and stuff for reasons that aren't necessarily medical or similarly re-present other people's findings and try to get it into print first. So I don't know I've probably become pretty cynical about the whole medical research and publication area. Similarly even when you read medical research in journals and stuff now because the - particularly in the American market but even to some degree in ours, getting publications on your CV is a very important part of how you build your career and get your positions or how the department gets its funding. The volume of publication has probably exploded and the quality of it has decreased considerably. (ID20)
	I mean even things - you had groups that tried to do it, like the Cochrane Research Institute and stuff like that and even the way that they filtered their information now comes under question. You'll have a Cochrane Review that says one thing and three years later it says the complete opposite because they've changed their methodology. I think even just recently they said they started looking at non-significant papers and non-significant - and of course that completely changes the whole evidence-base that you're using and can change your whole view on what you actually do. (ID20)
	We work in areas where new techniques and stuff are coming up all the time and it's 20 years before we know whether we've been doing the right thing or not, so we've just got to in good faith make the best guess [laughs]. But yeah I think I healthy cynicism is probably a good thing. (ID20)
	Yes I do because each author has certain experience, so that shows the bias to me straightaway. You see because it's a veteran radiologist who is doing it and he will say what he has done. So that gives me the bias and some of them also say they are industry-based. (ID15)
Competing powers	
Hierarchical conflict	If it comes from us - comes from senior people they will listen. But I think when it comes to junior people then he may not, but the trouble is you can't be there all the time, because there is so much case loading you have and you may know about that case only after somebody said it. (ID25)
	Yeah, there's that issue, because we're perceived as a service provider. The referrer will fill in the request and request a certain test, so oftentimes it's easier just to do the

test as requested, otherwise they send their work somewhere else. You want to keep the referrers happy. Also if you want to speak to the referrer to discuss the case and say look, I really think that this is more appropriate, it takes time. A lot of people don't have the time to get on the phone. The other issue is that sometimes they think he's requested this but this patient actually needs this, so they'll come back and have the right test later and there'll be more revenue generated for my practice. It's kind of a financial incentive for them to do more tests. There are financial - some radiologists who are running private practices may just do as many tests - they encourage as many tests and when they report studies they'll suggest another test to confirm the diagnosis even though it may not be - it may or may not be strictly required. (ID25)

We often image the brain and the cervical spine even if they don't have any particular symptoms in the neck. We often are battling with the emergency room people to - does this patient really need to have that done? (ID25)

Well to try and use clinical indicators. There's a website - the government of Western Australia set up a website and it gives you a decision tree. If someone with neck - some sort of trauma, query neck injury, and it will give you a decision tree. Do they have tenderness over the cervical spine? Yes, then do this. No, don't do anything. That sort of thing. (ID25)

Well yeah, because we - it is frustrating because we're trained to take note of the safety issues for the patients. Sometimes clinicians may be unaware or not interested in the safety issues of radiation on patients, so we see ourselves as the patient's advocate for safety as well. It's not because we don't want to do the test, it's also the other issue is patient safety. We feel - at least I feel that I should be an advocate for the patient. If they don't need to be irradiated or if they're being irradiated just for expediency rather than a clinical indication, I feel that I should advocate on their behalf that they don't do the test, they treat - they manage the patient in a different way or use another test that doesn't involve radiation. (ID25)

I think if you ring them and say look and you sell it to them and you say, look I have got something which is better for your patients and which is therefore as a consequence better for you, can make a more accurate diagnosis. Look I think that this is better well then that's a win win all round. Now occasionally you will get some referrers that are obstinate, stubborn. Or they might say to you, well look I have a specific question that can only be answered with this and you would say, now I can understand. So - but it does occasionally happens, but like all things it's I think if you have good people skills and you try and talk to people and you can talk to them. (ID08)

We still do lots of [the test], even though we tell them don't do it, it's useless, they still request, we still end up doing it. Resigned to my fate. What can you do? No, once you accept it it's not frustrating. It's only frustrating if you try to resist. Of course, but can you change it? I'm a realist - I'm a pragmatist, it can't be changed, so don't bother even trying. (ID25)

When I try and suggest it to my peers that hey look, there are all these studies showing that we don't need to do this anymore, they still refuse to accept and still insist on it happening. (, ID25)

We'll have to rely on the referrers to be agreeable but on the other hand we're the gatekeepers. If you think of it, you are going to refer your patient to me, I'm going to look at - and we do that all day, every day. I'm going to look at it and you've written down that you want this and this and this, and I look at this and I say no, that's no longer indicated, we just do this. I will then pick up the phone and phone you and say it's not indicated, this is what we're going to do. So you can't send me - gone are the days where you send me your shopping list and then I just fulfil it. There's an active role to play. (ID21)

I know a few years ago I probably wouldn't have even considered consulting with others when I was doing radiology, because people just send the request along and that's it. Back when I was Director, they'd send a request and you'd go, well I don't really believe this is the right test. They'd go, I don't care. That's what I want. So over time I guess there's been a bit of an evolution. (ID16)

You do it. You might put up a little bit of a fight and point to the article or the literature or say something, but you wouldn't expect to win. Occasionally you do I suppose, occasionally you do. I had a win last week, but that's a rare event. Usually they will say - they have more - you're not arguing on a level playing field there. So they're coming at it from a different perspective. (ID22)

Because we're at arm's length for the referrals is a good thing in one way, because we're not self-referring. But it's bad, because we don't get to influence this. The referrers don't feel that radiology should be gatekeepers, because they know what tests they need on their patients. However, the government does feel that radiology should be capping the expenses on - for imaging, so making us gatekeepers. We are the experts in that area, so we should be trying to do that. (ID11)

It's a difficult thing to do, and even if you've got evidence-based, a lot of - or consensus guidelines, or whatever. A lot of people don't - no, no, it's my patient, I demand that we have this done. (ID11)

It's frustrating in a sense, because you know it's happening. I mean I've had clinical doctors tell me, yeah well we'll say whatever we need to, to get you to do the scan. We'll make a headache sound like a subarachnoid haemorrhage, we'll make chest pain sound like a possible aortic dissection, we'll make abdominal pain sound more sinister because we just want you to do the scan. And we know they do that; and they know that we know that they do that. And I've had one's even straight out admit to me. (ID02)

Well for the reasons I've said. With the diagnosis ones it's harder because you are then trying to change the behaviour of the referrer as much as the radiologist. And we don't get as much control over the imaging strategy as we should. The referrer has to come along with us, if you like. And that's hard. Because it's a funny relationship,

	we're sort of seen as a service provider. (ID02)
	We always have a discussion when we turn down a request. That's where it becomes an art ant. We take time when I really feel for it, but others won't, they just say just do it. So that 50 per cent of them will just do it, and 50 per cent of them we will have an argument. We are so busy it is easier - the path of least resistance. That happens when you are busy. But it may not be the right thing. (ID15)
	You try and educate the clinician, but I think in real practice you just do what they ask you to do, which is the expectation by the clinicians. (ID05)
	Unless it has an adverse effect on the patient outcome, generally I just do it because it's easier to do it than to argue and then they still go over your head and get it done. So unless it's, for example, you're radiating a pregnant woman or a child, if it's an older person and you think that's a low probability for risk then it's better to do it or easier to do it than to argue. (ID05)
	The joy of working in paediatrics is most of the people work as a team and everyone respects their specialties there. I can see that's the reason, for example, why I choose to do paediatrics, because I think I'm dealing with people more open, more gentle and less dogmatic in a way and in paediatrics in a way radiology or imaging plays a major field in a way, because you can't get the clinical side or history as easy as from the adults there. I think for getting a right diagnosis or you put on a new treatment, the right treatment there very much depends you established a disease, you know, making the diagnosis there, so I guess that's the joy of being a diagnostician in the paediatrics there. (ID24)
	See mammography is quite different because it's a multidisciplinary team so everyone gets together. But things like intervention, I don't think it's quite as multidisciplinary. It's more the referring physician or surgeon or whoever and you're at the end of that list and you just get the request and you just have to go off and do it. That's right. I think with that evidence-based medicine, I think it has to be more of a team approach. That's my thoughts on it. Yes, I think it might happen in oncology and radiology because oncology relies on radiology for the results. So I think they have a lot more meetings and get together and discuss things more. But basically, some of the other specialties just want the answer. They want their answer. (ID16)
	I do attend multidisciplinary meetings like lung cancer then you have to make a decision. To say whether - you have said this patient has lung cancer when the decision is multi-factorial because you have to decide whether the patient is fit enough for surgery or fit enough for radiotherapy or whatever. So it's not that difficult to judge on those ones where you are giving an opinion. Your opinion is taken as a part of a broad decision-making. So you feel that you not - still stressed but not much stress, do you know what I mean? Because it's part of a group decision rather than a single decision. (ID15)
	Those are evidence-based because it's a multidisciplinary meeting and everybody comes and everybody has their previous - not only previous experience but research has been done. (ID15)
	think in our department we like to share problem cases around a lot and so it's an open department where people can share without feeling they're going to be picked on or someone's going to make fun of them for making a mistake. So it's actually quite collaborative. We refer to journals and multidisciplinary teams to get the answers. (ID13)
Prevailing commercial interests	The other issue is that sometimes they think he's requested this but this patient actually needs this, so they'll come back and have the right test later and there'll be more revenue generated for my practice. It's kind of a financial incentive for them to do more tests. Some radiologists who are running private practices may just do as many tests - they encourage as many tests and when they report studies they'll suggest another test to confirm the diagnosis even though it may not be - it may or may not be strictly required. (ID25)
	The financial issues potentially could come before patient safety issues. (ID25)
	It's a money-making or it's - you have to generate revenue to keep the practice going. You're trying to encourage people to image, not necessarily inappropriately, but just you're trying to get as much throughput through the practice as possible, whereas in the public hospital there's such a demand already that we just have to try and prioritise a little bit. (ID25)
	I suppose my feeling is that evidence-based medicine will never ever work in an item for service based medical culture and that's the bottom line. The trouble with evidence-based medicine is that best practice doesn't always align itself with best ability to make money and there's going to be that tension. (ID18)
	Now the reason you have to be a little bit careful with some things, now whether it's endoscopy or radiology, is that if there's harm involved and with radiology you could say no we shouldn't do that because there's a potential downside. With MR you can say well look there doesn't appear to be any downside. With ultrasound well there's no downside, it won't harm the patient, let's do it. Now it may harm the patient's bank balance but we tend not to involve ourselves in that. (ID18)

*Quotations identified only by ID to protect anonymity

Supplementary File. COREQ Checklist

No.	Item	Comment
Domain 1: Research team and reflexivity		
1	Interview/facilitator	AT
2	Credentials	AT (PhD, MPH, MM)
3	Occupation	AT, Associate Professor in Public Health; SEM, Lecturer in Clinical Epidemiology; JCC, Professor of Clinical Epidemiology; GL, Radiologist; AJP, Professor of Medical Imaging; CL, Senior Lecturer in Clinical Epidemiology
4	Gender	AT (Female)
5	Experience and training	AT has conducted and published qualitative research and lectures in qualitative methods and methodology.
6	Relationship established	None
7	Participant knowledge of the interviewer	AT is conducting a study to elicit radiologists' perspectives on evidence-based medicine (EBM) to inform ways to improve EBM training.
8	Interviewer characteristics	AT is a qualitative health researcher.
Study design		
9	Theoretical framework	Grounded theory
10	Sampling	Purposive and snowballing
11	Method of approach	Email
12	Sample size	N=25 (refer to table 2)
13	Non-participation	N=6 due to travel and clinical committments
14	Setting of data collection	Clinic offices, hospital meeting rooms, conference venue
15	Presence of non-participants	None
16	Description of sample	Refer to Table 2
17	Interview guide	Provided in Supplementary File 2
18	Repeat interviews	Single interview conducted
19	Audio/visual recording	Interviews were audio recorded
20	Field notes	AT recorded field notes
21	Duration	Mean duration 35 minutes
22	Data saturation	Yes
23	Transcripts returned	No
Analysis and findings		
24	Number of data coders	AT/SM
25	Description of the coding tree	No
26	Derivation of themes	Inductively derived from data
27	Software	HyperRESEARCH
28	Participant checking	Yes, preliminary results were sent to all participants who were given two weeks to provide feedback for integration into the final analysis
29	Quotations presented	Refer to Table 2
30	Data and findings consistent	Quotations provided to illustrate each theme.
31	Clarity of major themes	Yes
32	Clarity of minor themes	Yes