

Final Report

Evaluation of the BreastScreen Remote Radiology Assessment Model of Service Delivery

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Version 2

College of Medicine and Dentistry James Cook University

Cairns Singapore Townsville

An evaluation study of the BreastScreen Remote Radiology Model for Service Delivery

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Abbreviations

- AOR Adjusted Odds Ratio
- **BSA** BreastScreen Australia

BreastSurgANZ Breast Surgeons of Australia & New Zealand,

- CALD Culturally and Linguistically Diverse
- CI Confidence Interval
- CJAG Combined Jurisdictional Advisory Group
- CT Computed Tomography
- **DICOM** Digital Imaging and Communications in Medicine
- DCIS Ductal Carcinoma in Situ
- FDA US Food and Drug Administration
- FNA Fine needle aspiration
- IQR Interquartile Range
- NAS BreastScreen Australia National Accreditation Standards
- NQMC National Quality Management Committee
- NSW New South Wales
- NT The Northern Territory
- PACS Picture Archiving and Communication System
- QLD Queensland
- RA Remoteness Area
- RANZCR Royal Australian and New Zealand College of Radiologists

RRARGC Remote Radiology Assessment Research Governance Committee

- SCU State/Territory Coordination Units
- SD Standard Deviation

SEIFA IRSAD Socio-Economic Indexes for Areas, Index of Relative Socio-Economic Advantage and Disadvantage

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Glossary

- Adjusted odds ratio The AOR indicates that for a unit increase in a continuous predictor, or level change of a categorical predictor, the outcome variable is expected to change by the respective coefficient value, adjusted for by the other variables in the model.
- Assessment clinic The centre where women are recalled for diagnostic work-up due to an abnormality detected as a result of the screening visit, signs/symptoms reported at the screening visit, or for other reasons, within BreastScreen Australia. (Adapted from BreastScreen Australia data dictionary, 119).
- Assessment episode An assessment episode includes all attendances for assessment during a particular screening episode. An assessment episode is complete when there is one of three outcomes: return for routine rescreening, referral for definitive treatment or recommendation for early review (119).

Assessment team meeting

A meeting held between the remote radiologist, onsite medical officer and other onsite health professionals (nurses, sonographers, radiographers) during remote radiology assessment clinics.

Assessment visit Any visit by a woman to an assessment clinic for the purpose of all followup investigative procedures arising from a woman's attendance for screening up to and including cytological or histological diagnosis. This includes attending the assessment clinic for the purpose of receiving results (119).

Multidisciplinary approach

Where the radiologist and the surgeon, or other designated examining clinician, are in attendance together at assessment to correlate and evaluate the clinical and imaging findings and to decide on further investigations or management (119).

Onsite model Standard radiologist onsite model of assessment. In some cases this operates with local radiologists contracted to work with the local BSA Assessment Clinic team, and in others it involves a radiologist flying in from another centre to take part in the assessment clinic. A radiologist onsite assessment clinic is one where the participating radiologist is available in person onsite at the assessment clinic, whether they are a local radiologist or have flown in for the occasion.

Remote radiology assessment model

A remote radiology assessment clinic is one where the radiologist is not physically present, but instead participates in the clinic via appropriate technology/telehealth facilities. The term has been used interchangeably with 'Remote radiology model' throughout the report.

Second or subsequent screen

Women who are attending for any screening episode in BreastScreen Australia other than their first screen (and the corresponding assessment episode).

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Store and forward	The transmission of imaging from one site to another without the need for the client and remote provider to be available at the same time. For example, a remote radiologist may read an image that has been transmitted to them after the image has been taken.
Teleradiology	"The electronic transmission of diagnostic radiological images in digital form from one location (acquisition site) to another (reporting site) for diagnosis and reporting by a clinical radiologist or any other appropriately credentialed medical specialist using a bi-directional data communication link that keeps all patient data secure." (17)
Telesonography	The transmission of ultrasound imaging using telehealth. Telesonography may be synchronous , employing real-time transmission of ultrasound imaging. Telesonography may also involve asynchronous transmission of imaging (store-and-forward).

Executive summary

Breast cancer is the most commonly diagnosed cancer among Australian women. All women between 50 and 74 are offered a 2-yearly mammogram through BreastScreen with follow up assessment visits as required. One issue in providing this service to all eligible women in Australia is workforce shortages, particularly in terms of specialist radiologists. BreastScreen has addressed the challenge of inadequate access to local radiological workforce through a trial of the remote radiology assessment model for service delivery. The remote radiology assessment model has been implemented in a staggered start approach at seven sites across Queensland (Townsville, Rockhampton and Wide Bay assessment services), Northern Territory (Darwin assessment service) and New South Wales (Greater Southern New South Wales assessment service which includes sites at Albury, Wagga Wagga and Queanbeyan). The BreastScreen Townsville assessment service piloted the model from 2014 and the other services implemented the model from 2016 onwards, with a formal trial period beginning in 2017 and ending in May 2019. This innovation addresses workforce challenges for regional, rural and remote services, and implementation has been careful with thorough clinical governance procedures. However, there is a need for this formal, external evaluation to ensure that the service delivery model is safe, effective and appropriate for consumers.

A comprehensive evaluation of the remote radiology assessment model was conducted by drawing on several sources of information. Firstly, a systematic review of published literature on service delivery models incorporating teleradiology was completed. The review summarised the current state of knowledge about the use of teleradiology in diagnostic services worldwide, and integrated findings from the literature about what is required to ensure a safe, high quality service. Despite the paucity of high quality evidence, current literature suggests that with attention to the appropriate training, regulatory and monitoring guidelines, that it is quite possible to implement a safe, effective and high quality teleradiology service. The factors important in fostering a quality teleradiology service include teamwork; selection and training of the workforce; equipment; protocols and communication; and clinical governance frameworks.

Then, a mixed methods approach was used to comprehensively evaluate the efficacy, safety, quality and acceptability of the remote radiology assessment model. This utilised a large database cataloguing 21,117 visits to assessment clinics (following a screen-detected abnormality) across the three jurisdictions to compare the clinical outcomes associated with the remote radiology and onsite models. The database included 3,904 assessment visits conducted under the remote radiology assessment model. Surveys were conducted with 144 women attending remote radiology assessment clinics in all three jurisdictions, and semi-structured interviews were performed with 55 service providers involved in implementation and operation of the remote radiology assessment model. These interviewees represented a wide range of health care providers, administrators, managers and regional stakeholders involved in the provision of the model. A cost comparison study was also conducted at the jurisdictional level.

The key findings of this evaluation indicate that the remote radiology assessment model is safe and effective – it is clinically equivalent to the onsite assessment model in terms of cancer detection and has significantly improved timeliness to assessment and recommendation, minimising anxious waits for women attending assessment visits. There was no greater uncertainty in the outcomes of assessments conducted under the remote radiology model, though the number of mammography images for assessment visits using the remote radiology model was slightly higher than for the onsite model.

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Women who attended remote radiology assessment clinics were accepting of the remote radiology model for their care, with the majority reporting no particular preference for either service delivery model. Moreover, satisfaction with their clinic experience appeared linked to positive interactions with, and characteristics of service providers (frequently described as friendly, helpful, comforting, compassionate and professional), rather than whether or not the radiologist was onsite.

Health care providers across the sites were supportive of the remote radiology assessment model overall, given the benefits of increasing access to timely care for women in rural and remote areas. They also reported high satisfaction with the remote radiology assessment clinic processes, and provided thoughtful responses about the implementation process, and factors important to the successful and safe operation of the model. These factors related to teamwork and trust, the technology or equipment, and strong processes, training and governance support required to support the model.

This evidence supports consideration of broader roll-out of the model with existing programmatic guidance, with the proviso that consideration should be given to recommendations for safe and sustainable operation of the model and monitoring of outcomes. There is a need to balance programmatic guidelines and oversight with flexibility to operationalise the model in a manner appropriate and feasible for the local context. Recommendations are drawn from the data collected and analysed for this evaluation. In keeping with the clear themes of the findings (including input from our expert stakeholders), these recommendations have been classified into three main groups: i) teamwork and trust; ii) technology; and iii) governance, monitoring, systems and processes. Further detail about each is available in the body of the report.

- 1. Teamwork and Trust
 - 1.1 Assemble an appropriately skilled team of health professionals who have experience in teamwork, established relationships and have developed a high level of trust.
 - 1.2 Provide ongoing opportunities for the whole team to spend time together face-toface to develop and maintain relationships.
 - 1.3 Ensure that optimal means of communication during, and between, remote radiology assessment clinics are available to all onsite service and remote providers.
 - 1.4 Facilitate opportunities for learning, professional development and upskilling, to all team members.
 - 1.5 Ensure that training is provided for new team members, and for succession planning.
 - 1.6 Monitor appropriate competencies and credentialing for all health professionals, with regular review.

2. Technology

- 2.1 Strengthen best-practice guidelines for quality assurance of the technology associated with synchronous telesonography used in remote radiology assessment.
- 2.2 Provide and maintain fit-for-purpose equipment at both sending and receiving sites.

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2.3 Ensure that onsite and remote providers have access to immediate technical support.

- 2.4 Provide training for onsite and remote providers regarding operation of equipment and other technological aspects required for the remote radiology model.
- 3. Governance, monitoring, systems and processes
- 3.1 Governance and monitoring
 - 3.1.1 The BSA NQMC has a role in developing and continuously reviewing best-practice guidelines to support the safe and high quality provision of remote radiology assessment services in appropriate circumstances. High level oversight of safety and quality outcomes is an important part of their role.
 - 3.1.2 SCUs have a continuing role in monitoring clinical outcomes, quality and safety of remote radiology assessment models within their jurisdictions.
 - 3.1.3 Continued monitoring of outcomes in terms of quality, safety and timeliness of assessment services is important when considering requests to further implement the remote radiology assessment model.
 - 3.1.4 Work to refine client information and data monitoring systems so that they use consistent data fields across jurisdictions that in turn align with the BSA Data Dictionary.
 - 3.1.5 Assessment services have a responsibility to undertake continuous self-monitoring of remote radiology assessment clinics and review processes as appropriate.
 - 3.1.6 Jurisdictions consider mechanisms to accurately gather cost data for assessment visits performed under remote radiology and radiologist onsite models.
- 3.2 Systems and processes for planning and implementation
 - 3.2.1 Consider designation of a project officer to coordinate change management processes in preparation for the remote radiology assessment model.
 - 3.2.2 Jurisdictions and services planning to implement the remote radiology assessment model should consult widely with telehealth and biomedical professionals, medical physicists and access advice and support from existing users of the model.
 - 3.2.3 Client information systems that facilitate effective and efficient sharing of client information between local and remote service providers should ideally be available.
 - 3.2.4 Duties specific for the efficient operation of remote radiology assessment clinics for both onsite and remote staff should be clear.

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3.2.5 Processes used for remote radiology assessment clinics should facilitate optimal service provision for the local context.

1. Introduction

1.1 Breast cancer screening in Australia

Breast cancer is the most commonly diagnosed cancer in Australian women (1). To enhance early detection and treatment, all women in Australia between 50 and 69 years (recently extended to 74 years) are invited to attend for a 2-yearly screening mammogram at their nearest BreastScreen location or outreach service. According to the latest publicly available data, 54.8% of Australian women in the target age group participate in this screening (1.7 million women in 2015-16; 2). This was significantly lower for Aboriginal and Torres Strait Islander women at 39% in 2015-16 (2). Approximately 12% of women attending their first screening and 4% of women attending subsequent screens are recalled for further investigation at an assessment clinic (2). This evaluation and report concerns the remote radiology model as applied at BreastScreen assessment clinics only. This model is not used in BreastScreen screening services, and screening data is not reported.

While mammography screening and assessment is vital to the early detection of breast cancer, the appropriate and acceptable provision of these services must contend with a number of issues which are common to many other health services, including: workforce maldistribution (in a geographic sense and by specialty; 3, 4); populations dispersed over large geographic areas outside metropolitan centres; current health system constraints (present focus on sustainability and cost containment); and community expectations for timely and acceptable care (5). These challenges make it particularly difficult to provide care for non-metropolitan communities and can reinforce persisting health inequities seen amongst rural and remote, and Aboriginal and Torres Strait Islander populations (6-9).

1.2 Remote Radiology Assessment Service Delivery Model

Telemedicine is widely used in a variety of diagnostic, therapeutic and educational settings to either: i) increase rural and remote residents' access to specialist health care and expertise; or ii) overcome workforce shortages in regional, rural and remote areas through remote service provision (10-13). To address some of the challenges associated with providing BreastScreen assessment services outside capital cities (namely, difficulty in recruiting onsite radiologists to participate in assessment clinics held at rural and regional centres), a remote radiology assessment service model was piloted from 2014 in the BreastScreen Townsville assessment service, located in an outer regional setting, with endorsement from the BreastScreen Australia (BSA) National Quality Management Committee (NQMC). This model of service delivery involves regionally-based BreastScreen staff engaged with radiologists based in another centre (usually metropolitan) using telehealth technology for and during assessment clinics. In comparison, during the standard service delivery model for assessment, radiologists work with BreastScreen staff in a co-located fashion (herein referred to as the onsite assessment model).

The remote radiology assessment model was rolled out through other assessment services in Queensland and two other jurisdictions, Northern Territory and New South Wales from 2016, as part of a national trial (2017-2019) under protocol requirements of the BSA NQMC and State/Territory Coordination Units (SCUs). Trial sites were established initially at two sites in northern Australia (Townsville and Darwin assessment services) with further trial sites established at Rockhampton and Wide Bay assessment services in Queensland, and at the Greater Southern New South Wales assessment service which included sites at Albury, Queanbeyan and Wagga Wagga. Each jurisdiction considered the experiences of other users of the model, and followed their own procedures for establishing the remote radiology model in their region.

1.3 Research study on outcomes of the Remote Radiology Assessment Service Delivery Model at trial sites

Whilst engaging a remote radiologist may assist with overcoming some of the workforce challenges of providing assessment services in a regional, rural or remote location there is a need to ensure that changes to models of care are "consumer-centred, data-driven and organised for safety" (14, p.1). There is a wide variety of literature now documenting experiences in both store and forward and real time telemedicine, including teleradiology. However, much of this literature consists of program descriptions and observational studies, with limited high quality studies about what factors are important in providing a safe and effective teleradiology service. A series of guidelines and quality standards now reflect emerging consensus about the training, system infrastructure and equipment, regulatory and communication requirements to ensure a strong and safe system (15, 16, 118).

James Cook University was contracted by the Department of Health to undertake an independent evaluation of the remote radiology assessment service model. This evaluation has been conducted under the governance of the Governance Committee of the BreastScreen Australia Remote Radiology Assessment Research Project that in turn reports to the NQMC. For this independent evaluation, a mixed methods approach was used to evaluate the efficacy, safety, quality and acceptability of the remote radiology assessment model. The evaluation was informed by client clinical outcomes data, client views obtained through a survey, service provider views obtained through semi-structured interviews, and cost data. The components of the evaluation are described in detail in Chapter 3.

2. Remote radiology and equivalent telehealth activities: A desktop review

In September 2017, a literature review of remote radiology and equivalent telehealth activities was completed and reported to the National Quality Management Committee's Remote Radiology Assessment Research Governance Committee (RRARGC). The review is presented in full in this chapter.

2.1 Executive summary

Breast cancer is the most commonly diagnosed cancer among Australian women. All women between 50 and 74 are offered a 2-yearly mammogram through BreastScreen with follow up assessment as required. One issue in providing this service to all eligible Australian women is workforce shortages, particularly in terms of specialist radiologists. Recently, BreastScreen has addressed the difficulties of local radiologist recruitment through a trial of remote radiology assessment at two sites in northern Australia (Townsville and Darwin) with roll-out of the program to other sites in Queensland and New South Wales. This innovation addresses workforce challenges for regional, rural and remote services, and implementation has been careful with thorough clinical governance procedures. However, there is still a need to ensure that the model of care is safe, effective and appropriate for consumers. This desktop review aims to summarise the current state of knowledge about the use of teleradiology in diagnostic services worldwide, and to integrate findings from both grey and white literature about what is required to ensure a safe, high quality service.

We conducted a systematic review of published literature on service delivery models incorporating teleradiology. The team reviewed one hundred and seven (107) articles with a range of methodological approaches along with published teleradiology guidelines from a number of radiology professional bodies worldwide. Information was synthesised into four themes and then compared with a published taxonomy for telemedicine.

- 1. Drivers of teleradiology included:
 - Issues with timely access to radiology services for populations in rural and remote centres.
 - Shortage of radiologists, including urban settings and in higher income countries.
 - General improvement in technology for timely and high quality image transmission.
- 2. Teleradiology for health care provision.

Findings from these articles were synthesised into categories.

- Application: Teleradiology is used in various care settings and in the management of a range of conditions, including cancer. It was found to be well established in some medical specialties and emerging as a possibility in other disciplines.
- Technology: Asynchronous (store and forward) teleradiology, where imaging studies are sent from the local site to a remote site for interpretation, was an important feature of models aimed at reducing unnecessary patient transfers and for regional teleradiology networks. Synchronous (real-time) models of teleradiology involved real-time consultations that facilitated treatment decisions or diagnosis. There were few examples of synchronous models involving remote guidance by specialists. Both models, but particularly synchronous models, require fast efficient internet and equipment as well as consideration of the security of patient information. There was a lack of rigorous evidence on the technological aspects of teleradiology.

- Functionality:
 - Consultation for diagnostic processes: Teleradiology was often used to guide physicians in rural or regional centres on a particular course of action. In rural and remote areas, diagnostic workflows were used to prevent unnecessary trauma patient transfers.
 - Diagnosis: Many articles discussed the use of teleradiology for diagnostic interpretation, without requirement for consultation, at remote sites. Articles described regional networks of teleradiology for the exchange of imaging and facilitation of specialist diagnosis as well as outsourced image interpretation to external local or international organisations. Some medical specialties used teleradiology for diagnostic purposes, in real-time and with guidance from remote experts.
- 3. *Aspects of safety and quality for teleradiology*: Four key measurable outcomes were identified.
 - Diagnostic accuracy was of great importance and was measured in some form in the majority of studies that evaluated a teleradiology model and found equivalent to standard models.
 - Accuracy of treatment or triage decisions facilitated by teleradiology was assessed through health outcome data.
 - The ability of specific health professionals to achieve high diagnostic accuracy was discussed in some articles, including training of operators.
 - Diagnostic accuracy was reduced with outsourced and cross-border care and with reductions in image quality.
 - Communication was an important aspect of safety and quality; essential for remotely-guiding imaging examinations. The ability to share patient clinical information between institutions was valued for diagnostic accuracy.
 - Improvements in the time taken to achieve specific outcomes was important for safety and quality in some models; particularly time-sensitive conditions
 - Of the articles included in this review, few were found to particularly consider user perceptions; with the focus on clinician views over patient views. Clinicians cited the advantages of teleradiology to be greater availability and efficiency of radiological services (leading to better patient care). While the majority of studies found respondents believed there was a future for teleradiology models, there were a number of concerns including sharing of patient records, privacy and consent, relationships and interprofessional care.
 - **Cost** or efficient use of resources was considered when assessing the feasibility of teleradiology services. A number of international and Australian studies concluded that telehealth leads to significant cost savings. However, the quality of this literature is poor. Furthermore there are no cost-effectiveness evaluations or measurements of outcomes.
- 4. Barriers and enablers for implementation of teleradiology:
 - There is a need to **involve relevant stakeholders** for design and implementation of services involving teleradiology; including a variety of practitioners from both local and remote sites.

- Agreements between participating organisations around workflow and licencing appear to be necessary.
- **Qualities of teleradiology service providers** included those who would embrace change and education about the new services.
- The integration and benefits of teleradiology for service **workflow** were important in design and implementation; including patient information systems and imaging databases. Patient security was an important consideration in many studies. The impact of technological issues including the need for quality images and backup systems were also discussed.
- The **cost** of expensive, specialised equipment was mentioned for design and sustainability of a teleradiology model; particularly in low-resourced settings. While innovative models were designed to overcome costs, this may raise issues in terms of safety and security. Contrastingly, high cost models may not be sustainable.
- Environmental aspects included ergonomics and workplace environmental factors for professionals; as well as physical space for equipment that may be cumbersome and interfere the availability of services.

There is a growing body of international grey and peer reviewed literature on teleradiology and its use in diagnostic processes. The development of new models and programs is driven by response to local need; usually due to the lack of access to radiological expertise. Despite the wide range of publications describing these new models, including feasibility and cost effectiveness, there is very little high quality evidence evaluating benefit in terms of outcomes. There is no reliable research on the safety and quality of teleradiology used specifically in mammography and breast assessment services. There is also limited research on consumer satisfaction with teleradiology. A synthesis of consensus guidelines for teleradiology from professional bodies and Chang's 2015 framework for evaluating telemedicine services suggests that a range of human (provider and patient/client), system (organisation and technological) and environmental (societal and regulatory) factors need to be considered for safe, high quality operation of these systems. Despite the paucity of quality evidence, current literature suggests that with attention to the appropriate training, regulatory and monitoring guidelines, that it is quite possible to implement a safe, effective and high quality teleradiology service. Factors that are important in fostering a teleradiology service include teamwork; selection and training of the workforce; equipment; protocols and communication and clinical governance frameworks. There is an ongoing need for reliable research to assess the quality and safety of such models, including patient and clinician views.

Many of the factors reported on in this review are now reflected in the range of consensus guidelines published by professional organisations around the world (notably US, UK, Europe, Canada and New Zealand) to guide the design and implementation of teleradiology services. Guidelines from the Royal Australian and New Zealand College of Radiologists are out for review, but were not yet available in final form at the time of completion of the review.

Factors that appear to be important in terms of fostering a safe and effective service include:

- 1. Shared commitment to teamwork for positive outcomes;
- 2. Appropriate selection and training of workforce (including radiologists, sonographers and mammography technicians);
- 3. Appropriate equipment;
- 4. Protocols around communication; data storage; data security; recording and management;

- 5. Strong clinical governance frameworks incorporating credentialing; monitoring and evaluation and professional development;
- 6. Involvement of stakeholders early in design process (and ongoing through implementation).

It seems likely that periodic face-to-face meetings between local and distant team members to facilitate relationships and a shared understanding of the context of service delivery are also important in the promotion and development of a high quality service.

2.2 Aim

This desktop review aims to summarise the current state of knowledge about the use of teleradiology in diagnostic services worldwide, and to integrate findings from both grey and white literature about what is required to ensure a safe, high quality service. For the purposes of this review teleradiology is defined as:

".....The electronic transmission of diagnostic radiological images in digital form from one location (acquisition site) to another (reporting site) for diagnosis and reporting by a clinical radiologist or any other appropriately credentialed medical specialist using a bi-directional data communication link that keeps all patient data secure." (17)

2.3 Methods

Scope

We conducted a systematic review of published literature on service delivery models incorporating teleradiology. The review focused on teleradiology consisting of a diagnostic component. Applications with education as the primary goal for use of teleradiology were excluded. Purely technical descriptions of imaging, viewing, videoconferencing, network design or connectivity were outside the scope of this review. Articles investigating teleradiology models that involved 'field reporting" using tablet devices and smart phones were also outside the scope of this review. Mobile devices for imaging interpretation are becoming more frequently used in clinical practice, however the ability to use these devices safely is still being considered. The US Food and Drug Administration (FDA) approved the use of certain medical applications for the viewing of radiological imaging on mobile platforms such as tablet and smart phone devices (18). However, these devices are then considered to be Class II PACS (Picture Archiving and Communication System) and must meet the requirements of a Class II PACS (18). The implications of the use of these devices in models of teleradiology should be considered carefully.

Search strategy

Several databases were accessed: CINAHL, Cochrane Database of Systematic Reviews, Joanna Briggs Institute EBP, Informit, Medline/PubMed and Scopus. The search terms used a combination of MeSH terms, keywords and delimiters as appropriate for each database (Box 1). A search of major telemedicine journals was also performed. The journals accessed were: Journal of Telemedicine and Telecare, Telemedicine Journal and E-Health, Telemedicine Journal, Journal of Medical Systems, Journal of Medical Imaging and Radiation Oncology.

For information about policies and guidelines related to teleradiology, the following websites were also searched: Robert Graham Center, Analysis and Policy Observatory, University of Queensland Centre of Research Excellence in Telehealth, Australia and New Zealand College of Radiologists, Australian Society of Medical Imaging and Radiation Therapy, BreastScreen Australia, National Breast Cancer Foundation, Cancer Australia, Australian Institute of Health and Welfare and Australian Bureau of Statistics (Health services).

Database	Search terms	Limits	
CINAHL	Teleradiology (Subject) OR teleradiolog* OR tele- radiolog*	2007 – current, English language, Exclude Medline records	
Cochrane Database	(Radiolo* AND (telemedicine OR telehealth)) OR teleradiology	2007 - current	
Joanna Briggs	Teleradiology OR ((Radiolog* AND (telehealth OR telemedicine))	2007 - current	
Informit	Teleradiolog* OR tele-radiolog*	2007 - current	
Medline	 telehealth.mp. telemedicine.mp. or exp *Telemedicine/ 1 OR 2 radiology.mp. or exp *Radiology/ 3 AND 4 teleradiology.mp. or exp Teleradiology/ 5 OR 6 	2007 – current, Human, English language	
Scopus	(teleradio*) OR (tele-radio*)	2007 – current, English language	

Box 1: Search terms used for each database

Search results

A total of 1213 articles were identified from the search of published literature (Figure 1). The article titles and abstracts were screened for relevance. From the 1213 identified articles, 499 articles were imported to the bibliographic manager software Endnote. After duplicates were removed, 342 articles remained. An additional 58 articles were found during searches of specific journals. The 400 articles were sorted according to relevance for the review resulting in exclusion of 222 articles. The remaining 188 articles were grouped into general themes based on information contained in the abstracts: teleradiology or other telemedicine (these latter articles were excluded from any further processing), cost/benefit evaluation, quality assurance, readiness and implementation issues, low resourced settings, service delivery using teleradiology, imaging, security and views of teleradiology consumers. The groups of articles were distributed amongst the research team for critical review. We extracted information from articles into a template developed by the research team. Information about the type of teleradiology model, article type or study design, methods, outcomes measured and insight gained from the article was extracted.



Figure 2. Search flow chart

Analysis and synthesis

Information was synthesised from all team members' reviews of the articles into themes: Drivers of teleradiology, teleradiology for health care provision, aspects of safety and quality for teleradiology, and barriers and enablers for implementation of teleradiology. Additionally, findings from the review of articles about teleradiology in health care provision were synthesised using Chang's taxonomy for telemedicine as a framework (112). The taxonomy identifies telemedicine as one of four health care domains dependent on information and communication technology. The other three health care domains are telehealth, e-health and m-health. Bashshur (2011) describes telemedicine as consisting of three dimensions namely functionality, application and technology that each consist of multiple components (Table 2.1.; 19).

Table 3.1	Тахопоту	of telemedicine	consists of	three din	nensions,	each with	multiple	componei	nts
(19; p.49)	1)								

Functionality	Applications	Technology		
Consultation	 Specialty 	Synchronicity		
Diagnosis	Disease	Network		
Mentoring	• Site	Connectivity		
Monitoring	Treatment			

Technology

The technological dimension is explained by synchronicity, network design and connectivity. For the purposes of this review, teleradiology using a synchronous model refers to transmission of imaging studies to a remote site for consultation or interpretation in real-time (19, 20). This may occur over video-conference or telephone consultation. Additionally, acquisition of imaging studies may also occur in real-time under remote guidance by a specialist. Asynchronous teleradiology refers to a store-and-forward modality, where imaging studies are sent to another site for sharing or

interpretation at a later time and there is no real-time interaction. The type of network design and connectivity used in the model infers different levels of data security and transmission quality.

Application

Teleradiology may be used in specialised medical disciplines or for the simple exchange of imaging studies between or within organisations. It is used in a variety of different settings ranging from image exchange from mobile sites to exchange between hospitals, for example to make decisions about transfer for patients in rural emergency departments.

Functionality

Functionality refers to activities performed in the medical care process using teleradiology (19). Activities may be grouped into the components of consultation, diagnosis, mentoring or monitoring noting that consultation and diagnosis are not mutually exclusive. The articles included in this review focused on:

- (i) Consultation with diagnostic processes. This is where consultation occurred between health professionals, specialists and/or patients with interpretation of transferred imaging studies by remote specialist health professionals, often to inform treatment decisions.
- (ii) Diagnosis. This is where definitive diagnosis of transferred imaging studies was carried out by specialist health professionals at a site remote from the origin site of the studies. This included real-time consultations involving remote guidance of imaging operators by a specialist health professional.

Mentoring has a focus on guidance by specialists in performing new or complex procedures and may be viewed as having an educational goal. Monitoring relates to the use of telemedicine to monitor treatments from a remote site. Both of these functions are outside the scope for this review.

2.4 Results

Following review by team members, 109 articles were deemed suitable for inclusion in the review. The articles included program descriptions, literature reviews and empirical studies. Articles were excluded for the following reasons: irrelevant, reported on highly technical issues, very low quality, opinion or commentary piece, focused on models for education or included the use of mobile devices. Teleradiology was represented in articles set in many countries worldwide and both low resourced and high resourced settings were represented (Appendix 1). Overall, we found the articles to be of generally of poor quality. Details relating to research design, methodology and analysis of findings were frequently lacking, research was based on small scale studies and literature was usually reviewed in an unsystematic way.

Despite these limitations, the articles provided insight into drivers of teleradiology implementation and aspects of teleradiology that are required for the implementation of a safe and quality teleradiology service model. We present the review findings under four major themes: i) drivers for the development of teleradiology; ii) teleradiology for health care provision; iii) aspects of safety and quality for teleradiology; and iv) barriers and enablers for implementation of teleradiology.

Drivers of teleradiology implementation

Content analysis of all reviewed articles identified several major drivers for the investigation or implementation of teleradiology for health care provision. Workforce shortage characterised by a lack of discipline-specific specialist expertise in rural and remote centres was frequently described (21-24). For example, the use of teleradiology by physicians in rural or regional hospitals to consult with neurosurgeons in specialised centres was commonly described in models of telestroke (25, 26). In telestroke, physicians based in rural centres sent computed tomography (CT) scans and patient information to neurosurgeons to diagnose the absence of contraindications for administration of tissue plasminogen activator (tPA), a time-sensitive treatment for management of acute ischaemic stroke (27, 28). Models of telestroke were found to be implemented in Australia (29), Hong Kong (30), Norway (31), Thailand (32) and the United States (27, 28, 33).

A shortage of radiologists was also described as a driver for teleradiology (34-38). In Japan in 2006, the number of radiologists practicing in urban areas was 3.1 times greater than in rural areas, and this increased to 3.9 times in 2012 (35). The number of hospitals and clinics using teleradiology also increased and rural hospitals were more likely to use teleradiology than urban hospitals. In Sweden, a shortage of in-house radiologists drove changes to workflow to include sharing of radiology workload with other hospitals and outsourcing of radiology imaging interpretation to private teleradiology partners (36).

Increasing timely access to health care services for populations in rural and regional areas was another major driver for teleradiology. Services included diagnostic screening services for foetal congenital heart disease in a regional setting (22, 39), colorectal cancer screening for Native American communities living in medically underserved areas (40), mammography screening and diagnostic services (41), neurosurgical trauma services (42-44), pulmonary clinic (21) and fracture clinics (45-47). Improving the speed at which a diagnosis for time sensitive conditions could be made and appropriate care accessed was a major driver for implementation of telestroke, prehospital trauma services and assessment for acute pulmonary embolism (27, 32, 48, 49).

General improvement in access to timely and high quality imaging interpretations was an important driver for hospital system change. In some settings, this fueled the outsourcing of teleradiology services to private enterprise or other partner organisations (36, 50, 51). In less resourced settings, teleradiology was investigated to address poor local knowledge about use of imaging equipment that resulted in high levels of misdiagnosed or undiagnosed imaging studies (52).

Another driver for the use of teleradiology in health systems was the need for collaboration to facilitate better patient outcomes as cost effectively and efficiently as possible (53). Several researchers described the need for better exchange of imaging studies between health care institutions (54). Exchange of imaging through teleradiology was thought to allow for better facilitation of expert consultation for treatment decisions, reduced patient transfers, enable faster interpretative report turnaround and improve cost efficiency (24, 42, 55-59).

Teleradiology for health care provision Application

Teleradiology was implemented in various care settings and included general practice, dental practice, emergency care involving mobile units and, military and hospital settings. Regional networks for sharing of imaging and related information made use of teleradiology. Teleradiology was used in the management of stroke, neurosurgical complications of trauma, acute trauma

injuries including fractures and head injuries, breast and colorectal cancer, congenital heart disease, pulmonary conditions including acute pulmonary embolism and tuberculosis.

Teleradiology was firmly established in some medical specialties and emerging as a possibility in other disciplines. In particular, the use of teleradiology for stroke management was prominent in the literature and appears to be well established. Following a review of available evidence on telestroke, the American Stroke Association recommended the use of telestroke for acute ischaemic stroke in the absence of a local stroke specialist (60). Other medical specialties that investigated or described the use of teleradiology were neurosurgery, prenatal, neonatal and adult cardiology, colorectal cancer, dentistry, respiratory, breast and colorectal screening, orthopaedics, paediatrics, trauma and prehospital trauma, and sonography for clinical investigation.

Technology

Many articles described or explored asynchronous, or store-and-forward, models of teleradiology. In these models, imaging studies were sent from the local site to a distant site for interpretation by a specialist health professional at a later time. Asynchonous teleradiology was an important feature of models aimed at reducing unnecessary patient transfers and for regional teleradiology networks. A study involving tele-echocardiography for diagnosis of congenital heart disease in foetuses, reported that asynchronicity was important for workflow, saving specialists time in not attending the examination and facilitating interpretation of imaging in a shorter timeframe (22). In contrast, synchronous models of teleradiology were usually real-time consultations that facilitated treatment decisions or diagnosis. These consultations included the use of videoconference or telephone interaction between service providers, in conjunction with reading or imaging studies.

Synchronous models of teleradiology involving remote guidance by specialists were few (39, 61-67). Garg et al. (2015) described a model for remote delivery of congenital cardiac magnetic resonance imaging (CMRI). This model was developed to address a shortage of expertise in performing and interpreting CMRI in the United States and to increase access to this diagnostic service for patients with congenital heart disease. In the model, a consultation was performed in real-time between a technologist, patient and remote specialist physician. The specialist physician guided the technologist through the examination and images were transmitted to the remote site for immediate review by the physician. The consultation was performed using FDA approved software that interacted with a Digital Imaging and Communications in Medicine (DICOM) viewer, PACS system and RIS. An onsite cardiologist was available for administration of medications if required. Imaging studies that were guided by experts in real-time were reported to be beneficial for accurate capture of pathologies, improving ability to diagnose and reducing the need for repeat imaging (66). The use of remotely guided sonography was also investigated in less resourced settings. For example, Adambounou et al. (2012) piloted teleradiology software that used low cost equipment and low bandwidth (64). Real-time remote guidance was possible through transmission of video flow from the sonograph to the internet, when the internet connection was sufficient.

The application of teleradiology, in particular remotely guided synchronous teleradiology, requires consideration of internet speed and equipment as well as consideration of the security of often sensitive patient information. Detail relating to the technological aspects of teleradiology models in relation to accepted standards, was lacking in the majority of articles. Overall, rigorous assessment of equipment, data security and quality of imaging in piloted models of teleradiology was lacking. In less resourced settings, reporting on the feasibility of teleradiology using low cost solutions was prominent and often included some comment on the adequacy of the technology and equipment for

patient safety. Issues with integration of networks and maintenance of data security were also discussed, regardless of setting. There are several standards that may be used to guide the sharing of data through teleradiology, though there appears to be no agreed consensus internationally (68). The Digital Imaging and Communications in Medicine (DICOM) standards guides the communication and management of medical imaging information and data (69). This standard appears to be well accepted internationally, and perhaps explains the lack of comment on patient safety in terms of technology standards. Additionally, some countries have developed specific standards or guidelines for the use of teleradiology (70-73), that are coming to some consensus about features required in safe operation of such systems, although with limited evidence-base on which to draw.

Functionality

Consultation with diagnostic processes

Teleradiology was often used to guide physicians in rural or regional centres on a particular course of action. In a pre-hospital setting in Germany, the Stroke Emergency Mobile Unit (STEMO) consisted of a neurologist, paramedic and radiographer who travelled to call-outs in vehicles fitted with teleradiology equipment and a CT scanner (49). In the case of suspected acute stroke, a head CT image was taken in the field and sent to the remote radiologist for interpretation. The neurologist in the field then consulted with a senior neurologist by telephone to determine if tPA could commence. Other studies used similar diagnostic workflows for timely decision making in the hospital setting.

Similar diagnostic workflows, involving consultations, were also used to prevent unnecessary patient transfer of trauma patients to larger referral centres (31, 43-45, 74). At Mount Isa Hospital in Australia, videoconference fracture clinics with an orthopaedic surgeon replaced face-to-face clinics attended by an unaccredited orthopaedic registrar (46). The benefits of this model included imaging performed on the same day as the consult; reducing the need for repeat imaging and delay of management, early diagnosis of pathology and reduced patient transfer to the referral centre. Workflows made use of telephone or videoconferencing capabilities with some studies investigating the role of videoconferencing and telephone consultation in teleradiology (30, 56). Videoconferencing or ability to view imaging videos was associated with better decision making in management of minor injuries (56) while Fong and others (2015) found that teleradiology with telephone consultation was safe (30).

Diagnosis

Many articles discussed the use of teleradiology for diagnostic interpretation, without requirement of consultation, at remote sites. These articles often described the availability of a teleradiologist or other specialist to consult over the telephone if required. Regional networks of teleradiology for the exchange of imaging and to facilitate diagnosis by medical specialists were described in Sweden, Uruguay, Australia, Canada and Ethiopia (23, 36, 54, 75, 76). Outsourced teleradiology services, where the interpretation of images was completed by an external local or international organisation, was discussed in some settings (50, 51). A survey of members of the American College of Radiology (ACR) in the United States found that almost half of all radiology practices used outsourced services and half of all radiologists were practicing in services that used outsourced services (77).

Several medical specialties used teleradiology for diagnostic purposes. A trial screening service for colorectal cancer using CT colonography (CTC) was described on a remote island in Portugal (78). The CTC was performed at a local radiology service by a radiographer under the supervision of a local radiologist. The imaging data was sent to the remote expert interpreter for assessment of presence

of polyps or tumoral lesions of 6mm or greater. The authors concluded that teleradiology facilitated reliable polyp detection.

McCrossan et al. (2011) described a real-time guided model of teleradiology for the detection of foetal congenital heart disease (39). An obstetric sonographer performed the echocardiogram with guidance from a foetal cardiologist. The authors found that in 94% of telelinks, at least 11 of 12 markers of the echocardiogram were assessed with confidence. Importantly, 97% of diagnoses made during the telelink were confirmed through hands on scanning by the foetal cardiologist.

Aspects of safety and quality for teleradiology

Aspects considered important for the safety and quality of a teleradiology model emerged from content analysis of the reviewed articles. Researchers often measured outcomes with and without teleradiology involvement. Outcomes measured included diagnostic accuracy, the time taken to achieve a specific outcome, quality of reporting, user perceptions and cost. The availability of patient information for reliable imaging interpretations, integration and capability of systems within and between institutions, efficiency of workflow and security of patient data was also discussed in some studies.

Diagnostic accuracy

Health outcomes

Diagnostic accuracy was of great importance and was measured in some form in the majority of studies that evaluated a teleradiology model. Accuracy of treatment or triage decisions facilitated by teleradiology was assessed through health outcome data. Some cohort studies compared health outcomes with and without teleradiology implementation (30, 32, 74). Health outcomes during a hospital admission period were used to assess the success of triage decisions facilitated with teleradiology in acute trauma (43). Several studies using teleradiology for stroke management assessed the functional outcomes of patients 3 to 6 months following a stroke incident in the traditional compared with the teleradiology workflow (30, 49, 74). These studies also measured the absence of complications and mortality rates. None of these studies reported that teleradiology was significantly different to conventional methods in terms of health outcomes. However, assessment of health outcomes in the longer term, comparing models of service provision with and without teleradiology, were lacking in the reviewed articles.

Reduction in repeat imaging was reported as beneficial for patient safety and the use of store-and-forward application between hospitals was effective in reducing repeat imaging for patients (58, 79).

Professionalism

The ability of specific health professionals to achieve high diagnostic accuracy was discussed in some articles. Questions about professionalism applied to operator capability at the local site to identify, capture and transmit appropriate images for diagnosis. Most teleradiology models involved non-radiologists at the local site. These non-radiologists may have been operators with minimal training, technologists (though it was not always clear if technologists were professionals with formal training), radiographers, sonographers or physicians. Teleradiology models involving non-radiologists to conduct imaging examinations with or without guidance from experts at the remote site were reported to be acceptable (22, 39-41, 45, 49, 61, 64).

Specific training for these operators was usually incorporated into the model. A feasibility study for remote colorectal cancer screening involved transmission of CTC imaging captured by a technologist

trained in CTC examinations for interpretation by a remote radiologist (40). Ninety-two percent of examinations were found to be of diagnostic quality. However, some studies did not provide training for local operators. Surprisingly, Garg et al. (2015) reported that specific training was not necessary as the session was remotely guided by an expert (61). In another study involving remote guidance in Canada, there was no mention of training. This study investigated the use of a robotic ultrasound machine with a probe attached to a robotic arm that was remotely operated by a sonographer (63). A patient assistant moved the probe and applied pressure to the arm when instructed by the sonographer. Fine movements were controlled by the sonographer remotely. The authors concluded that a person with no health care background could correctly position the probe as instructed.

Professionalism also applied to the ability of interpreting specialists at the remote site to achieve diagnostic accuracy. Zennaro et al. (2016) investigated the diagnostic accuracy of paediatric ultrasound performed by emergency physicians with guidance from a remote paediatric radiologist compared with radiologist examination (62). The authors found that the model of remote guidance facilitated reliable and timely diagnoses. Likewise, ability of remote specialists to accurately diagnose imaging studies was investigated (28, 33). Demaerschalk et al. (2012) found no significant differences in identification of contraindication to tPA administration for acute stroke management between vascular neurologists (telestrokologists) and neuroradiologists (28).

A change in professional role was found in a study investigating the use of a PACS in orthopaedic departments (80). PACS was found to change the skills and nature of work undertaken by staff, facilitate team work between orthopaedic surgeons and radiologists, and was reported to improve dialogue with patients. It allowed other health professionals to take over work traditionally done by radiologists but also potential for radiology work to become more specialised in certain fields (e.g. orthopaedics). This study underscores the need for care to facilitate the changing nature of work when implementing a new system of care.

Outsourcing and cross-borders teleradiology

Diagnostic accuracy of outsourced imaging studies was also explored. Hohmann et al. (2012) found that 0.8% of reports from a hospital teleradiology service provider, relating to 1028 patients, were definite cases of misinterpretation with "strong likelihood of moderate morbidity but not threat to life" (51). Considering the smooth workflow, faster report turnaround and similar findings reported in larger studies, the authors supported the use of an outsourced after hours teleradiology service. Similarly, a study of international teleradiology services provided to US hospitals with radiologists based in India, China, Europe and the US found that there were 330/126449 discrepancies reported (0.26%). The majority of discrepancies were minor or an error of long term significance but not in the acute setting (81). On the contrary, a study compared in-house radiology with teleradiology (after hours service) in the ED and reported that major discrepancies in 21% of scans (82). The authors concluded that caution should be exercised using teleradiology in emergency settings. The impact of inadequate clinical information and patient history were suggested to contribute to discrepancies (81, 82).

Image quality

Achievement of diagnostic accuracy was also associated with the quality of images. Some studies explored the difference in image quality when using teleradiology compared to traditional methods through evaluation of perceptions of those specialists interpreting the imaging (52, 66, 67, 83) and evaluation of image degradation (40, 66, 67). These studies reported varying degrees of difference in

diagnostic quality ranging from comparable to unsuitable, by certain standards, for diagnostic quality. Popov et al. (2007) found that despite significant differences in mean gray value of transmitted images compared with original images, interpreters were unable to make a clinical differentiation (67). Two studies also investigated the use of consumer grade monitors compared with medical grade monitors for diagnostic interpretation (84, 85). These studies found that despite radiologists' perception of image quality differences between the monitors compared, the specific consumer grade monitors were as good as the medical grade monitors for diagnostic interpretation. It is important to remember that the studies reviewed differed greatly in design and there was substantial variation in the type of technology used and the way that it was used.

Communication

Another important aspect of safety and quality in teleradiology models was the ability to communicate easily with remote experts. Communication was especially important for remotely-guided imaging examinations with audio or videoconferencing used to facilitate communication in these settings. Telephone communication between local physicians and remote radiologists or experts was also commonly used as needed, particularly for outsourced teleradiology and in management of acute trauma and acute stroke. One study found that videoconferencing improved facilitation of decision-making compared with telephone (56). Communication between the local and remote site was also important for planning imaging studies (61). The ability to share patient clinical information between institutions was valued for diagnostic accuracy though sometimes difficult due to incompatibility of organisational patient information systems and a lack of resolution of potential issues with confidentiality and data security. This was also true for outsourced teleradiologists.

Time taken to achieve a specific outcome

Improvements in the time taken to achieve specific outcomes were important for safety and quality in some models involving teleradiology. Earlier access to appropriate treatment through faster turnaround of imaging reports or access to specialist consultation was a goal of teleradiology in many cases (34, 59, 86). For time-sensitive conditions such as acute pulmonary embolism and acute ischaemic stroke this was especially important (27, 48).

User perceptions

Of the articles included in this review, few were found to particularly consider users' views of teleradiology services. Where they were found, the majority were focussed on clinician views (radiologists, primary care, other medical/surgical specialists) and focussed on opinions and use of (mostly general) teleradiology services. Throughout these articles, researchers found varying levels of teleradiology uptake/usage which appeared quite dependent on the availability of a good PACS network and appropriate technological infrastructure. However, an article also discussed the low uptake of telemedicine in light of perceived patient preference for physical attendances at medical appointments (87).

The major advantages of teleradiology services as indicated by clinicians included: greater availability and efficiency of radiological services (leading to better patient care) (34, 88-90); opportunity for increased collaboration in patient care (88, 91); ability to obtain a second or expert

opinion in a patient matter (92); decreased costs of radiological services (88), improved ability to communicate with radiologists (34) and improvements in workflow (61). One article looked at the use of teleradiology in emergency trauma situations between a remote and referral hospital (93) and found high rates of satisfaction with the teleradiology service. Clinicians felt that the system benefitted patients, improved collegiality and most agreed that the teleradiology system improved their own ultrasound skills.

Some studies assessed the views of non-physicians on teleradiology. Radiographers were highly satisfied with a model of remotely guided foetal echocardiography (39). Radiology technicians reported better supervision and training with teleradiology compared with on-call radiology for a hospital emergency department (34).

Though the majority of articles showed a significant proportion of respondents perceived a future for teleradiology services, there were a number of concerns cited about ongoing use of such services; including:

- the encouragement of more impersonal relationships between patients and clinicians, and even between clinicians ('the invisible radiologist') that would lead to further concerns about the patient-centeredness of the health care system (88);
- less capacity for radiologists to participate in multidisciplinary team meetings (90);
- deterioration of hospital-based radiology services and commoditisation of low-cost external teleradiology services (90)
- lack of access to patient data, history, local context (90, 92, 94);
- licensing and accreditation concerns of external providers (90);
- legislation concerns (e.g. which jurisdiction will liability lie in malpractice cases) (90, 91, 95);
- having a common quality assurance framework (90, 91);
- patient privacy and consent issues (92, 95);
- fee-setting (91, 95);
- the need for adequate funding to allow for the growth of appropriate teleradiology services (92)

Many issues (e.g. legislation, licensing, quality assurance frameworks) were specific to 'outsourcing' teleradiology services. Here, it is important to make the distinction between outsourcing (which may be in the same or another country) and 'inhouse' teleradiology services where radiologists in the same business or service provide radiology services but may use teleradiology technology as part of their normal workflow or for after hours services. In terms of preferences, a US-based study found that if all other things were equal, physicians would prefer a local teleradiology service; especially if the qualifications of the international radiologists were unknown or different to that required domestically (96). Where out-of-pocket costs were lower and turnaround on reports faster, there was greater inclination to use international services. A European-wide survey found national radiological societies throughout the region had particular concerns for the use of teleradiology outsourcing, with quite low rates of perceived positive impact of such services (90). Many of the concerns cited in the literature lead to consideration of broader issues about the future sustainability of the radiology profession and its traditional practice methods/business model.

Though a number of articles pointed to the need to better understand patient perspectives regarding the use of teleradiology, few articles specifically focussed on patient views. One study of island-based primary care patients regarding the use of a teleradiology service with a mainland hospital found high levels of satisfaction (97). Here, patients appeared to value receiving care on the island close to home and the opportunity for relational continuity. Another study of a pulmonary telemedicine service that involved patient consultations and sharing of patient information including imaging studies, found that patients viewed the model positively (21).

<u>Cost</u>

It is important to consider the efficient use of resources when assessing the feasibility of teleradiology services. The expense of appropriate equipment and software was often discussed in terms of saved costs in avoidance of unnecessary patient transfers and benefits to be gained from improved workflows and service accessibility. A number of studies, internationally and within Australia, have assessed the cost savings associated with telemedicine. Nearly all have concluded that telehealth - for the provision of a variety of services - leads to significant cost savings. However, the quality of these studies appears to be variable with a lack of robust and transparent methodology. Furthermore, there is a stark absence of cost-effectiveness evaluations - the comparison of costs and outcomes produced by the different types of treatment. Many studies have simply not measured outcomes at all (46, 47, 98-101). Other studies have also noted that when outcomes have been measured this has been in an ad hoc way with no consistent and validated approach taken to outcome evaluation, making comparisons between studies difficult (102).

Barriers and enablers for implementation of teleradiology

Involvement of relevant people

Some articles discussed the need to involve relevant stakeholders for design and implementation of services involving teleradiology (31, 36, 54, 61, 76, 103). Lundberg et al. (2010) collaborated with a variety of practitioners to design and implement a region wide teleradiology service (36). This was seen as essential for understanding workflow and the information infrastructure. In Mali, local ownership developed with collaboration amongst hospital leadership, specialists and other service providers was necessary (103). The need for organisations involved in a teleradiology service to feel a part of a professional community was important (31). For safe implementation of their remotely guided cardiac MRI model, Garg et al. (2015) recommended a local qualified physician be available (61). The locally based physician was viewed as necessary for administration of medication if needed and acted as a facilitator between the patient and remote physician, and performed a coordination role in management of the patient in the hospital system.

Agreements

On occasion, agreements between participating organisations were reported as necessary (31, 36, 75, 79). Agreements covered consideration for terms of collaboration and standardisation of workflow (36) and patient data security between institutions (79). Additionally, Sorenson and Dyb's study reported that lack of clarity around responsibility for maintenance of a communication network stalled the implementation of a teleradiology solution at one hospital (31). Licensing and cross-border requirements were mentioned particularly in the case of outsourced teleradiology (104).

Qualities of teleradiology service providers

Resistance to change was reported by Acosta and Ruibal Faral (2015) in their pilot of a teleradiology network in Uruguay. Their solution was to provide information, training opportunities and to continue to improve the usability of the system (75). One research article found a marked difference between the views of managers and clinicians regarding the future use of teleradiology in the same hospitals. This underscores the importance of persuading all stakeholders of the value of a new system prior to implementation. In their review of telemedicine for acute stroke in Norway, Sørensen et al. (2015) reported that successful implementation of a telemedicine model required staff perception that it would improve the quality of treatment (31). In one case of teleradiology in this study, the presence of adequate local expertise precluded the need for telemedicine. Findings from Korea (95) found that Korean physicians were concerned and reluctant to participate in telehealth technologies – further highlighting the need for policy-makers to consult with clinicians and other users of a new system prior to implementation.

Education for service providers was reported to be an important component for implementation of teleradiology solutions. Protocols appeared to be well defined in many teleradiology models, particularly for telestroke studies. An education component of a stroke network focused on information about stroke, and when it was appropriate to activate teleradiology (32, 54). Zennaro et al. (2016) implemented highly focused and practical training in their model of teleradiology, and recommended that local training needs should be considered (62). As previously mentioned, training for service providers of remotely guided teleradiology was usually provided both to familiarise operators with the equipment and process, and to provide background knowledge into a medical specialty.

Workflow

The integration and benefits of teleradiology for service workflow were important in design and implementation. The compatibility of patient information systems and imaging databases between organisations influenced the model implemented. Lundberg at al. (2010) considered the uniformity of codes and descriptions for patient imaging records when designing a system for the sharing of services and reports (36). Moreover, the ability to integrate systems that ensured patient security was an important consideration (25, 36, 44, 104, 105). Compression of images for transmission was balanced with the volume of imaging studies, the need for timely transmission, image quality and was dependent on available bandwidth (41, 86, 106, 107). Technical issues with equipment, including technical failure and issues for the user were noted in some cases (61, 65, 67, 103). These sometimes eased with experience. Some models incorporated a backup solution in case the bandwidth dropped below that which was sufficient for transmission of imaging (64, 67).

<u>Cost</u>

The cost of expensive, specialised equipment was mentioned for design and sustainability of a teleradiology model. This was particularly true in low resourced settings and in settings with low demand where equipment costs may be prohibitive. Innovative models of teleradiology were designed to overcome cost, however this sometimes raised questions about the safety and security of the service (52, 62, 66, 108). The high cost of some models was considered an issue for implementation and sustainability (39, 64, 108).

Environmental aspects

One study focused on ergonomics and discussed the workplace setting and setup as important for telehealth (109). Using teleradiology recommendations as a guide, the authors suggested that optimisation of viewing workstations required choice of equipment that reduced strain and use of appropriate light ambience to avoid reflections on viewing monitors. The authors argued for the need for more understanding of how telehealth is integrated into workflow and its usability for sustainability. Additionally, physical space for equipment associated with telestroke was found to be cumbersome and interfered with availability of the service (31).

2.5 Discussion

This desktop review has collated and synthesised the growing body of global grey and white literature on teleradiology and its use in diagnostic processes. There is a wide diversity in the ways in which teleradiology is used, and the development of new models and programs is almost invariably driven by a response to a local need - commonly limitations in access to radiological expertise.

There are a wide range of publications describing new models; some with some basic evaluation of process and outcomes. However, these demonstrate feasibility of the approach and in some cases cost effectiveness, rather than a broader range of health and quality outcomes. We found very little strong evidence about the factors associated with quality and effectiveness, although the limited published studies did suggest that with careful implementation, a safe, high-quality service using teleradiology was possible. Given the breadth of literature, it is striking that there was limited research on patient views about teleradiology services, and limited studies concerning the views of clinicians. There were many mentions of the need to further investigate patient views on teleradiology but only one study specifically addressing this issue. The need for better understanding of patient views is an important point; specifically, their awareness of the process, and skills and registration of the remote clinician and any privacy concerns that they may have. Furthermore, there is very little high quality research evidence demonstrating benefit in terms of outcomes (diagnostic accuracy; timeliness to diagnosis; radiation exposure). These are both areas where further high quality research is needed to develop the evidence-base to inform future program development.

Few studies explored the application of teleradiology to mammography services. The first study, to our knowledge, was in 2006 and was set in the United States. This study used transmission of digitised mammograms acquired by technologists in "almost real-time" to a remote site for interpretation by radiologists, while the woman remained in the clinic (110). The protocol was activated if a technologist suspected that supplementary imaging may be required. If this was the case, patient and clinical information was transmitted and extra images could be acquired following instructions from the remote radiologist. Whilst the technology was inferior to that available today, the study reported a reduction in unnecessary recall to the clinic for additional imaging and did successfully prove the concept of a remote radiology in mammography program. Another program description from about the same time discussed the incorporation of telemammography with telepathology and teleoncology to offer clients a one day privatised diagnostic service (111). Unfortunately, details about the telemammography component of this model is lacking. A clinic located in a rural town transmits mammographic images to the remote university radiologist. Clients receive a report in an hour. The authors reported better client follow up on their diagnoses and high satisfaction.

Despite the caveats in terms of quality raised above, the evidence to date suggests that with attention to the appropriate training, regulatory and monitoring guidelines, that it is quite possible to implement a safe, effective and high quality teleradiology service. In areas where access to a radiologist would otherwise be delayed, this might likely be advantageous in terms of timeliness of diagnosis and treatment, and (again on limited evidence) it appears to be cost-effective.

Many of the factors reported on in this review are now reflected in the range of consensus guidelines published by professional organisations around the world (notably US, UK, Europe, Canada and New Zealand) to guide the design and implementation of teleradiology services. Guidelines from the Royal Australian and New Zealand College of Radiologists are out for review, but not yet available in final form.

Factors that appear to be important in terms of fostering a safe and effective service include:

- 1. Shared commitment to teamwork for positive outcomes;
- 2. Appropriate selection and training of workforce (including radiologists, sonographers and mammography technicians);
- 3. Appropriate equipment;
- 4. Protocols around communication; data storage; data security; recording and management;
- 5. Strong clinical governance frameworks incorporating credentialing; monitoring and evaluation and professional development;
- 6. Involvement of stakeholders early in design process (and ongoing through implementation).

It seems likely that periodic face-to-face meetings between local and distant team members to facilitate relationships and a shared understanding of the context of service delivery are also important in the promotion and development of a high quality service.




In 2015, Chang et al, published a model for evaluating telemedicine initiatives (112). This framework suggests that there are six main areas to consider in terms of implementing a safe and effective telemedicine model. These are grouped into three main areas: i) human factors (service provider factors and patient/client factors); ii) system factors (organisational factors and technological factors); and iii) environmental factors (societal/financial factors and regulatory factors). An effective evaluation of teleradiology services should be guided by consideration of all these factors (Figure 3), evaluating them against desired outcomes of cost-effectiveness, quality of care and patient satisfaction. This approach and the related logical framework incorporates the human, system and environmental factors and barriers of implementation of a telemedicine service; as outlined by the literature discussed by this review (112).

Limitations

A limitation of this study is that only literature published on teleradiology was included. Many additional models of teleradiology may have been implemented but were unevaluated, unpublished or published only in in-house reports. Other sources could be hospital annual reports, teleradiology databases, and other grey literature. Furthermore, terminologies made interpretation of studies difficult. For example, the technologist/operator referred to a radiologist or to a non-expert in some cases or the health professional role was not defined. In addition, interpretation of the review findings should consider the low quality of the majority of the articles reviewed. It appears that telestroke is a well-established model that incorporates teleradiology, and studies from more resourced countries were generally well designed and executed. Given that the field of telestroke is so well developed and the limited relevance of this model for the BreastScreen application, studies reviewed here were limited to those identified in the literature search.

3. Methods

3.1 Approach

A mixed methods approach was used to evaluate the efficacy, safety, quality and acceptability of the remote radiology assessment model. This approach enabled the evaluation to be well informed through the inclusion of: (i) client data to assess clinical outcomes; (ii) experiences and perspectives of service providers involved in delivery of the model; (iii) experiences and the perceptions of clients on their experience of the model; and (iv)assessment of costs.

Specifically, the project evaluated the outcomes of the remote radiology assessment model of service delivery in terms of:

• Safety and quality

Client outcomes were assessed using client data from assessment visits at participating trial sites to answer questions about quality and safety of the remote radiology assessment model compared with the onsite model. In addition, a cost assessment was conducted to provide information on another aspect of the service that is an important component of high quality care and sustainability.

- Client acceptability Clients of remote radiology assessment clinics were surveyed about their satisfaction and confidence in the model, and their preference regarding service delivery.
- Staff acceptability of service provision
 Service providers involved in implementation and delivery of the remote radiology assessment model were interviewed about their perspectives on implementation processes, quality, safety and acceptability of the model.

Overall, the methods employed for this evaluation provide a thorough independent external evaluation of the remote radiology assessment model and the factors important in safe implementation of the model.

3.1.1 Combined Jurisdictional Advisory Group

Communication between the research team and stakeholders was facilitated through the establishment of the Combined Jurisdictional Advisory Group (CJAG). This group consisted of clinical service providers and management staff from each participating site, and State Coordination Unit (SCU) staff including data management staff. A consumer representative reviewed the client survey but was unable to regularly attend the CJAG meetings. CJAG meetings were held quarterly via teleconference for the duration of the research project. At these meetings, members were updated on project progress and project activities were discussed. CJAG members kept staff at their clinic sites updated on progress, also advising and facilitating project activities as necessary to ensure that the project progressed in a timely fashion.

3.1.2 Project Governance

The project was under the overall governance of the BreastScreen Australia National Quality Management Committee (NQMC) through the Remote Radiology Assessment Research Governance Committee (RRARGC). The RRARGC consisted of a radiologist nominated by RANZCR (Royal Australian and New Zealand College of Radiologists), a breast surgeon nominated by BreastSurgANZ (Breast Surgeons of Australia & New Zealand), a SCU representative, a jurisdictional representative, a research member, a consumer representative, a Commonwealth representative and a safety/clinical governance member. The committee provided project oversight and were tasked with ensuring that the project was progressing in line with budget and project objectives. Meetings were held every six months for the duration of the project.

3.2 Sites

Seven sites across New South Wales, Queensland and the Northern Territory that had implemented the remote radiology assessment service delivery model, participated in this evaluation study (Table 3.1). Services participated in various aspects of the evaluation. Assessment of clinical outcomes included client data from all seven sites, and client perceptions and service provider perspectives were obtained at four sites (Table 3.1). The cost study was conducted at the jurisdictional level.

Implementation of the model at the sites was staggered. In Queensland, staff at the Townsville site initiated development of the model and began delivering remote radiology assessment clinics from January 2014, with more regular clinics occurring from June 2014. Rockhampton and Wide Bay sites followed in 2016 and 2017, respectively. Formal training and programmatic guidelines were provided by the Queensland SCU in 2017, setting the conditions for the remote radiology assessment model trial for Queensland. In the Northern Territory, the Darwin site implemented the model in 2016. In New South Wales, the Albury and Queanbeyan sites started transitioning towards use of the model in 2016, with both sites and the Wagga Wagga site conducting more regular clinics from 2017.

Site	State or Territory	Date	Clinical outcomes	Client perceptions	Service provider perspectives
Townsville	Queensland	June 2014	•	•	•
Rockhampton	Queensland	July 2016	•	•	•
Wide Bay	Queensland	Jun 2017	•		
Albury	New South Wales	July 2017	•		
Queanbeyan	New South Wales	Sep 2017	•	•	•
Wagga Wagga	New South Wales	Aug 2017	•		
Darwin	Northern Territory	June 2016	•	•	•

Table 3.1. Participating sites, date of commencement of regular remote radiology assessment clinics and phase of the research that the site participated in.

3.2.1 Approvals

Ethical approval was obtained from the Townsville Hospital and Health Service Human Research Ethics Committee (HREC/17/QTHS/76), the Human Research Ethics Committee of the Northern

Territory Department of Health and Menzies School of Health Research (2017-2893) and the James Cook University Human Research Ethics Committee (H7082). Governance approval was obtained from the Townsville Hospital and Health Service (SSA/17/QTHS/150), Central Queensland Hospital and Health Service (SSA/18/QCQ/23), Top End Health Services (support letter form Executive Director of Medical Services) and Murrumbidgee Local Health District (SSA/18/MLHD/18). Approval to access BreastScreen client data was obtained from the Queensland Department of Health (PHA007000, PHA007805, PHA007854), NSW Population & Health Services Research Ethics Committee (2017/HRE1101) and BreastScreenNT.

3.3 Clinical outcomes

3.3.1 Rationale

The primary outcome, in terms of quality and safety of the remote radiology assessment model, is whether this model is equally good at detecting cancer as the standard radiologist onsite model of assessment. Therefore, statistical analyses of client data aimed to demonstrate non-inferiority of the remote radiology assessment model in specified outcomes, particularly the likelihood of cancer detection. Clinical outcome measures were considered in two groups and covered various aspects of assessment, as outlined below. Outcome measures were defined in terms of the BSA Data Dictionary wherever possible, and times were categorized according to NAS guidelines.

Primary outcomes

- 1. Likelihood of cancer detection
 - (i) total cancers (including cancer in situ/ Ductal Carcinoma in Situ; DCIS)
 - (ii) total invasive cancers (excluding DCIS)
 - (iii) small invasive cancers (less than or equal to 15mm)

2. Timeliness

- (i) Time from screen to first attendance for assessment
- (ii) Time from screen to assessment recommendation
- (iii) Time from first attendance at assessment clinic to assessment recommendation

Secondary outcomes

- 1. Proportion of clients requiring more than one assessment visit to obtain an outcome
- 2. Work-up imaging Number of mammography images required for work up at assessment clinics
- 3. Assessment recommendation
 - (i) Assessment recommendation of early review compared with routine rescreen in 1 year or 2 years
 - (ii) Assessment recommendation of routine rescreen in 1 year compared with routine rescreen in 2 years
- 4. Likelihood of assessment visit requiring biopsy with and without remote radiology assessment model

Outcomes excluded from analysis

Attendance at assessment visits

Initially, the intention was to compare the proportion of clients in BSA target populations attending assessment clinics before and after implementation of the remote radiology assessment model: rural; Indigenous; Culturally and Linguistically Diverse (CALD). These data, whilst reassuring in terms of a largely pro-equity effect have been excluded on the guidance of the RRARP Governance Committee, as women are usually assigned to the next available assessment clinic, and thus this variable does not assess inherent differences in the models.

Interval cancers

Quality and safety could not be reliably assessed in terms of numbers of interval cancers given the unavailability of data for the time period of the remote radiology trial from all three jurisdictions. True interval cancers emerge and grow rapidly between scheduled screening episodes or have characteristics that are undetectable on screening mammography (120). These have been found to represent 80% of cases of interval cancer (120). The remaining 20% of cases of interval cancer represent a failure of the screening process, that is, the breast cancer can be retrospectively detected on a previous screening mammogram; but the client was erroneously not recalled for assessment (120). Given this, and the resulting time-lag, interval cancers had little value as an outcome for effectiveness of assessment visits.

3.3.2 Data

Client data were provided by the appropriate data management bodies in each of three health jurisdictions that had implemented the remote radiology model at assessment services, with appropriate approvals in place. All jurisdictions provided data to May 2019 and included between seven and 8.5 years of data. Variables to be included in the dataset were identified in consultation with data management teams, SCUs and CJAG members. Data were provided by jurisdictions in various formats: i) row per attendance at assessment clinic in a screening episode where there could be multiple attendances per screening episode; ii) row per procedure per attendance in a screening episode where there may be multiple procedures in an attendance, and multiple attendances in a screening episode, and; iii) row per client where there could be duplicate screening round numbers or multiple screening round numbers per client. The datasets were harmonised and merged into a single master dataset. Considerable care was taken to ensure that variables were equivalent across jurisdictions, requiring consultation with data management teams and SCUs throughout data cleaning and analysis phases.

3.3.3 Analysis

The remote radiology assessment model was implemented at sites in a staggered start approach, allowing for a multiple baseline design for intervention at each site, comparing pre-implementation and post-implementation outcomes. In addition, for visits after the implementation of the model, direct comparisons were conducted between outcomes of assessment visits conducted under the remote radiology assessment model and the radiologist onsite model. Data were excluded from QLD and NT datasets (620 assessment visits in total) in consultation with data team representatives in QLD and NT. The unit of analysis for the majority of analyses was assessment visit. A total of 21,117 assessment visits were included in the final combined jurisdictional client dataset (10,595 visits in NSW; 8,457 visits in QLD, and; 2,065 visits in NT; Table 3.2). These assessment visits related to 21,009 assessment episodes.

	Pre-implementation of remote radiology assessment model	Post-implementation of remote radiology assessment model	Total
NSW	7,733	2,862	10,595
QLD	1,688	6,769	8,457
NT	1,087	978	2,065
Total	10,508	10,609	21,117

Table 3.2. Number of assessment visits pre-implementation and post-implementation of the remote radiology assessment model.

Of the 10,609 visits conducted post-implementation of the model at each of the sites, data from a total of 3,904 remote radiology assessment clinic visits were received, with the majority (3,046) of these from Queensland. Over the equivalent time period, data from 6,705 onsite assessment visits were received (see Table 3.3 for more detail). A priori power calculations suggested 90% power to detect a true difference in our primary outcomes with a sample size of 3000 women assessed under the remote radiology model – thus we had adequate power for all our analyses as performed.

Table 3.3. Number of assessment visits conducted with remote radiology assessment and onsite	2
assessment, post-implementation of the remote radiology model.	

	Remote radiology assessment model	Radiologist onsite assessment model	Total
NSW	245	2,617	2,862
QLD	3,046	3,723	6,769
NT	613	365	978
Total	3,904	6,705	10,609

Comparison of outcome indicators between groups was conducted using t-tests for means and chisquare tests for proportions as indicated, with adjusted odds ratios and 95% confidence intervals calculated for each of the primary outcomes. Logistic regression analyses were performed to calculate adjusted odds ratios for the detection of cancer within the sample. Three outcomes (any cancer diagnosis, any invasive cancer, or any small invasive cancer) were assessed using the same predictors.

The dependent variables used for these analyses were either assessment clinic type (remote radiologist versus onsite) or pre-implementation or post-implementation timing of assessment clinic visit. These variables were highly collinear, thus one or the other was used, depending on what made logical sense. Other confounding factors adjusted for in the analysis included: i) assessment visit related to first or subsequent screen (episode number 1 vs all others); ii) age at time of screen; iii) jurisdiction where assessment was carried out; iv) CALD (Culturally and Linguistically Diverse) status; v) SEIFA IRSAD score (Socio-Economic Indexes for Areas, Index of Relative Socio-Economic

Advantage and Disadvantage; 1-3, 4-6, 7-10); vi) Indigenous status (not received for NSW); and, vii) remoteness (Remoteness area; RA category). Remoteness area related to the postcode of residence of the woman attending the assessment clinic. Clustering by clinic was considered, but was highly collinear with jurisdiction and was had an insignificant effect on the analysis so was omitted from the final model. On the advice of the RRARP, year of assessment was also excluded from the final model – again, the overall likelihood of cancer detection was unaffected by this.

More details about the quantitative data analysis plan are provided in Appendix 2.

3.4 Client perceptions

3.4.1 Rationale

Many elements of the remote radiology assessment model may not be immediately apparent to clients. However, experiences and expectations of the remote radiology assessment model, as viewed by clients, are an important measure of the quality of a service.

3.4.2 Survey tool

A short survey for clients who had attended a remote radiology assessment clinic was developed with advice from clinic representatives and a consumer representative. The survey aimed to gather the perceptions of clients on their satisfaction and confidence in the remote radiology assessment model, and their preference for service delivery. The survey consisted of Likert-style questions, multiple response questions, open-ended responses, and was available in paper format, or online format through the SurveyMonkey platform (Appendix 3). Demographics collected were age range, Australian Indigenous status, language other than English, postcode and suburb of residence. Identifying information was not collected.

The survey tool was piloted face to face with five clients at a remote radiology assessment clinic. Minor changes to wording were made to improve the clarity of two questions, in response to feedback from clients. Clients were otherwise satisfied that the survey questions and explanations made sense to them.

3.4.3 Recruitment

Client responses to the survey were collected in person, with a research officer present, wherever possible. A time for a research officer to access a site for data collection during a remote radiology assessment clinic was agreed upon with clinic staff in advance. During a site visit, a nurse or doctor informed each client that a research officer was present and directed clients to them. Clients were aware that they could leave without talking to the research officer. The research officer informed the client about the project and the survey, explained that participation was voluntary and was available to talk the client through the survey or provide information on any questions that the client had. Informed consent was accepted as given by the participant through a separate question specifically addressing consent to participate.

In the absence of a research officer, staff and volunteers at the participating services distributed surveys. Clients were able to complete the survey in person at the clinic if they desired. Alternatively, the client could take a project flyer home with a link to the online survey, or a paper copy of the survey with a return, postage paid envelope. Information about the study and what involvement entailed was included with the surveys, together with contact details for the research team.

3.4.4 Analysis

Following reporting of participant demographic characteristics, basic descriptive statistics (frequencies, means and percentages) were used to summarise client preference, satisfaction and perceived quality of care for the remote radiology assessment model. Bi-variate comparisons of views by jurisdiction and demographic characteristics (age, and Indigenous or CALD status, remoteness) were conducted where relevant. Open-ended responses were analysed by two researchers using simple content analysis, grouping responses into categories. The researchers met to discuss and cross-check emerging categories and associated frequencies for these.

3.5 Service provider perspectives

3.5.1 Rationale

The views of service providers at participating sites who were involved in implementation and delivery of the remote radiology assessment model were gathered through semi-structured interviews. A number of documents about the program at services and field notes from the interviewers contributed to data for this qualitative phase of the research. Drawing on a social constructivist perspective, the research team envisaged that this qualitative phase would provide insight into the process of establishing the model, the challenges and enablers of successful implementation and operation of the model, and factors important in the provision of a model that is safe and acceptable for service providers.

3.5.2 Interview guide

An interview guide was developed for conducting semi-structured interviews based on the teleradiology literature and aims of the evaluation (Appendix 4). Semi-structured interviews offered flexibility to explore concepts as they emerged from interview participants. The guide was piloted internally and minor changes were made accordingly. The guide aimed to elicit views on:

- (i) Parts of the remote model that have benefits for staff and/or clients and service operation;
- (ii) Parts of the model that could pose risks to clients and/or staff or limitations to the service provided;
- (iii) Processes that worked well or posed challenges in the smooth implementation of the new model at their site;
- (iv) What could be done differently to improve the remote radiology assessment model at their site;
- (v) What advice they would provide to other sites seeking to implement the remote radiology assessment model; and
- (vi) Staff perceptions of client acceptance and team functioning that affect the safety and quality of the care provided via the remote radiology assessment model.

3.5.3 Recruitment

Service providers at participating clinical sites and the SCUs were invited to participate in the interviews through site visits, email and snowball recruitment. It was anticipated that service providers would include medical officers, breast nurses, local radiologists, remote radiologists, radiographers, sonographers, data managers, data administrators, health promotion officers, managers and Indigenous liaison officers. Service providers who were external to BreastScreen but provided services to BreastScreen that enabled the remote radiology assessment model were invited to participate. Such providers included telehealth or information technology service specialists.

Service providers who had worked in the past with clinics and SCUs to implement the model were also invited to participate.

Information about the study was shared through site visits and information sheets. Interviewers explained the project, the voluntary nature of participation and what participation involved prior to conducting an interview. Informed consent was collected prior to interviews, including consent to audio-record.

3.5.4 Analysis

Interviews were audio-recorded, transcribed verbatim and imported to the qualitative management software package, QSR NVivo (version 12; 113), to facilitate data management and qualitative analysis by the research team. Deductive analysis was initially undertaken, using the interview questions as a classifying framework. Subsequently, line by line inductive thematic analysis was employed by the research team. Each transcript was independently coded by two members of the research team. The team met on several occasions to discuss the codes and emerging themes. Differences between team members were resolved by consensus, and involved the team returning to the transcripts to consider and verify the context of the differences. Further investigation of coder differences improved the quality of the analysis and conclusions.

Together, the coding team aggregated the codes into overarching themes. The team considered any variations between sites and between types of service providers (e.g. nurses, radiographers, radiologists, on site doctors) and managers (on site or from state-wide coordination units). A formal, multiple case study approach was beyond the scope of this evaluation.

Various strategies were used throughout to enhance qualitative rigour and trustworthiness of findings. Regular meetings to discuss interpretation of codes and themes, sharing of memos and notes, co-coding of qualitative data, data triangulation (using multiple data collection methods and sources including interviews with a range of service providers, documents and field notes) and consideration of disparate views ensured balanced investigation of service provider perspectives. Provision of ample and rich quotes from participants has been used to enhance the connection between data and conclusions.

Data collected during this phase of the project were also used to develop descriptions of the remote radiology assessment model at each participating site. The research team developed flow charts and consulted with CJAG site representatives from each site to ensure that the descriptions of the remote radiology assessment models were accurate. Feedback from site representatives was incorporated into the model descriptions.

3.6 Cost assessment study

3.6.1 Rationale

Evaluating costs of the remote radiology assessment model compared with the onsite assessment model is an important element of evaluating quality of care in terms of affordability and sustainability. It is important to emphasise that cost savings were not the motivation for establishing and supporting the remote radiology assessment model. Driving factors for innovation and implementation of the remote radiology model are described in Chapter 4.

3.6.2 Data

A list of potential costs to consider in the cost study of the remote radiology model was developed by the research team. Potential sources of cost were identified based upon the qualitative component of the project. Potential costs included onsite and remote radiology model travel costs for the radiologist and other health professionals as applicable, costs of remote and onsite radiologist consultation time for assessment clinics, set-up and maintenance costs of the remote radiology assessment model, and average cost per mammogram and biopsy.

To ensure that all possible costs were considered, the list of potential costs was circulated to the CJAG for members' feedback. Feedback on the costs list was received from CJAG members through email communication and CJAG meetings, and the list was revised and recirculated several times. Following endorsement of the cost study by the BSA NQMC, further discussion on relevant costs and costs that could be provided, occurred between the SCUs, and the SCUs and the research team. Maintenance costs for equipment were unavailable to be included in the analysis following these discussions.

The research team requested data from each jurisdiction (QLD, NSW and the NT) on each of the sources of costs identified by the jurisdictions, except for the number of mammographic exposures and number of biopsies used for diagnosis. Cost data were received from each jurisdiction in Microsoft Excel format. The number of mammographic exposures and biopsies used for diagnostic assessment was taken from the client datasets supplied by each jurisdiction that recorded the number of mammograms and biopsies that were utilised for each assessment episode. We did not receive data about costs of mammogram or biopsies, therefore elected to use the published MBS benefit rebates (85%).

3.6.3 Analysis

The methods for analysis for the cost study were dependent on demonstration, or not, of differences in clinical effectiveness of the remote radiology assessment model compared with the onsite assessment model. Given that our quantitative analysis demonstrated equivalence of the two models in terms of clinical outcomes and likelihood of cancer detection, the appropriate cost analysis was determined to be a simple cost -comparison study.

More details about the economic analysis plan are provided in Appendix 5.

4. Operation of the remote radiology assessment model at each site

Overview

This chapter describes how the remote radiology assessment model operates at each site. The operational model descriptions were drawn from field observations, and information obtained during service provider interviews and consultation with site representatives. At all sites, the remote radiology assessment model was implemented in response to a lack of local and locum radiologists, with availability and appropriate experience in breast work, to attend assessment clinics. Travel delays for locum radiologists exacerbated the issue. These workforce challenges meant that the clinics were unable to provide timely assessment services to clients, affecting the quality of the service for clients and having negative implications in terms of service accreditation. In one jurisdiction, it was reported that the ability to offer assessment clinics in various locations also reduced long travel times for clients, increasing their access to the BreastScreen assessment service following an abnormal screen.

4.1 Townsville

Townsville is a major outer regional centre with a population of around 200,000 people, located on the Queensland coast around 1400 km north of Brisbane. Townsville Hospital Health Service serves a resident population of almost 240,000 people in a geographic footprint of 148,000 square kilometres that spans north to Cardwell, west to Richmond, south to Home Hill and east to the Palm Islands. The broader catchment area includes around 700,000 people over 750,000km², stretching from the Torres Strait, to the NT border and south to Mackay (114) Almost 8% of the catchment identify as Aboriginal and Torres Strait Islander and 7% speak a language other than English at home (114). The region¹ is served by the BreastScreen Townsville service which provides screening at the Townsville location (located off hospital grounds) and through mobile units to rural and remote towns, and provides regular assessment services at the Townsville location, and at other sites less regularly. In Townsville, radiologist onsite assessment clinics utilise the services of a local Townsville-based radiologist when available.

The BreastScreen QLD Townsville assessment service began delivering regular remote radiology assessment clinics from June 2014. The innovative remote radiology model was developed at this BreastScreen service when service providers saw possible solutions to their workforce issues (i.e. difficulty engaging appropriate onsite radiologists in a timely manner) through the use of newly available PACS technology. The service team and SCU considered the possibilities and challenges of implementing the model, eventually forming protocols and procedures for the Townsville site. The Townsville site has been used as a basis and exemplar for other sites.

The remote radiology assessment workflow (Figure 4.1) that operates at the Townsville site sees clinic service providers working through a pre-prepared work-up plan. An assessment team meeting is held two to three times throughout the clinic involving onsite and remote providers. The work-up (clinical examination, mammographic imaging, ultrasound) that has been completed for clients up until the meeting time is discussed and next steps are communicated. Clients may then be cleared of any further assessment, and may leave at this time. Clients requiring biopsy or further assessment are required to wait or return to the clinic later in the day. Telesonography is available and is used if required.

¹ The BreastScreen Townsville catchment area may vary from the Townsville Hospital Health Service catchment.

Service process

- The service manager schedules and confirms remote radiologists and dates of remote radiology assessment clinics.
- The clients are booked by a nurse counsellor with advice from the medical officer and senior radiographer. Final numbers for the clinic can be influenced by who the scheduled remote radiologist is and anticipated clinical procedures.
- Paperwork (one page Remote Assessment Form) for each client is completed by the medical officer and faxed to the remote radiologist the day before the clinic. This includes a workup plan for the clients which is developed by the clinical team. A time for the first assessment team meeting to occur on the clinic day is made.
- The Medical Officer with Senior Radiographer reviews the assessment clinic list and organise prior images to be digitised for viewing by Remote Radiologist via PACS.
- The communication white board is populated with names of clients who are booked into the clinic.
- The clinic begins at 7.30am. The on-site team works to the pre-prepared plan.
- All service staff who interact with the client on her journey through the assessment clinic explain aspects of remote radiology assessment that are relevant at the particular point in time, ensuring that it is clear that all imaging is viewed by the remote radiologist and final decisions about the client's care are made by the clinical team and remote radiologist.
- Clients move through each step of the clinic with the remote radiologist reporting findings from imaging on each client, at each step.
- The on-site radiographer takes diagnostic mammographic images of the breast/s. These are viewed by the remote radiologist who then advises regarding the ultrasound area to target.
- Ultrasound is performed for each client. The remote radiologist views the ultrasound either as it is performed (telesonography) or after it is complete, depending on radiologist preference. A sonographer report is available on the last examination for the remote radiologist to view in PACS.
- The sonographer/medical officer conducts the ultrasound with support from the nurse. The remote radiologist converses with the sonographer/medical officer (and client) during telesonography if that option is chosen by the remote radiologist.

The remote radiologist reviews imaging and discusses the biopsy procedure with on-site staff. Two on-site medical officers are specialised in specific biopsy procedures and together can perform the spectrum of biopsy procedures that the remote radiologist may request.

- The medical officer conveys the biopsy results to the remote radiologist and pathologist (where required) usually within the next two days.
- The medical officer notifies the client and treating GP of result and outcome (including need for surgical referral).
- A clinic-pathological meeting is held within 4 weeks of the assessment clinic and every biopsy case is reviewed. If the review team decides to re-biopsy the client, the client attends an on-site clinic.

Client journey

The nurse counsellor informs the client of recall to assessment clinic, via telephone. The client is given an appointment time to attend the assessment clinic. The client is informed that the clinic is scheduled as a remote radiology assessment clinic and is given an explanation of what this is and what to expect during the appointment.



Figure 4.1. Flow chart of BreastScreen Townsville's remote radiology assessment clinic describing the service process in relation to the client journey.

benign results provided by a medical officer/nurse) and

future screening/assessment regime or referral to a

surgeon if needed.

4.2 Rockhampton

The Central Queensland Hospital and Health Service serves a population of over 220,000 people in the regional town of Rockhampton and surrounding rural areas, distributed over 110,000km² (115). Rockhampton is a regional centre located on the Queensland coast around 600km north of Brisbane. Seven percent of the catchment population identify as Aboriginal and Torres Strait Islander (115). The region² is served by the BreastScreen Rockhampton service which provides screening services at the public hospital location and through mobile units to rural and remote towns, and provides assessment services at the Rockhampton location.

The BreastScreen QLD Rockhampton assessment service began delivering regular remote radiology assessment clinics from July 2016. The remote radiology assessment workflow (Figure 4.2) operational at the Rockhampton site was based on the existing processes and workflow implemented at the Townsville site, with some adaptations to suit local requirements. The workflow at the Rockhampton site sees onsite providers working through a pre-prepared work-up plan. The medical officer, nurse and other staff available meet two to three times throughout the clinic with the remote radiologist. The work-up (clinical examination, mammographic imaging, ultrasound) that has been completed for clients up until the meeting time is discussed and next steps are communicated. Clients may then be cleared of any further assessment, and may leave at this time. Clients requiring a biopsy or further assessment are required to wait or return to the clinic later in the day. Tele-sonography is available and is used if required.

² The BreastScreen Rockhampton catchment area may vary from the Central Queensland Hospital Health Service catchment.

Service process

- The service manager schedules and confirms remote radiologists and dates of remote radiology assessment clinics in advance.
- The clients are booked by a nurse counsellor with advice from the medical officer. Final numbers for the clinic can be influenced by who the scheduled remote radiologist and sonographer are and anticipated clinical procedures.
- Paperwork (one page Remote Assessment Form) for each client is completed by a nurse counsellor and faxed to the remote radiologist the day before the clinic. This includes a workup plan for clients in the clinic which is developed by the clinical team. A time for the first assessment team meeting to occur on the clinic day is made.
- The Medical Officer with Senior Radiographer reviews the assessment clinic list and organises prior images to be digitised for viewing by the Remote Radiologist via PACS.
- The tracking sheet (communication sheet) is populated with names of clients booked into the clinic.
- The clinic begins at 7.30am. The on-site team works to the pre-prepared plan.
- All service staff who interact with the client on her journey through the assessment clinic explain aspects of remote radiology assessment that are relevant at the particular point in time, ensuring that it is clear that all imaging is viewed by the remote radiologist. Decisions about the client's care are made by the remote radiologist and the clinical team.
- Real-time ultrasound/telesonography is available if deemed appropriate by the radiologist and clinical team.
- Clients move through each step of the clinic with the remote radiologist reporting findings from imaging on each client, at each step.
- The on-site radiographer takes diagnostic mammographic images of the breast/s. These are viewed by the remote radiologist who then advises regarding the ultrasound area to target.
- Ultrasound is performed for each client. The remote radiologist views the ultrasound either as it is performed (telesonography) or after it is complete, depending on radiologist preference. A sonographer report is done on the last examination for the remote radiologist to view in PACS.
- The sonographer conducts the ultrasound with support from the nurse. The remote radiologist converses with the sonographer (and client) during telesonography if that option is chosen by the remote radiologist.
- The remote radiologist reviews imaging and discusses the biopsy procedure with on-site staff. Two on-site medical officers are specialised in specific biopsy procedures and together can perform the spectrum of biopsy procedures that the remote radiologist may request.
- A follow up multi-disciplinary team meeting is held a couple of days after the clinic with the designated radiologist, medical officer, pathologist and clinical nurse and radiographer to review the biopsy results and determine outcome and recommended pathway for client. The medical officer notifies the client and treating GP of result and outcome (including need for surgical referral).

Client journey

The nurse counsellor informs the client of recall to assessment clinic, via telephone. The client is given an appointment time to attend the assessment clinic. The client is informed that the clinic is scheduled as a remote radiology assessment clinic and is given an explanation of what this is and what to expect during the appointment.



Figure 4.2. Flow chart of BreastScreen Rockhampton's remote radiology assessment clinic describing the service process in relation to the client journey.

benign results provided by a medical officer/nurse

counsellor) and future screening/assessment regime or

referral to a surgeon if needed.

4.3 Darwin

The Northern Territory has a resident population estimated at around 250,000 people dispersed over regional, rural and remote northern Australia (116). Darwin is the capital city of the Northern Territory and is located on the northern coast. Thirty-one percent of the population are Aboriginal and Torres Strait Islander with 79% of this population residing in remote areas of the Northern Territory, and 72% of the non-indigenous population residing in the greater Darwin area (116). The BreastScreenNT service provides screening services at the Darwin location (off hospital grounds) and through extensive outreach services to rural and remote towns. Assessment services are provided regularly at the Darwin location and are provided at the Alice Springs location less frequently.

The Darwin assessment service began delivering regular remote radiology assessment clinics from June 2016. The remote radiology assessment workflow (Figure 4.3) operational at the Darwin site, sees a breast physician flying in from Sydney for the assessment clinic and performing all ultrasoundguided procedures with support from a nurse. The remote radiologist and onsite team are in constant communication through the use of a mobile phone. Text messages are usually used to notify clinicians at send and receive sites about progress and next steps for clients. This can also be achieved through phone calls. When text messaging, care is taken to protect client confidentiality. Synchronous telesonography is available and is used if required, in line with preferences of the remote radiologist. For clients, the workflow is similar to onsite clinics, allowing them to leave as soon as the remote radiologist has reported on their imaging and determined that no further assessment is required. Clients requiring biopsy procedures or further assessment are required to wait, or return in the afternoon or the next day.

Service process

- The medical officer schedules and confirms remote radiologists and dates of remote radiology assessment clinics. The clinics are held over 1.5 or 2 days.
- The medical officer and nurse organise the clients for the clinic. Clinic appointments are scheduled based on the fly-in breast physician and remote radiologist for the clinic, and anticipated clinical procedures.
- The medical officer ensures that client history and previous films are collated and sent to the remote radiologist in preparation for the clinic. The data administrator sends the client list to the remote radiologist.
- The remote radiologist at the Sydney clinic reviews the images and prepares a workup sheet for the onsite radiographer.
- The breast physician, medical officer, nurse and radiographer review the work-up sheet and images with the reader sheets, immediately before the clinic begins.
- The communication white board is populated with names of clients who are expected to attend the clinic.
- The clinic begins at 8.00am.
- All service staff who interact with the client on her journey through the assessment clinic explain aspects of remote radiology assessment that are relevant at the particular point in time, ensuring that it is clear that all imaging is viewed by the remote radiologist and final decisions about the client's care are made by the clinical team including the remote radiologist.
- Clients move through each step of the clinic with the remote radiologist reporting findings from imaging on each client, at each step.
 - The on-site radiographer takes diagnostic mammographic images of the breast/s. These are viewed by the remote radiologist who then advises regarding the ultrasound area to target.
 - Ultrasound is performed for each client. The remote radiologist views the ultrasound either as it is performed (telesonography), or after it is complete, depending on radiologist preference. The breast physician conducts the ultrasound with support from the nurse. The remote radiologist converses with the breast physician using telehealth communications during the ultrasound scanning.

 The remote radiologist reviews imaging and discusses the biopsy procedure with on-site staff. The breast physician can perform the spectrum of biopsy procedures that the remote radiologist may request.

- The medical officer, pathologist, remote radiologist and breast physician meet via telehealth within 3 days of the clinic to discuss the biopsy results at a multidisciplinary meeting.
- The medical officer gives the results to the clients after this meeting.

Client journey

The nurse informs the client of recall to assessment clinic, via telephone. The client is given an appointment time to attend the assessment clinic. The client is informed that the clinic is scheduled as a remote radiology assessment clinic and is given an explanation of what this is and what to expect during the appointment.



The client and treating GP are advised of the outcome and future screening/assessment regime or referral to a surgeon if needed.

Figure 4.3. Flow chart of BreastScreen Darwin's remote radiology assessment clinic describing the service process in relation to the client journey.

4.4 Queanbeyan

The BreastScreen NSW Queanbeyan service is located in the Southern NSW Local Health District. This health district serves a population of around 200,000 people, with about 8% of the population identifying as Aboriginal and Torres Strait Islander³ (117). The town of Queanbeyan is located adjacent to Canberra, with a population of around 57,000 people.

The Queanbeyan BreastScreen site began offering more regular remote radiology assessment clinics in in September 2017 (Figure 4.4). At this site, the remote radiologist is available online at all times through a video-link. Onsite clinicians and the remote radiologist can interact and converse at any time. Telesonography is available and is used if required. Usually, the onsite sonographer captures cine loops (ultrasound video) and sends this to the remote radiologist. For clients, the workflow is similar to onsite clinics, allowing them to leave as soon as the remote radiologist has reported on their imaging and determined that no further assessment is required. A medical officer is available onsite to conduct ultrasound guided biopsies as required. Clients requiring stereotactic biopsy procedures are required to return to the next clinic with an onsite radiologist. Currently, a medical officer is training in stereotactic biopsy procedure, which should obviate the requirement to return. Tomosynthesis is available for use in assessment at this site.

³ The BreastScreen Queanbeyan catchment area may vary from the Southern NSW Local Health District catchment.

Service process

- The service managers schedule and confirm remote radiologists and dates of remote radiology assessment clinics. The clinics are held over 1 day (usually 12 clients max).
- The designated radiographer, or their delegate, categorises the clients. Clinic appointments are scheduled based on anticipated clinical procedures. (Clients who are expected to require a stereotactic biopsy are booked into a clinic where a radiologist is onsite. The clinical coordinator has the skills to conduct ultrasound biopsy). The assessment bookings officer contacts clients and books them in to the clinic.
- The assessment receptionist sends the client list to the remote radiologist. The day prior to the clinic a network test is undertaken between the sites.
- The remote radiologist and all clinical team members access client information through the BreastScreen Information System (BIS) and PACS.
- The communication white board is populated with names of clients booked into the clinic, as well as their home town and reason for recall.
- The clinic begins at 8.00am. An assessment team meeting to plan the day is undertaken at 0900 and at 1230.
- The remote radiologist is available via video link in the reading room throughout the clinic.
- Clients move through each step of the clinic with the remote radiologist reporting findings from imaging on each client, at each step. The whiteboard is updated documenting the clients journey.
- All service staff who interact with the client on their journey through the assessment clinic explain aspects of remote radiology assessment that are relevant at the particular point in time, ensuring that it is clear that all imaging is viewed by the remote radiologist. Decisions about the client's care are made by the remote radiologist and clinical team.
- An ultrasound is conducted for each client as required and sent through to PACS for review by the remote radiologist. Telesonography is available upon request through screen sharing in the health conferencing application. The remote radiologist may request further investigation including more mammography or a clinical examination.
- The remote radiologist reviews imaging and discusses the investigations/biopsy procedures with on-site staff. The medical officer onsite can perform ultrasound guided biopsies. Patients requiring stereotactic biopsies are booked into future clinic when a radiologist is onsite.
- The medical officer, remote radiologist and pathologist meet via telehealth within 1 week of the clinic to discuss the biopsy results. The medical officer gives the results to the clients via phone if they are benign, or notifies the GP for discussion with the patient at their follow-up appointment.

Client journey

The assessment bookings officer informs the client of recall to assessment clinic, via telephone using an approved script. The client is given an appointment time to attend the assessment clinic and is informed that the clinic is scheduled as a remote radiology assessment clinic and is given an explanation of what this is and what to expect during the appointment.



Figure 4.4. Flow chart of BreastScreen Queanbeyan's remote radiology assessment clinic describing the service process in relation to the client journey.

4.5 Summary

The operation of remote radiology assessment clinics was documented at four sites located in regional areas across Queensland, Northern Territory and New South Wales. Remote radiology assessment clinics were implemented in response to inadequate access to a local radiological workforce that supported regular and timely provision of BreastScreen assessment services. The clinics have operated relatively regularly at each of the sites for varying amounts of time: Townsville since 2014, Rockhampton and Darwin since 2016, and Queanbeyan since 2017. Remote radiology assessment clinics, whilst all following the overarching NQMC guidelines, are implemented slightly differently at each site in terms of service workflow, communication methods and use of telesonography and tomosynthesis, based on local contextual factors, workforce capabilities and equipment availability.

5. Clinical outcomes

Overview

This chapter presents the findings of analysis of client data. The remote radiology assessment model was implemented at sites in a staggered start approach, allowing for a multiple baseline design for intervention at each site, comparing pre-implementation and post-implementation outcomes. In addition, direct comparison between outcomes of assessment visits conducted under the remote radiology assessment model and the radiologist onsite model were conducted, using post-implementation data. The primary outcome of interest, in terms of quality and safety of the remote radiology model, is whether the model is equivalent to the onsite model in terms of detecting cancer. Several secondary outcomes are also presented and relate to: timeliness, proportion of women requiring more than one visit to obtain an outcome, work-up imaging, assessment recommendations and numbers of biopsies.

5.1 Client data from assessment visits

Client data from seven sites across three jurisdictions was obtained from the appropriate data management bodies. The client data included assessment visits conducted pre-implementation and post-implementation of the remote radiology model at each site. Datasets were received from each jurisdiction by the end of May 2019. A total of 21,117 assessment visits (that is, individual attendances at assessment clinics) were included in the final combined jurisdictional client dataset (10,595 visits in NSW; 8,457 visits in QLD and 2,065 visits in NT). 10,609 of these visits took place after the implementation of the remote radiology assessment model. Of these, 3,904 were conducted under the remote radiology assessment model, leading to ample statistical power to be confident in the findings presented.

5.2 Likelihood of cancer detection

Logistic regression analyses were performed to calculate adjusted odds ratios for the detection of cancer within the sample. Three outcomes (any cancer diagnosis, any invasive cancer, or any small invasive cancer) were assessed using the same predictors. The dependent variables used for these analyses were either assessment clinic type (remote radiologist versus onsite) or preimplementation or post-implementation timing of assessment clinic visit. These variables were highly inter-related (collinear), thus one or the other was used, depending on what made logical sense. In general, comparing assessment visits conducted under the remote radiology model directly with the onsite model was used for the cancer detection primary outcome, and comparing pre-implementation with post-implementation timing was used for the timeliness comparisons. Other confounding factors adjusted for in the analysis included: i) assessment visit related to first or subsequent screen (episode number 1 vs all others); ii) age at time of screen; iii) jurisdiction where assessment was carried out; iv) CALD status; v) SEIFA IRSAD score (1-3, 4-6, 7-10 with 1-3 being the most disadvantaged and 7-10 being the least disadvantaged); vi) Indigenous status (not recorded for NSW); and, vii) remoteness of residence of the client (RA category).

Following implementation of the remote radiology model, there were no statistically significant differences in cancer detection, for any outcome category, between assessment visits carried out using the remote radiology model and onsite models after adjusting for subsequent screen, age, CALD status, Indigenous status, remoteness of residence, SEIFA IRSAD score and jurisdiction (Table 5.1; Unadjusted figures in Appendix 6). Consistent with existing data from the NQMC and others, an assessment clinic visit resulting from a subsequent screen and age were statistically significant predictors of an increased likelihood of positive cancer detection (Table 5.1).

Table 5.1. Likelihood of cancer detection for assessment visits conducted using the remote radiology model versus the onsite model, post-implementation (final numbers included in the regression model; n=8,109; Supplementary material Appendix 7)

Variable	Level	Cancer (any)⁺	Invasive Cancer**	Small Invasive
		AOR (95% CI)	AOR (95% CI)	Cancer ⁺⁺⁺
				AOR (95% CI)
Remote clinic	No		REF	
	Yes	1.02 (0.86-1.19)	1.02 (0.85-1.21)	0.79 (0.62-1.01)
Subsequent	No		REF	
screen	Yes	1.54 (1.29-1.85)***	1.43 (1.18-1.75)***	1.81 (0.38-2.40)**
Age at screen		1.05 (1.04-1.05)***	1.05 (1.04-1.06)***	1.05 (0.04-1.06)***
CALD	No		REF	
	Yes	0.93 (0.68-1.26)	0.85 (0.59-1.19)	0.75 (0.44-1.20)
SEIFA	1-3		REF	
	4-6	0.95 (0.80-1.12)	0.96 (0.80-1.16)	1.15 (0.90-1.48)
	7-10	0.93 (0.76-1.13)	0.93 (0.76-1.15)	1.17 (0.88-1.56)
Indigenous	No		REF	
	Yes	0.68 (0.41-1.08)	0.61 (0.33-1.03)	0.58 (0.22-1.24)
	Unknown	1.11 (0.06-6.43)	1.49 (0.08-8.73)	3.07 (0.16-18.36)
Remoteness of	RA1		REF	
residence of	RA2	1.06 (0.71-1.62)	1.26 (0.80-2.06)	1.17 (0.67-2.21)
woman	RA3	1.13 (0.76-1.74)	1.45 (0.92-2.38)	1.40 (0.80-2.65)
	RA4	1.40 (0.78-2.51)	1.31 (0.66-2.58)	1.28 (0.52-3.09)
	RA5	1.44 (0.71-2.84)	1.69 (0.76-3.63)	0.94 (0.25-2.91)
Jurisdiction	1		REF	
	2	0.63 (0.03-3.70)	0.82 (0.04-4.82)	1.69 (0.09-10.18)
	3	0.61 (0.03-3.68)	0.83 (0.04-5.09)	1.84 (0.09-11.79)

⁺Cancer (any) consists of DCIS, and large and small invasive cancers.

⁺⁺ Invasive cancer consists of large and small invasive cancers.

***Small invasive cancer consists of small invasive cancers only.

p<0.01,*p<0.001

AOR: Adjusted odds ratio

CI: Confidence interval

There was a slightly greater likelihood for cancer (any) and invasive cancer to be detected after implementation of the remote radiology model (AOR 1.14, 95% CI 1.03-1.27, p<0.05; AOR 1.17, 95% CI 1.05-1.32, p<0.05, respectively) after adjusting for subsequent screen, age, CALD status, Indigenous status, remoteness, SEIFA IRSAD and jurisdiction (Table 5.2). This observed increase in likelihood of cancer detection is likely to be influenced by a range of contextual factors, outlined in the discussion (Section 9.1; p88). Again, subsequent screen and age were significant predictors of positive cancer detection.

Table 5.2. Likelihood of cancer detection for the time period post-implementation of the remote radiology model versus pre-implementation (final numbers included in the regression model; n=17,339; Supplementary material Appendix 8).

Variable	Level	Cancer (any)⁺	Invasive Cancer ⁺⁺	Small Invasive
		AOR (95% CI)	AOR (95% CI)	Cancer ⁺⁺⁺
				AOR (95% CI)
Pre-Post	Pre		REF	
	Post	1.14 (1.03-1.27)*	1.17 (1.05-1.32)*	1.05 (0.91-1.21)
Subsequent	No		REF	
screen	Yes	1.46 (1.3-1.64)***	1.39 (1.23-1.58)***	1.78 (1.50-2.11)***
Age at screen		1.06 (1.05-1.06)***	1.06 (1.05-1.06)***	1.06 (1.05-1.06)***
CALD	No		REF	
	Yes	0.86 (0.69-1.08)	0.75 (0.57-0.96)*	0.62 (0.43-0.88)*
SEIFA	1-3		REF	
	4-6	0.96 (0.85-1.08)	0.97 (0.86-1.11)	1.05 (0.90-1.24)
	7-10	0.97 (0.85-1.12)	0.92 (0.80-1.07)	1.01 (0.84-1.23)
Indigenous	No		REF	
	Yes	0.62 (0.40-0.92)*	0.63 (0.38-0.98)*	0.60 (0.29-1.12)
	Unknown	1.14 (0.06-6.70)	1.47 (0.08-8.74)	2.91 (0.15-17.31)
Remoteness of	RA1		REF	
residence of	RA2	1.09 (0.85-1.41)	1.02 (0.78-1.35)	1.20 (0.84-1.76)
woman	RA3	1.25 (0.97-1.63)	1.23 (0.94-1.64)	1.48 (1.02-2.19)*
	RA4	1.43 (0.97-2.10)	1.20 (0.78-1.84)	1.52 (0.86-2.65)
	RA5	1.65 (0.99-2.70)	1.24 (0.69-2.19)	1.26 (0.53-2.76)
Jurisdiction	1		REF	
	2	0.70 (0.04-4.14)	0.89 (0.05-5.32)	1.62 (0.85-9.66)
	3	0.85 (0.04-5.05)	1.09 (0.06-6.60)	2.15 (0.11-13.17)

⁺Cancer (any) consists of DCIS, and large and small invasive cancers.

⁺⁺ Invasive cancer consists of large and small invasive cancers.

***Small invasive cancer consists of small invasive cancers only.

*p<0.05, ***p<0.001

AOR: Adjusted odds ratio; CI: Confidence interval

Note: Post-implementation data includes both remote radiology assessment clinics and onsite assessment clinics.

5.3 Timeliness

Ordinal regression was used to analyse the impact of the assessment service model on the timeliness of assessment. The predictors used for these analyses were time of intervention (pre-implementation vs post-implementation), clinic type (remote vs onsite), age at time of screen, jurisdiction where assessment was carried out and remoteness of residence of woman (RA category). Three separate outcomes were defined to measure timeliness categorised with consideration for NAS timeliness measures, as described below.

- Time from screen to first attendance for assessment
 Categorised into 3 time frames: ≤28 days, 29-35 days, ≥36 days
- Time from screen to assessment recommendation
 Categorised into 3 time frames: ≤28 days, 29-35 days, ≥36 days

3. Time from first attendance at assessment to assessment recommendation Categorised into 3 time frames: ≤15 days, 16-22 days, ≥23 days

Overall, implementing the remote radiology assessment model had statistically significant positive effects on the timeliness of assessment. The NAS timeliness standards aim for clients to attend an assessment clinic within 28 days of their screening appointment. In the time period prior to implementation of the remote radiology model, 62% of assessment visits began within 28 days of clients' screen dates. In the time period following implementation of the model, 88% of assessment visits began within 28 days of clients' screen dates, meaning that fewer women had long anxious waits to be assessed.

Clients were significantly less likely to experience a long time period from their screen date to first attendance in the post-implementation period compared with the pre-implementation period (AOR⁴ 0.21, 95% Cl 0.20-0.24, p<0.001; Pre-implementation median 8 days, IQR 5 days to post-implementation median 4 days, IQR 4 days; Table 5.3 and 5.4). A similar significant association was evident when comparing the time from screen date to assessment recommendation (AOR 0.28, 95% Cl 0.26-0.31, p<0.001; Table 5.3). Unsurprisingly, remoteness of residence of the woman was also found to be significantly predictive of timeliness to assessment, with those in more remote areas more likely to have a longer time from screen date until date of first attendance than those from RA1 (RA5 - AOR 4.54, 95% Cl 3.43-6.01, p<0.001). An alternative grouping of remoteness of residence of clients was tried to account for relatively smaller numbers of women residing in both RA1 and RA5, however this made no difference to the outcomes (Appendix 9).

Variable	Level	Time from screen date until date of first attendance	Time from screen date until assessment	Time from date of first attendance until assessment
		AOR (95% CI)	recommendation	recommendation
			AOR (95% CI)	AOR (95% CI)
Pre-post	Pre		REF	
	Post	0.21 (0.20-0.24)***	0.28 (0.26-0.31)***	0.82 (0.66-1.01)
Age at screen		1.00 (1.00-1.01)*	1.01 (1.00-1.01)**	1.00 (0.99-1.01)**
Jurisdiction	1		REF	
	2	1.32 (1.17-1.47)**	1.34 (1.21-1.48)**	2.31 (1.84-2.90)***
	3	2.21 (1.97-2.49)***	2.04 (1.82-2.28)***	0.85 (0.56-1.24)
Remoteness of	RA1		REF	
residence of	RA2	0.81 (0.68-0.97)**	0.84 (0.72-0.99)*	1.00 (0.69-1.51)
woman	RA3	1.06 (0.89-1.27)	0.96 (0.81-1.14)	0.52 (0.35-0.80)***
	RA4	1.77 (1.37-2.27)***	1.45 (1.14-1.83)**	0.30 (0.13-0.64)***
	RA5	4.54 (3.43-6.01)***	3.67 (2.81-4.82)***	0.64 (0.27-1.37)

Table 5.3. Timeliness of assessment and assessment recommendations between pre-implementation and post-implementation periods of the remote radiology model (final numbers included in the regression model; n=17,386).

*p<0.05, **p<0.01, ***p<0.001

AOR: Adjusted odds ratio; CI: Confidence interval

Note: Post-implementation data includes both remote radiology assessment clinics and onsite assessment clinics.

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⁴ The AOR indicates that for a unit increase in a continuous predictor, or level change of a categorical predictor, the outcome variable is expected to change by the respective coefficient value, adjusted for by the other variables in the model.

	Number of days from screen date until date of first attendance* Median (IQR)	Number of days from date of first attendance until assessment recommendation Median (IQR)
	Days	Days
Pre-implementation	25 (17)	8 (5)
Post-implementation	17 (11)	4 (4)
4		

Table 5.4. Median number of days for timeliness outcomes pre-implementation versus post-implementation of the remote radiology model (N=21,117)

* Excluding assessment visits where the number of days from screen date to date of first attendance was more than 137 days, as per analysis plan (Appendix 2)

Note: Post-implementation data includes both remote radiology assessment clinics and onsite assessment clinics.

Moreover, clients attending remote radiology assessment clinics in the post-implementation time period, were significantly less likely to have longer waits from screen date to assessment recommendation compared with clients attending onsite assessment clinics (AOR 0.68, 95% CI 0.59-0.77, p<0.001; Table 5.5). They were also less likely to have a longer assessment period (that is, time between first attendance and assessment recommendation; 0.45, 95% CI 0.33-0.60, p<0.001; Table 5.5). In the post-implementation time period, 95% of clients who attended an onsite assessment clinic had an assessment recommendation made within 15 days compared with 98% of clients who attended a remote radiology assessment clinic.

Table 5.5. Timeliness of assessment and assessment recommendations for remote radiology assessment clinics versus onsite assessment clinics, in the post-implementation period (final numbers included in the regression model; n=8,117).

Variable	Level	Time from screen date until assessment recommendation	Time from date of first attendance until assessment recommendation
		AOR (95% CI)	AOR (95% CI)
Remote clinic	No	R	EF
	Yes	0.68 (0.59-0.77)***	0.45 (0.33-0.60)***
Age at screen		1.01 (1.01-1.02)***	1.00 (0.99-1.01)**
Jurisdiction	1	REF	
	2	1.52 (1.32-1.74)**	2.97 (2.26-3.95)***
	3	3.64 (2.97-4.48)***	1.03 (0.48-2.01)
Remoteness	RA1	R	EF
	RA2	0.87 (0.63-1.23)	0.64 (0.36-1.19)
	RA3	0.56 (0.40-0.79)**	0.28 (0.16-0.54)***
	RA4	0.83 (0.55-1.29)	0.08 (0.01-0.30)***
	RA5	2.05 (1.33-3.20)***	0.23 (0.05-0.74)***
*p<0.05,**p<0.0	1,***p<0.001		
AOR: Adjusted o	dds ratio		
	1.1.1.1		

5.4 Proportion of women requiring more than one assessment visit to obtain an outcome

Logistic regression analyses were used to predict the proportion of clients requiring more than one assessment visit to obtain an outcome for an assessment episode. NT data were excluded from these analyses due to absence of the required data. Following implementation of the remote radiology model, clients who attended remote radiology assessment clinics for their first visit in an assessment episode, were significantly less likely to need more than one assessment visit to obtain an outcome than clients who attended radiologist onsite clinics (AOR 0.49; 95% CI 0.33-0.71; p<0.001; Table 5.6). The analyses adjusted for age at time of screen, jurisdiction where assessment was carried out and remoteness of residence (RA category). Analysis comparing pre-implementation and post-implementation for this outcome may be found in Appendix 10.

Table 5.6. Likelihood of women requiring more than one assessment visit to obtain an outcome for an assessment episode conducted using the remote radiology model compared with the onsite model, post-implementation (final numbers included in the regression model; n=7,171).

Variable	Level	AOR (95%CI)		
Remote clinic	No	REF		
	Yes	0.49 (0.33-0.71)***		
Age at screen		1.00 (0.98-1.01)		
Jurisdiction	1	REF		
	2	0.93 (0.69-1.24)		
Remoteness	RA1	REF		
	RA2	0.74 (0.42-1.42)		
	RA3	0.55 (0.31-1.07)		
	RA4	0.14 (0.07-0.72)*		
	RA5	N/A		
*p<0.05				
***p<0.001				
AOR: Adjusted odds ratio				
CI: Confidence interval				

5.5 Work-up imaging

Poisson regression with a negative binomial distribution to account for overdispersion was used to predict the number of mammography images required for work up at assessment. Mammographically guided stereotactic biopsies were not included in these figures. In the time period after implementation of the remote radiology model, 10,253 mammography images were taken during remote radiology assessment clinics (2.63 images per assessment visit) compared with 16,261 mammography images taken during onsite clinics (2.43 images per assessment visit).

In the post implementation time period, attending a remote radiology assessment clinic was significantly predictive of a greater number of mammography images required compared to attending an onsite clinic, although the effect size was small (Ratio of means 1.10, 95%CI 1.07-1.14, p<0.001; Table 5.7).

Variable	Level	Ratio of means		
		(95%CI)		
Remote clinic	No	REF		
	Yes	1.10 (1.07-1.14)***		
Age at screen		1.00 (1.00-1.00)		
Jurisdiction	1	REF		
	2	0.76 (0.74-0.79)***		
	3	1.19 (1.13-1.26)***		
Remoteness	RA1	REF		
	RA2	1.04 (0.95-1.13)		
	RA3	1.05 (0.96-1.14)		
	RA4	1.05 (0.94-1.18)		
	RA5	1.12 (0.99-1.27)		
***p<0.001				
AOR: Adjusted odds ratio				
CI: Confidence interval				

Table 5.7. Number of mammography images required for work up at assessment clinics conducted using the remote radiology model versus the onsite model, post-implementation of the remote radiology model (final numbers included in the regression model; n=8,148).

Interestingly, the assessment visit occurring after the implementation of the remote radiology assessment model was also predictive of the number of mammography images for work up at assessment, with greater numbers post-implementation of the remote radiology model regardless of whether the remote or onsite assessment model was used (Ratio of means 1.12, 95% Cl 1.10-1.15, p<0.01; Appendix 11).

5.6 Assessment recommendations

Logistic regression analyses were used to predict the likelihood of clients with uncertain outcomes after their assessment visit (i.e. those receiving equivocal assessment recommendations). The analysis adjusted for the type of assessment clinic (remote vs onsite), time of intervention, age at time of screen, jurisdiction where assessment was carried out and remoteness (RA category). Two outcomes were defined for this analysis:

- 1. Assessment recommendation of early review compared with routine rescreen in 1 year or 2 years; and
- 2. Assessment recommendation of routine rescreen in 1 year compared with routine rescreen in 2 years.

Neither time of intervention nor type of assessment clinic were significantly predictive of assessment recommendations (as per outcome 1 and outcome 2; Table 5.8; Appendix 12). Significant jurisdictional differences in the recommendations for equivocal outcomes between jurisdictions were apparent.

Table 5.8. Likelihood of women not diagnosed with cancer who received equivocal assessment recommendations at assessments conducted using the remote radiology model compared with the onsite model, post-implementation (final numbers included in the regression model; n=6,864).

Variable	Level	AOR (95%CI)		
		Early Review vs Rescreen	Rescreen 1 year vs Rescreen 2	
			years	
Remote clinic	No		REF	
	Yes	0.90 (0.63-1.28)	0.98 (0.84-1.17)	
Age at screen		1.00 (0.98-1.02)	0.99 (0.98-1.00)	
Jurisdiction	1		REF	
	2	6.11 (3.49-11.62)***	0.37 (0.30-0.46)***	
	3	6.31 (2.90-14.08)***	0.40 (0.30-0.55)***	
Remoteness	RA1		REF	
	RA2	2.19 (0.46-39.42)	0.96 (0.51-1.68)	
	RA3	1.13 (0.23-20.33)	0.96 (0.51-1.67)	
	RA4	0.87 (0.12-17.53)	1.25 (0.59-2.54)	
	RA5	0.89 (0.11-18.59)	1.08 (0.50-2.30)	
***p<0.001				
AOR: Adjusted odd	s ratio			

CI: Confidence interval

5.8 Likelihood of assessment visit requiring biopsy with and without remote radiology assessment model

When considering assessment visits conducted post-implementation of the remote radiology model, more core biopsies (PNB CB: 19.2% versus 14.7%) were performed during remote radiology assessment clinics compared with onsite assessment clinics (Table 5.9). Small sample sizes mean that caution needs to be used in interpreting these results. Findings for fine needle aspiration (FNA) biopsies are not reported due to the very small sample size for these biopsies. Underlying variations in the propensity to recommend biopsies appeared to exist between different radiologists, however we did not have available data to assess changes to this level pre- and post-implementation of the remote radiology assessment model.

Variable	Core biopsy performed	
	Yes	No
	n (%; 95% Cl)	n (%; 95% Cl)
Remote radiology	749	3,155
(N=3,904)	(19.2; 18.0-20.5)	(80.8; 79.5-82.0)
Onsite	987	5,718
(N=6,708)	(14.7; 13.9-15.6)	(85.3; 84.4-86.1)

Table 5.9. Number of assessment visits conducted with the remote radiology model compared with the onsite model where core biopsies were performed (post-implementation).

A logistic regression analysis was conducted to adjust for age, jurisdiction and subsequent screen, all factors considered important to understand the impact of the remote radiology assessment model on numbers of biopsies conducted at assessment. There was no significant difference between the remote radiology model and onsite model in the likelihood of a core biopsy being performed, during the post-implementation time period (Table 5.10).

Variable Level AOR (95%CI) Remote clinic No REF Yes 1.00 (0.89-1.11) Age at screen 1.02 (1.01-1.02)** Jurisdiction 1 REF 2 4.56 (3.84-5.46)*** 3 4.04 (3.19-5.12)*** Subsequent No REF Screen 0.98 (0.86-1.12) Yes **p<0.01 ***p<0.001 AOR: Adjusted odds ratio **CI: Confidence interval**

Table 5.10. Likelihood of a biopsy being performed at an assessment visit under the remote radiology assessment model versus the onsite model, post-implementation (final numbers included in the regression model; n=10,608)

5.9 Summary

Clinical outcomes in terms of quality and safety from the remote radiology assessment model can be summarised as follows:

- No statistically significant differences in the age-standardised likelihood of cancer detection (any cancer, invasive cancer or small invasive cancer) between assessment visits conducted under the remote radiology assessment model and the onsite assessment model (Table 5.1; p50). The models can be viewed as clinically equivalent in terms of cancer detection.
- Both timeliness to assessment, and timeliness to assessment recommendation improved following implementation of the remote radiology model (Table 5.3, Table 5.4, Table 5.5; p52-53).
- Clients who attended a remote radiology assessment clinic were significantly less likely to require more than one assessment visit to obtain an outcome (Table 5.6; p54).
- There were more mammograms performed per assessment visit for the remote radiology assessment model compared with the onsite model (Table 5.7; p55).
- There was no significant difference between the models in the proportion of assessment visits where a biopsy was performed (Table 5.10; p57).
- There were no statistically significant differences in assessment recommendations of early review versus rescreen, or rescreen in one year versus rescreen in two years, between the models (Table 5.8; p56).

There are no causes for concern in terms of quality and safety, however, ongoing monitoring of the numbers of mammograms performed per assessment visit is warranted.

6. Client perceptions

Overview

Experiences and expectations of the remote radiology assessment model, as viewed by clients, are an important measure of service quality. The client survey gathered client perceptions on their satisfaction and confidence in the remote radiology assessment model, and their preference for service delivery at four sites. The survey consisted of Likert-style questions, multiple response questions and open-ended responses, and was available in paper or online format (Appendix 3).

6.1 Recruitment

A research officer attended remote radiology assessment clinics at each location between June 2018 and July 2019. Three visits were made to clinics in Darwin, three visits in Townsville, three visits to Rockhampton and one to Queanbeyan. The visit to Queanbeyan was done as soon as practicable but further visits were not undertaken as no further remote radiology assessment clinics were conducted during the data collection time period for this study.

Surveys were administered during site visits through a brief face to face interview with a research officer. Clients were also able to complete the survey themselves online with an iPad or on paper versions of the survey. When a research officer was not in attendance at a remote radiology assessment clinic, surveys were distributed to clients by staff and volunteers at the participating sites, to obtain further input from clients. At these times, clients were able to complete a paper copy of the survey and return it to the research team via a postage paid envelope.

6.2 Dataset

Survey responses collected on paper versions of the survey were manually entered into a Microsoft Excel spreadsheet. Survey responses collected online were retrieved from the SurveyMonkey platform and added into the dataset. Basic descriptive statistics (frequencies, means and percentages) were used to summarise client preference, satisfaction and perceived quality of care for the remote radiology assessment model. Open-ended responses were analysed by two researchers using simple content analysis, grouping responses into categories. The researchers met to discuss and cross-check emerging categories and associated frequencies for these.

A total of 89 surveys were completed during site visits, most through interview with a research officer. A further 48 surveys were received by postal mail and seven were completed online, resulting in a total of 144 surveys. The majority of surveys were completed in full, with little quantitative date missing. Some participants did not provide comments in relation to their responses to the scale questions. Figure 6.1 shows the breakdown of surveys received by site. Of the 144 surveys completed, 38.9% were completed by clients from Rockhampton (n=56), 27.8% from Townsville (n=40), 27.1% from Darwin (n=39) and 6.3% from Queanbeyan (n=9).



Figure 6.1. Participant surveys received by site (n=144).

6.3 Participants

Figure 6.2 shows that over a third of participants were aged between 50-59 years (38.2%, n=55), followed by 26.4% (n=38) in the 40-49 years age bracket and 22.2% (n=32) in the 60-69 years age group. A small proportion of participants were aged 70 years or older.



Figure 6.2. Age group of participants (n=144).

A minority of participants identified as being Aboriginal and/or Torres Strait Islanders (2.4%, n=4). The majority were non-indigenous Australians (95.8%, n=138). The majority of participants usually spoke English at home (91.0%, n=131). The remaining participants spoke another language (9.0%, n=13). Data on other languages spoken was not collected.

Participants were asked how many visits in total they had made to a BreastScreen clinic in total for either screening or assessment. There were 59.9% (n=85) of participants who had attended on two to five occasions (Table 6.1). A quarter of participants had attended on 10 or more occasions (25.4%, n=36).

Number of visits	Number of participants (%)
2-5 times	85 (59.9)
6-9 times	21 (14.8)
10 times or more	36 (25.4)

Table 6.1. Total number of visits to a BreastScreen clinic altogether for either screening or assessment (n=142).

Just under half of participants (44.1%, n=63) had travelled 20 kilometres or less to access the remote radiology assessment clinic. However, over a quarter (28.0%, n=40) had travelled more than 100km to attend the clinic (Table 6.2).

Distance travelled	Number of participants (%)
20kms or less	63 (44.1)
21-50km	24 (16.8)
51-100km	16 (11.2)
more than 100km	40 (28.0)

Of the clients surveyed 72.3% (n=102) had not experienced telehealth previously. Thirty-eight participants reported having had a previous experience of telehealth. Of these 38 participants, there was a higher proportion of participants (56.4%, n=22) from one site, compared with all other sites totalled, who reported having had a previous experience of telehealth.

6.4 Satisfaction

All participants but one (98.6%) were 'extremely satisfied' or 'quite satisfied' with their experience at a remote radiology assessment clinic (Figure 6.3). This one participant did not make any comments as to why they were 'very dissastisied' with their experience.



Level of satisfaction with clinic experience

Figure 6.3. Clients' satisfaction with their clinic experience under the remote radiology assessment model (n=143).

The majority of participants provided reasons for their high levels of satisfaction. Overwhelmingly, participants were satisfied based on their positive interactions with staff members and the explanations of the care that they were provided. Interactions commonly related to the friendly, helpful, comforting, compassionate and professional characteristics of the service staff. Feedback from participants included:

"The staff were so lovely and caring and explained everything that was happening or going to happen."

"Everything explained in detail. They're wonderful, lovely, friendly staff. They go out of their way to explain everything."

Other reasons for reporting positive satisfaction included the efficiency of the staff, the way the clinic was run and being able to have further tests done on the same day. Positive outcomes and perceived high quality of care were also mentioned by some participants. Examples of comments:

"Seems very efficient, all done in one day, don't have to come back or too long, nice environment, remote radiologist works fine, explained by nurse so you know steps."

"Fantastic to be able to consult with multiple doctors on one day and have the various tests done as required."

"Everything's here and you know straight away."

Although most participants reported that they were 'quite satisfied' or 'extremely satisifed' with their clinic experience, there were a few negative comments, mostly relating to the length of time that participants had to wait in the clinic. Participants said:

"I had expected the appointment might take 30 minutes but I was there for almost 4 hours. That was a bit inconvenient, however, I was extremely satisfied that the care was of the highest quality."

"Very long wait but not their fault the machine broke down. Usually it's fine."

6.5 Awareness that the radiologist was working from a remote location The majority of participants (91.6%, n=131) were aware that the radiologist was working from another location, and not located onsite. Participants reported that they were informed that the radiologist was working remotely, some at several different times or through different methods (Table 6.3). One client stated that they were informed *"..on arrival, and [by] each person along the way. Plenty of communication. Helps to feel more relaxed as not everyone has done this."*

The majority of participants reported that staff had informed them on the morning of the clinic (84.0%, n=110). Participants had also been informed by staff when making the appointment (26.7%, n=35) and through completing the consent form (25.2%, n=33). Of the 15.3% who said they were advised by other methods, half of these participants noted it was in written form via letter, information sheet or pamphlet. A handful of participants said they were told by each staff member they saw throughout their journey.

Methods	Number of participants (%)	
Staff told me on the phone when making this appointment	35 (26.7)	
When completing the consent form	33 (25.2)	
Staff told me this morning	110 (84.0)	
Other (please describe)	20 (15.3)	
*Participants could choose more than option to describe how they became aware that the radiologist was working from a remote location.		

Table 6.3. Methods of communicating the radiologist was working remotely (n=131).

6.6 Expectations of care

Participants were asked whether they thought the care they received through the remote radiology assessment service (experienced that day) would be different to the care they might receive with the radiologist physically present at the clinic (Table 6.4).

Table 6.4. Participants views on differences in care expected between the remote radiology and onsite models (n=142).

Response	Number of participants (%)	
Difference in care	11 (7.7)	
No difference in care	120 (84.5)	
Unsure*	11 (7.7)	
*Participants in this category did not give a 'yes' or 'no' response but provided an explanation in the text response section.		

The majority of participants did not believe there would be any difference in care between the remote radiology and onsite models (84.5%, n=120). Comments made by those participants included:

"A doctor met with me, discussed details and will teleconference with radiologist. Having had previous assessments with other private practices I have never personally seen/spoken with a radiologist, so it is irrelevant."

"I think it would be the same. Because she can see the same screen there and everyone is talking, explaining and clarifying."

"Happy to think this is a way of redistributing the resources. Had experience with onsite radiologist before. Happy to talk to medical officer or radiologist."

Some participants did think that the care they received would be different (7.7%, n=11). These participants mostly commented that the service would be quicker if the radiologist was onsite. A few participants said they would have liked to have spoken with the radiologist and had the opportunity to ask them questions. A couple of participants felt it was their right to have access to a radiologist onsite, as one participant commented:

"I have had a lot to do with the health system. It is really poor that we don't have the same services as they do in [metropolitan city]. There are a lot of people live here and we expect better."

Nine percent of participants (n=13) chose not to answer this question about differences in expected care under the service delivery models by choosing 'yes' or 'no'. However, 11 participants responded in the open response section that they didn't know or were unsure if the care they received would be different to the care they might receive with the radiologist physically present at the clinic. Factors they were unsure about included communication processes and the technology.

6.7 Preference

The majority of participants (59.4%, n=85) did not have a preference for any particular assessment service delivery model (Figure 6.4). Reasons for choosing 'no preference' usually related to a belief that the same conclusion would be arrived at under both models of service delivery. Other comments related to receiving the same level of care under both models, and that the images being viewed were the same no matter where the radiologist was located. Comments included:

"Going on today's experience, I don't see any need for the radiologist to be present. If tossing up [a] timely response to [having a] radiologist in the room - I would prefer a timely response."

"Looking at same images. Doesn't matter where they are."

"I think both is good. What has happened today was excellent and if the radiologist was here it would be just as good."



Figure 6.4. Participants' preferences regarding location of radiologist (n=143).

A further 21% (n=30) of participants did not have a preference as it was their first visit to an assessment clinic. One participant noted that *"…access to experienced staff in the assessment-diagnostic process is most crucial, with onsite or distance-based being secondary in importance."*

A preference for the radiologist to be present onsite was reported by 16.8% (n=24) of participants. Some of the reasons for this choice included the significant size of the town where clinics were held, the right to have equitable access to health care services in rural and regional areas, the time in the clinic being perceived to be quicker and having the opportunity to ask questions and discuss results. Comments from participants included:

"Around [town where clinic is located] is socio-economically diverse - farmers, lots of mining, lots of money in the community. Lots of FIFO money, it should be put into health. We should have better health care."

"Maybe quicker, the equipment broke down today."

"Would prefer to have a radiologist here to ask questions if needed."

Four participants indicated that they preferred the remote radiology assessment service (2.8%, n=4). One participant commented on the distribution of resources, stating:

"Makes more sense to have a remote radiologist to spread resources equitably"

6.8 Final comments from clients

Just under a third of participants provided final overall comments. The majority of these were positive and summed up their feelings and experiences received in the clinic. Some participants concluded:

"Good that they can do it. Allows specialist diagnosis to be delivered to regional services. Don't have to travel, prompt response and treatment." *"I thought it was interesting and we have this technology now and it's one way of providing health care to remote locations."*

"Seems an innovative idea. Time saving and hope it doesn't put people out of employment here. Expertise here - would prefer local but if not, this is the perfect solution."

Only a few final comments were negative and generally related to breakdowns in technology or the preference or expectation that a radiologist be onsite.

"Need more reliable hook-up. Not good for ladies to be sitting so long."

"Due to population and number of ladies needing assessment, would prefer a radiologist here."

6.9 Summary

Overall, the majority of clients (98.6%) who participated in the client survey during or following attendance at a remote radiology assessment clinic, at four BreastScreen assessment services, were satisfied with the service provided. Eighty-four percent of participants indicated that they were extremely satisfied with the service. The majority of participants (91.6%) were aware that the radiologist was working from a remote location. Most participants reported that they were informed on the day of the assessment clinic with about 25% of participants recalling that they were told on the phone when making the appointment. The majority of participants (84.5%) did not expect to experience any differences in care between the assessment models, and about 8% of participants were unsure. Eighty percent of participants did not have a preference for the model of assessment service delivery though about 17% of participants reported a preference for a radiologist to be onsite and about 3% reported a preference for the remote radiology model.
7. Service provider perspectives

Overview

The views of service providers at participating sites who were involved in implementation and delivery of the remote radiology assessment model were gathered through semi-structured interviews. This qualitative component of the evaluation provided insight into the process of establishing the model, the challenges and enablers of successful implementation and operation of the model, providers' experiences of working in the model and factors important in the provision of a model that is safe and acceptable for service providers.

This chapter starts with a description of participants and methods followed by a description of service providers' perceptions of changes or differences between the remote radiology assessment and onsite clinics. There follows a discussion of enablers and challenges for implementation and operation of the remote radiology assessment model, and the quality and safety of remote radiology assessment clinics.

7.1 Participants

A total of 55 service providers participated in semi-structured interviews about the remote radiology assessment model (Townsville, n=13; Rockhampton, n= 8; Darwin, n=14; Queanbeyan, n=9; SCU's, n=11). Participants were medical officers, breast physicians, nurses, radiologists, radiographers, sonographers, data managers, administrators, receptionists, service managers, project officers and a health promotion officer (Table7.1). Three interviews were conducted with multiple participants at the same time. Interviews ranged from 6 to 54 minutes in duration with an average duration of 22 minutes.

Participant role	Number of participants
Medical officer/Breast physician*	8
Clinical nurse/Nurse counsellor/Breast nurse	7
Radiologist	8
Radiographer/Sonographer	8
Data manager/Service manager	3
Data administrator	3
Receptionist/Administrator	5
State/Territory Coordination Unit and supporting staff	12
Health promotion officer	1

Table 7.1. Number of service provider participants and their roles.

*To maintain anonymity in reporting of qualitative findings, breast physicians are referred to as medical officers throughout the report, noting that the term 'breast physician' refers to a different role than 'medical officer' in the context of some remote radiology assessment models. Likewise, there were various titles for nurses reflecting the diverse roles and specialty areas for nurses involved in assessment clinics. To maintain anonymity in reporting, the term 'nurse' is used.

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For the majority of participants, remote radiology assessment clinics represented their first experience of teleradiology. Those participants with previous experience of teleradiology were mostly professionals in the field of medical imaging. Interviewees had been in their current role for a variety of time periods, with one site having a very experienced team with more than five years in the current role for most staff members and one site with the majority of participants having less than one year to five years' experience in the current role, and the other two sites had a range of experience in between.

7.2 Development of themes

Two researchers independently coded each transcript using the interview questions as a framework, with inductive coding occurring concurrently. The team discussed codes and emerging themes during several team meetings. The coding for five transcripts was compared and found to have a high degree of concordance between researchers. There were some subtle differences in coding between team members. These were resolved by consensus during the development and discussion of overarching themes by returning to the transcripts to consider and verify the context of the differences. The process of discussing codes and the emerging overarching themes and categories contributed to the rigour and trustworthiness of the findings overall.

The team considered any variations between sites and between types of service providers (e.g. nurses, radiographers, radiologists, on site doctors) and managers (on site or from state-wide coordination units). Findings are reported in aggregate except where there were important variations relating to the overall assessment of the quality and safety of the remote radiology assessment model. These variations, including the conditions and setting for these variations, are outlined separately. Care has been taken in reporting the findings to avoid compromising anonymity.

7.3 Differences between the remote radiology assessment model and onsite model

It is important to note, the remote radiology assessment model, whilst operating under the BSA National Accreditation Standards (NAS) and SCU guidelines, developed and evolved slightly differently between sites in response to local needs and availability of resources and personnel. However, the radiologist onsite model also operated slightly differently between sites according to the availability and willingness of local radiologists to take on this work, or whether an external radiologist was flown in. The physical absence of a radiologist from a remote radiology assessment clinic was reported to require changes to some aspects of the service. Differences between the remote radiology assessment clinics and onsite clinics that were reported by participants related to service provider roles, communication and service processes.

7.3.1 Roles

Over half of all participants reported that there were no substantial differences between the remote radiology assessment model and onsite model in terms of their own role and duties. Participants commented that there were some variations in the way they worked, such as needing to communicate by telephone with the remote radiologist, explaining client information in greater detail or process paperwork in a different manner, however these changes were considered to be minor in nature.

An increased requirement to do more procedural work was mentioned by some participants. Medical officers and nurses described an increase in procedural work, mostly relating to the conduct of biopsies or ultrasounds, required under the remote radiology assessment model. The amount of extra procedural work required, compared with the onsite assessment model, was dependent on the routine practice of onsite radiologists. However, it was noted that in a remote radiology assessment clinic, all procedural work was performed by an appropriately credentialed health professional other than a radiologist. Conversely, conducting assessment clinics from a remote location was described by one remote radiologist as a more 'passive' approach to the assessment clinic, in reference to less potential for client and staff interaction, and no procedural work. However, non-radiology participants commonly reported that radiologists usually had minimal contact with clients during onsite assessment clinics, though this was dependent on individual radiologists.

7.3.2 Communication

Different approaches for onsite service providers to communicate with the remote radiologist, and as a team, were required in the remote radiology assessment model. In the remote radiology model, service providers were unable to simply 'pop in' and discuss a client with the radiologist in person and implemented communication strategies formulated by other sites or developed alternative ways of sharing and discussing client information that would be conducive to efficient and safe conduct of the assessment clinic.

In two sites, assessment team meetings were introduced at intervals throughout the clinic day. These assessment team meetings served to provide a time for all health professionals (on and offsite) to discuss each client's progress up until the scheduled meeting time and the next steps for those clients (whether further assessment was required or clarification needed), as well as the imaging required for clients waiting to begin the assessment process. At these sites, the remote radiologist could also be contacted outside of assessment team meetings. At one site, it was reported that access to radiologists was better than with the onsite model due to the ability to call at any time. While at another site, it was reported that while the remote radiologist could be contacted at any time, this was not usually necessary.

At another site, a clinic mobile phone was used to discuss clients' imaging assessment using text messaging and phone calls. For instance, onsite service providers could alert the remote radiologist about when imaging was ready for assessment via a text message, with care taken to maintain client confidentiality. Importantly, at all sites, the style of communication used was acceptable for onsite and remote providers, and fit with local clinic workflows.

At yet another site, a video-link between the clinic and remote radiologist was maintained for the entirety of the clinic duration. In this model, onsite service providers could talk with the remote radiologist at any time, as described by a health professional "...it's so easy just to walk in to see the radiologist, talk to them. They access PACS the same way we do. We are all looking at the same things, so, I do, I think it works well." On the occasion that the remote radiologist was off-screen, they could be contacted by phone if needed online.

Communication in the remote radiology assessment model was reported to require some extra effort but providers largely found this acceptable. Steps that participants undertook to ensure clear communication included reducing background noise, speaking clearly and one person at a time, clarifying who was in a room during an assessment team meeting, spending time describing a client's clinical presentation if suspected to be important, and using marker arrows and description to talk about specific regions on images. At one site, a participant described their experience of communicating with the remote radiologist during synchronous telesonography (transmission of ultrasound to a remote location in real-time using telehealth). The participant took great care in talking the remote radiologist through the ultrasound whilst being considerate of the client, who could only hear the participant's side of the conversation. Additionally, the clinic communication

whiteboard, consisting of a grid that enabled each client to be tracked through the stages of the clinic, was commonly reported to be a very useful tool for communication in both the remote radiology and onsite assessment clinics.

7.3.3 Service processes

There were several differences in administrative and clinic processes reported between the remote radiology and onsite models.

Administrative processes

Some participants described changes in paperwork required under the remote radiology model, and changes in administrative processes. Participants reported a new data variable that indicated the model used for the assessment clinic needed to be introduced. This was considered to be an important variable for monitoring clinical outcomes for clients assessed under the model. Another change in paperwork reported was a separate consent form for clients attending remote radiology assessment clinics.

Changes in paperwork and administrative processes sometimes increased preparatory work for a clinic and finalisation of a clinic, as described in the following examples. Information about clients needed to be conveyed to the remote radiologist before the assessment clinic at one site; for instance relevant history, imaging and reasons for recall to assessment. At some sites, a modified assessment form was prepared by onsite providers and sent to remote radiologists in preparation for a remote radiology assessment clinic. Additionally, development of a workup sheet prior to the clinic by the medical officer and radiologist was required at some sites and was an important document for imaging staff, especially at sites where radiographic imaging of clients began prior to the first assessment team meeting for the clinic day. For finalisation of the clinic, some sites required transfer of information relating to the assessment of each client to another form, and careful checking that assessment documents used onsite and remotely matched. This was not an issue at one site where all client details and images for the assessment clinic used the online client information system, accessible by both onsite and remote providers.

There was a perception that changes in administrative processes also caused slight delays in reporting results in some circumstances (although this did not appear to be reflected in the quantitative data). Some participants commented that finalisation of a clinic was slightly delayed due to the wait for paperwork to be returned to the clinic from the location where the radiologist sat. This meant that there was a slightly shorter timeframe (as set in the National Accreditation Standards) to deliver results to general practitioners, with matching changes in workflow for some participants.

Clinic processes

Participants at all sites reported that explanations to clients about the use of the remote radiology model were necessary. These explanations were provided routinely by administrative staff, nurses and medical officers, and spanned the client's journey through the assessment process from the time of confirming the client booking on the phone through to various points during the clinic. Participants commonly reported that extra explanation was required when booking and consenting clients in the remote radiology model, and health professionals also reported spending extra time explaining telehealth processes to clients.

Participants at all sites commented that they scheduled smaller clinics for the remote radiology assessment model. Onsite assessment clinics were reported to be faster due to the presence of the radiologist who could often report on imaging immediately. Having to communicate with a radiologist at a remote location, whether at scheduled times or as required, tended to slow the assessment process. Clinic schedulers reported that they accounted for the practices of radiologists, sonographers, and breast physicians where relevant, and anticipated clinical procedures for clients when scheduling an assessment clinic. With remote radiology assessment clinics, clinic schedulers also accounted for a lag in the assessment process. At one site, there was a difference of seven clients that could be comfortably assessed in an assessment clinic under the onsite model compared with the remote radiology model. At another site, three less clients would be booked into a remote radiology assessment clinic. The value of clinical oversight in the scheduling process was reported as valuable by some participants and can be seen in the considerations outlined here.

Clinic processes at sites where assessment team meetings were held throughout the day required a more structured workflow to "...the more 'on the fly' decision making that happens in an onsite clinic" (remote radiologist). At these sites, discussion with remote radiologists occurred at set times and required staff to progress work in order to meet these times. At these sites, onsite providers began the assessment clinic prior to meeting with the remote radiologist, and used a work up sheet that had been developed earlier by the remote radiologist and medical officer. Real-time review of ultrasounds via telesonography, when considered necessary, required more organisation during a remote radiology assessment clinic "...instead of just getting a radiologist to wander into a room and have a look at it in real-time" (medical officer). At other sites, workflow was more similar to onsite assessment clinics but required some changes in processes to allow for conduct of ultrasound, in real-time depending on the remote radiologist, and reporting using telehealth.

Additional clinic processes reported by some participants involved telehealth equipment. Some participants reported a requirement to test the connection between the onsite clinic and remote provider prior to commencement of a clinic, to ensure that there would be time to address any problems with the telehealth system. Others reported that trouble shooting technological problems was required at times during a clinic.

7.4 Enablers and challenges for implementation and operation

Participants reported a range of important enablers and challenges for the safe implementation and operation of a remote radiology assessment clinic. These factors were slightly different across sites, but consistently reported enablers included strong team functioning, trust and collaboration, technical support and provision of adequate equipment, clinical governance support and training. Challenges mostly related to technology and internet (speed/bandwidth), and maintenance of relationships within the group.

7.4.1 Approaching implementation

Participants reported receiving support to implement the remote radiology model from the NQMC, SCU and services, and individual service providers with experience using the model. Engaging key people in a collaborative approach to implementation of the model was a valuable enabler for initial implementation. Key people included technology experts, jurisdictional and clinical management, clinicians, and project officers. Involvement of telehealth and biomedical equipment experts, and medical physicists was an important enabler in ensuring that the model not only worked in terms of technological processes, but that it worked to the optimum quality possible, as described by a

technology expert: "...the two groups working closely together is very integral as part of the whole success for the project so ...just to reinforce... that relationship between the telehealth team and the biomedical specialists." Some participants reported that collaboration between key people occurred through the formation of a governance structure, advisory committee and regular operational team meetings. Collaboration with private sector partners was also seen to provide a means for staying updated with changing practice in breast screening. SCUs in one jurisdiction also commented on the strengthened relationships with clinic service providers that had emerged during the planning and implementation of the remote radiology model.

Project officers provided another connection between onsite and remote providers, jurisdictional level management and technological experts, and also supported clinics at the early stages of implementation. In one jurisdiction, service staff were primarily responsible for navigating the requirements and processes necessary to implement the model. This was reported to be a particularly stressful period of time for those staff members involved. Conversely, a medical officer at one site commented that having a project officer available during the first few remote radiology assessment clinics was very useful *"because we... weren't naturally attuned to the process"* (medical officer).

Standardisation of paperwork and general processes for the remote radiology model within jurisdictions was considered important. Participants reported that monitoring the clinical outcomes of the model was important but burdensome in the earlier stages of implementation due to challenging reporting requirements to the NQMC. Standardised processes to monitor the outcomes of the remote radiology model have been put in place at the jurisdictional level. Programmatic guidelines for conduct of remote radiology assessment clinics were developed in one jurisdiction based on the experiences of a pioneering clinic and the existing NQMC guidelines. In this jurisdiction, existing paperwork used to facilitate remote radiology assessment clinics and processes for operation and monitoring were reviewed, and training and support provided to clinics wishing to implement the model to meet local needs. One participant commented that rolling out the remote radiology model within a jurisdiction would require the use of firm guidelines, consultation with services and learning from others' experiences.

7.4.2 Adapting the model

Remaining flexible and open to other ways of doing things was an important enabler reported for successful implementation of the remote radiology model. In the earlier phases of implementation, discussing the drivers and processes for implementing the model at the clinic aided with "...getting the team on board" (nurse). Team acceptance and investment in making the model work was another enabler reported, "...because the thing is, when you are very invested in something, the steps that have to be taken don't seem like challenges" (medical officer). Participants commonly reported that staff recognised the need for, and were supportive of the model, and were "more than happy to change their process, to have the possibility of a remote clinic" (manager).

As implementation continued, participants reported a need to continually review processes and trouble shoot problems as they emerged, as described by a medical officer: "You need to think outside the box. You can't be hamstrung by 'we've always done it this way'. You've gotta ...roll with the punches... a [remote] radiologist who's going, 'but I can't see what you're talking about'... you have to think, 'how can I communicate this?' 'I know, put an arrow on it'." The need to continually review processes was reported by some participants to extend to review of overarching guidelines so that the model remained responsive to changing conditions at the service level.

Innovation around ways to communicate in the remote radiology model were commonly reported. Strategies for communication sometimes changed over time as providers adapted to the work flow of the model and innovated solutions to emerging challenges. For instance, with synchronous telesonography, communication was reported to become easier as the ultrasound operator and remote radiologist became accustomed to how each other worked, and a way of communicating throughout the ultrasound became established. As described by a radiographer: *"I think initially when people are getting used to it, it obviously does change because you are getting used to that different dynamic of how do you communicate and things like that. But then as we've adapted to that and… now, it's kind of just normal."*

7.4.3 Teamwork and trust

With the radiologist located remotely, and away from the team environment, participants reported that team dynamics were slightly different. Participants at all sites frequently commented on the importance of relationships, communication and trust for effective team work, and successful operation of the remote radiology assessment model. The model involved a high degree of planning and organisation, *"things really have to be spot on"* (nurse), requiring strong teamwork. Many participants believed that strong relationships between service providers could be formed through a long history of working together, and could be maintained through regular face to face contact at onsite clinics, conferences and other networking opportunities. At one site, consistency of staff at onsite and remote radiology assessment clinics was facilitated through a contractual arrangement. In this case, existing relationships were built upon and maintained through regular conduct of assessment clinics. For other sites, conducting an onsite assessment clinic with a radiologist who worked in the remote radiology model at least once a year, was reported to be acceptable for maintaining strong team relationships.

The need for well established, strong team relationships was driven by recognition of the importance of trust amongst the team. It was noted by a medical officer that trust is implicit in medicine: "...that's basically medicine, a lot of it [is] just on trust, you... trust this person to consent this person fully so they understand what they are doing. I trust this person to do an ultrasound and do it well so they are actually imaging the area they are supposed to image. I trust the radiographers to take the right images and not to take 5 or 6 before they produce one". However, it was commonly reported that the telehealth aspect of remote radiology assessment clinics required an extra degree of trust. Trust in the remote radiology model implied an uncompromising confidence in the skills of all clinical service providers, a knowledge of how each other worked and their work capabilities.

"... that relationship that you build up by working with somebody over a long period of time, is absolutely imperative with this process. The other thing with it, is there's no position for any weak links when you are doing it remotely. You've got to have faith in every single member of the team, so even if there is a locum in town... you've got to have met them, worked with them".

remote radiologist

Ultimately, providers at either end of a remote radiology assessment clinic needed to have the kind of trust that meant they could "...discuss and question things without offence" (remote radiologist). As one medical officer described when asked about how 'knowing' the remote radiologist was important, "I think it just seems more friendly, you sort of feel like, if you did disagree or if you had an extra question, you feel like you can just butt in like you would if they were standing in front of you. Whereas if you have never met them before, if you had real doubts, you would probably still butt in I guess, but... it's just easier... know[ing] who [is] on the other end of the phone". For remote radiologists, comfort with reporting in the remote radiology assessment model was strongly linked with their confidence and trust in onsite clinical service providers. Trust in onsite professionals in conducting ultrasound and performing biopsies was of particular importance, as emphasised in the following quotes:

"I know the sonographers that are there and I have confidence in them, so I'm happy to look at their ... images and I guess I'm less, much less, concerned because I know the sonographer there. And that comes with time, you know, knowing how good the sonographer is."

- remote radiologist

"... you've got to trust the people you are working with. The radiologists have got to trust me. I've got to trust them. They've got to trust my ability to do biopsies. They've got to trust my judgement when I say this woman shouldn't have a biopsy done... they've got to cope with that sort of level of trust."

medical officer

A feeling of greater team collaboration and team cohesiveness under the remote radiology model was reported by some participants. Onsite providers sometimes felt more involved in the remote assessment clinic due to more involvement in procedural work, as described by a nurse:

"...it's sort of probably more of a team, where when it's the radiologist here... they're [the radiologist] just happy to do everything themselves so they don't need anyone else. They just make the call and they do everything themselves where I think yeah it is more of a collaborative team when it's the remote model."

Team meetings and discussions were viewed positively by participants and as an enabler of teamwork. Clinical service providers often reported that team meetings provided them with a better ability to follow clients and colleagues through a clinic as well as involve them in discussions about client care, as described by two nurses at different sites:

"I guess in a way it [assessment team meetings] gives an excuse for people to definitely be together at the one time as opposed to a radiologist being onsite and just looking with one person and saying 'oh... that client's fine. Can you send her off now?' So therefore you might still put information on the board but really only one or two people have heard it whereas you know when you've got the gathering everyone sort of checks in ... I think it's changed in the way that everyone does tell you know, for some time now there's been open honest disclosure of information and consenting. You're up front, you're telling people what's to be expected and that continues on through. So I think probably the staff pull together a bit more."

"There's probably more discussion when we have a remote clinic in the morning, where we'll sit and have a team meeting and they'll go through what images need to be done, what the radiologist has asked for. Where when it's the radiologist, they'll just ask as they go and they'll ask the radiographer, so you don't get that team meeting in the morning as well... And so you actually hear a little bit more about the client and what they're looking at and why... I get to see that side of it too where I miss that often in the non-remote."

7.4.4 Technology

The use of telehealth technology is the core enabler of the remote radiology assessment model. Initial setting up of technological aspects of the model were reported to be challenging at all sites. The need for secure transmission of client information and images required the use of existing telehealth networks within each government health jurisdiction. The ability to access telehealth networks made implementation of the model possible.

Telehealth and biomedical equipment experts, and medical physicists were integral to ensuring that the model was implemented to standards that were acceptable for health professionals. For instance, the quality of transmitted images was dependent on the bandwidth available which could cause some challenges for optimisation of imaging. The age of equipment was also reported to be an issue for transmission of quality imaging at one site. Testing of the quality of transmitted images was carried out in all jurisdictions, and issues were addressed by experts in consultation with health professionals. One jurisdiction reported that tests for imaging quality were carried out whenever new equipment was acquired and used in the model. Another example of the need to involve technology experts in implementation concerned troubleshooting around compatibility of PACS machines at sender and receiver sites, and compatibility of PACS machines with ultrasound machines.

Participants reported that issues with the technology failing during clinics was sometimes a problem, and that these issues eased over time. Participants reported that they adapted to the use of the technology as time progressed by adding in specific processes such as testing the technology prior to a clinic. Service providers reportedly became 'tech savvy' as experience with model grew, as described by one service manager: *"It took us a couple of goes... the first couple of clinics were a little bit hit and miss, but we improvised, and we made it work."* Having clinical service providers who were familiar with the technology and able to solve common technological issues enabled the smooth running of remote radiology assessment clinics. However, some participants commented on the lack of timely support for technological issues that occurred during clinics that were beyond the knowledge of service providers. This resulted in interruptions to the clinic, adding stress for the team.

Communication equipment that was not fit for purpose was reported as an issue by some participants. Communication during assessment team meetings was hampered by standard telephone equipment that was used with the speaker function enabled so that onsite providers and the remote radiologist could communicate. Remote radiologists also reported that the lack of a landline at their remote reading station required them to use a mobile phone to communicate with onsite providers, which negatively impacted on the quality of communication possible.

Importantly, the vast majority of participants reported that access to client records was the same for both assessment models, and that problems with access to client records were non-existent. One issue around having different PACS equipment at send and receive sites was noted to cause minor problems at times where professionals were unfamiliar with particular machines, and needed to seek information and advice from others. Additionally, it was reported that sharing client information outside the PACS environment would allow greater access to client data however was not possible due to a lack of scanning equipment and email availability at workstations.

It was also reported that improvements in client information systems would be beneficial for streamlining processes around client information. Cross-jurisdictional differences in client information systems meant that access to client information, such as client history, required extra processes and added to workloads. Additionally, one remote radiologist reported being reliant on

verbal descriptions of findings of a client's clinical examination to draw themselves a visual cue of areas of interest. This visual cue aided in relating radiographic findings with the clinical examination. On conclusion of the clinic, the radiologists' assessment form was matched up with the onsite assessment form, with reliance on the medical officer to ensure that findings aligned. This reportedly had no impact on quality or safety of the model, but was noted as an area that could possibly be improved through the client information system.

7.5 Views on the quality and safety of the remote radiology assessment model Aspects of quality and safety in the remote radiology model that emerged from interviews with service providers focused on the satisfaction of clients and service providers, the availability and timeliness of the service and risks associated with using the model.

7.5.1 Satisfaction

Overall, service provider participants were satisfied with the remote radiology model. Participants reported that the remote radiology model was a valuable model for providing quality assessment services to women living in regional, rural and remote areas of the country, as described by a remote radiologist.

"... I don't have a back-up... to get another radiologist to go to [regional town] is very hard because everyone else is busy that day and so if I can't go, then the clinic gets cancelled which is bad for patient outcomes. Whereas instead, I can do a remote radiology clinic from [metropolitan city], it will take me a few hours, it will be a smaller clinic than normal but at least there's a service delivery and so there's a timeliness and I think that's really the main benefit there." The model reportedly improved availability of the assessment service to clients (7.5.2), improved timeliness measures (see 7.5.2), was functional in terms of clinic processes (7.3.3), and increased communication and teamwork (see 7.4.3). It was clearly apparent that service providers were passionate about providing the best quality care and client experience possible, and were willing to put in the extra time and effort required to run assessment clinics using the remote radiology model.

Participants commented on several other benefits of the model for them as service providers. They valued the continuity of clinicians at remote radiology assessment clinics as strong relationships could be built, which led to strong teamwork and a better experience for clients. Health professionals also valued the experience of working with radiologists who were considered experts in their fields, particularly the fresh approaches that they brought to services and learning opportunities. A medical officer commented that access to remote radiologists with extensive experience in breast work improved safety: *"To be introduced to new ideas and to see a different way of doing things challenges the way you have previously done things and makes you think more. And when you start thinking it becomes safer for people."* Access to experienced remote radiologists was reported to benefit clients as high quality diagnostic services were available to them despite living in a regional or rural location where access to experienced radiologists was potentially lacking, as described by a medical officer: *"...this is giving women access to high-end radiology and high-end radiologists through technology."*

The reduced need for radiologists to travel to assessment clinics was appreciated by the majority of remote radiologists. Travel to clinics included overnight stays away from home and family, long waits at airports especially when there were delays in travel due to weather conditions and airline flight changes, road travel to assessment clinic sites (sometimes over long distances), and an inability to use work time efficiently. However, some remote radiologists reported that remote radiology

assessment clinics could be an isolating experience for them, as one remote radiologist said, "...it's nice being there (onsite) with the crowd... I guess it is quiet when you are remote, it is quieter...".

Participants also discussed some other negative aspects of the remote radiology model. Participants reported that the model improved their procedural skills and provided opportunities for learning. However, some participants felt that the model was not as supportive of their learning needs, due to the inability to talk directly with the radiologist as they would during onsite clinics. Additionally, assessment team meetings, while seen to provide all health professionals with a better overview of the client's journey through the assessment clinic, were found by some providers to be non-conducive to their input into the client's story. Some participants reported that there were time pressures associated with the remote radiology model as onsite providers worked to make sufficient progress to meet the next assessment team meeting time. This could be stressful for all service providers, and particularly so for new team members. In addition, one site reported that assessment days were sometimes longer with the remote radiology model, though efforts were made to account for the slower running of remote radiology assessment clinics, and this could be tiring and stressful.

The majority of participants reported that clients were informed of the remote radiology model through clinic processes. Clients were reportedly satisfied with the model and some participants reported that clients were accustomed to telehealth. Participants reported that there were very few negative comments about the model shared with service providers, with some participants reporting that clients were often excited by the use of telehealth as they could see the value for their own health care.

7.5.2 Views on availability and timeliness

Overwhelmingly, the remote radiology model was described as being at least equivalent to the onsite model in terms of perceived quality. Since implementing the model, service quality was described as having improved in terms of availability of assessment services for clients and timeliness of services. Services were better able to meet their timeliness measures which was important for accreditation.

For service providers, the remote radiology model provided a reliable and consistent pool of radiologists. Knowing that an assessment clinic would not be affected by delays in travel or untimely flight schedules on clinic days, reportedly relieved stress on staff and enabled better planning. Participants also noted that availability of radiologists was often increased in the remote radiology model due to the absence of travel delays and timing of flights on assessment days. Improved service availability also reduced work and stress involved in following up with clients who had sought to complete their assessment at external organisations, as described by a nurse: *"when they [clients] get assessed privately, often there's a cost associated to the client and that's distressing for the client but it's distressing for us too because we've found something. We want to assess them within the system..."* Technological issues (7.4.4) could sometimes be an issue for remote radiology assessment clinics, causing stress for staff. These issues were reported to have no influence on the safety of the remote radiology model, but impacted on the availability of the service on a few occasions.

For clients, the increased availability of the assessment service was perceived by service providers, to reduce the anxiety of long waits to assessment for clients, and ensured that cancer detection occurred as soon as possible. This also meant that costly visits to the private sector, or visits to BreastScreen clinics in other locations, were avoided. Participants at all sites commented that waiting times during clinics were longer for clients attending the remote radiology assessment clinics, and reported that this could prolong clients' anxiety and impact on time away from other

activities, such as employment. Client waiting times on the day of assessment were lengthened due to the inability for the radiologist to report immediately, as in the onsite model. Additionally, biopsies were usually performed towards the end of the day to fit in with the workflow of the clinic, lengthening the wait time for clients requiring biopsy procedures. At one site, clients requiring a certain type of biopsy were rebooked into the next assessment clinic. This was always the case for the remote radiology model at this site, however, this was also a possibility for the onsite model due to the onsite radiologist needing to meet travel commitments. Participants considered that these impacts on the client experience were minor in comparison to the reported timeliness benefits of the model overall.

7.5.3 Risks

The majority of participants reported that they felt the remote radiology model was as safe as the onsite model. Participants reported some possible risks around the use of telehealth, and risks to the service and workforce, that require consideration and management. These are outlined further below.

Telehealth and image quality

The use of the remote radiology model required transmission of quality images from the assessment clinic to the radiologist in another location. Telesonography presented a challenge in all jurisdictions in terms of optimal quality of imaging and quality assurance. An absence of existing guidelines around telesonography in breast cancer assessment was noted. During early piloting and implementation of the remote radiology model, testing was conducted by biomedical and equipment specialists, and medical physicists. Furthermore one jurisdiction reported that quality control protocols were developed. Testing involved configuration of equipment and transmission for the optimal image quality to be achieved at the receiving site, and a participant from one jurisdiction commented that all new equipment underwent quality control protocols. There was a possible risk identified that the quality of image may be poorer at the receiving site due to compression and decompression of images that occurs when using synchronous telesonography. However, following testing, this risk was reported to be low and the images were reported to be diagnostically comparable with images captured on the ultrasound machine. It is important to note that interviews with technology experts were limited to one jurisdiction only. All jurisdictions reported that procedures for checking image quality when using synchronous telesonography had occurred.

Some participants identified that ultrasound imaging could become pixelated during synchronous transmission using telehealth. Possible reasons for this were reported to be bandwidth issues in the telehealth network and the use of older equipment. It was reported that there was a reliance on the remote radiologist to identify when the quality of imaging was not optimal during telesonography. Pixelated imaging was cited as a concern that occurred at one site. This was reported by a remote radiologist to be frustrating and slowed the clinic but was something that could be managed.

The ways in which telesonography was used differed across sites and between remote radiologists. In two jurisdictions, remote radiologists could supervise an ultrasound over a video-conference link, collaborate with the ultrasound operator (medical officer or sonographer) to capture images of interest, and report on these images. In one jurisdiction, the ultrasound operator captured cine loops (video) of the ultrasound and transmitted these through the PACS to the remote radiologist for reporting. In this model, the remote radiologist could also request to supervise the ultrasound in real-time over a video-conference link. Overall, the employment of synchronous telesonography during client assessment depended on the preferences of the remote radiologist, with some preferring to use the technology for every assessment, and others using it if they thought it necessary to inform their decision making. Some remote radiologists commented that they did not supervise ultrasounds when they were onsite due to the level of trust they had in the ultrasound operator. In cases where the remote radiologist was equivocal about the ultrasound, clients could be recalled to the next assessment clinic with an onsite radiologist. For all remote radiologists, confidence and trust in the ultrasound operator was imperative to their comfort with using the remote radiology model.

In the remote radiology model, medical officers were required to carry out biopsy procedures. Participants commonly stated that this was also often the case in the onsite model, though this was dependent on radiologists' preference. Once again, a high level of trust in the medical officer and onsite team was required for radiologists to be comfortable with medical officers carrying out biopsy procedures. In the absence of a medical officer onsite with the appropriate skills to conduct certain biopsy procedures, clients were booked into the next assessment clinic with an onsite radiologist. This was perceived to have no influence on the safety of the remote radiology model, though it was noted that it was inconvenient for the client.

There was a potential risk that remote radiologists may change their biopsy practice in the remote radiology model. This risk was described as minimal, as a remote radiologist commented: "…we have already decided that there is something inherently abnormal on this woman's mammograms [when they are recalled to assessment] and so therefore our index of suspicion to moving to biopsy needs to be relatively low, and so if you are uncertain, you biopsy… I think for remote assessment purposes the data does not need to be as perfect, you just need to be much more willing to do a few extra biopsies than if you were onsite, be that as it may, that extra number of biopsies is small, and the harm and risk to the woman, I think, is low."

Other remote radiologists commented that the remote radiology model did not influence their decisions:

"The decision making process is the same wherever I am...."

remote radiologist

"I don't think it makes any difference to my diagnostic algorithms." – remote radiologist

One remote radiologist commented that clinics could not be as well supervised from a remote location, which could potentially pose risks to the safety and quality of the remote radiology model. Having strong relationships and trust amongst the team, as well as having remote radiologists with significant experience in breast assessment, were extremely important factors in addressing these perceived risks. Other remote radiologists indicated that they were comfortable with the quality and safety of the remote radiology model, as long as there were established relationships and strong levels of trust in the team.

Risks to the service and workforce

Participants reported concerns about workforce impacts of the remote radiology model. Some participants identified that there was a risk that services could 'lose the personal business' in the remote radiology model as the remote radiologist had very minimal contact with clients. This

decreased client contact was connected with the risk that radiologists may prefer not to engage with the remote radiology model.

There was also a risk that local radiological workforce (where available) could become deskilled by losing the opportunity to participate in breast assessment. Moreover, a perception that the remote radiology model could replace the onsite model (described as a possibility) was viewed to increase the risk to local workforce. Some participants commented that drivers for implementation of the remote radiology model stemmed from a lack of available local radiologists and the model was only used as necessary to ensure a timely service for clients, as a manager described: *"…you want to support your locals to learn a lot and for them to be available to provide resources. But there are times when they are not available, they have holidays, they're a scarce resource... So, what it means is you can have a timely service, even if you haven't got the resources of a metropolitan area."*

The preference for a local radiologist was commonly reported by participants, as described by a medical officer: "...onsite assessments with an interested and passionate radiologist, are infinitely better than remote radiology because you can have one-on-one interactions, that non-verbal communication, all that sort of stuff. But beggars can't be choosers. You live outside the major metropolitan areas, there's not a lot of radiologists to be had, certainly, not a lot who are interested in doing low remuneration work...". With access to local radiologists possibly being problematic in other areas, it was speculated that the remote radiology model would be considered at other clinics. In line with expected increases in the use of the model, some participants reported that consideration for availability of appropriately experienced and qualified workforce would be necessary as well as practical implications such as rostering of clinics to meet availabilities of remote radiologists.

Some participants were concerned that the remote radiology model may be implemented by clinics without appropriate experience and team dynamics in place first. As pointed out by one telehealth expert, it was important that telehealth users understood that: "...it's not just, 'ah, this is a videoconferencing system, there's an ultrasound or whatever other type of medical device it is, we can plug the two together, make a call on the way it works'. It's sometimes not as simple as that. From a functionality it can be but, if you want to ensure that you are transmitting for the optimum quality, to engage the relevant specialists at the very early stages..." There was an important role for SCUs in ensuring that services were ready to implement the model.

Ensuring that remote radiology assessment clinics were staffed with appropriately skilled and experienced staff was identified by participants as essential for the success of the remote radiology model. Extra procedural work (such as biopsy work carried out by medical officers) was reported to be accompanied by greater risk to the health professional. This was connected by some participants with possible issues recruiting health professionals to be involved in the remote radiology model. One participant commented that the expanded scope of duty was viewed to require protection for the health professional, and another participant commented that it could be accompanied by appropriate remuneration. It was also reported that new team members could find remote radiology assessment clinics stressful due to the high level of independence required, with the need for well supported training identified for new providers.

7.6 Improvements and advice for implementation

Overall, participants reported that the remote radiology model worked well. Some advice for implementation of the remote radiology model and suggestions for improvements were offered. These mostly focused on guidelines, processes, workforce, and technology and equipment.

Guidelines

Participants reported that the NQMC protocol guidelines informed the implementation and practice of the remote radiology model. Some aspects of the guidelines were noted by some participants to lack clarity leaving jurisdictions to interpret and apply the guidelines without explicit guidance. Other participants reported that the guidelines applied were overly prescriptive and had reportedly sometimes affected the availability of remote radiologists. Specifically, the requirement for synchronous telesonography to be available was noted to limit where remote radiologists could report from, due to equipment requirements, and added substantial cost to the model. Similarly, exact technical equipment specifications were felt to be a risk, where technological advances could move faster than the guidelines.

SCU guidelines provided another level of both guidance and restrictions, with recommendations made about the frequency of onsite assessment clinics. One participant reporting needing to cease providing remote assessment services due to the requirement to attend an onsite clinic which they could not do in the time period stated in the guidelines. One remote provider suggested that allowing remote radiologists to conduct remote assessment clinics while also conducting an onsite clinic could assist with ensuring that requirements for remote providers to attend onsite clinics were met.

The Teleradiology Standards (RANZCR; 118) were newly available at the time that the majority of interviews were undertaken. Most participants were unaware of these new guidelines. However, one participant commented that the guidelines did not cover the use of teleradiology for diagnostic procedures performed with a radiologist located remotely. Telesonography was reported to be uncommon for breast assessment in Australia. A suggestion was made that guidelines for quality assurance of telesonography applications would be useful for telehealth and technology experts.

Processes

Participants identified that guidelines for the use of the remote radiology model should be used to inform clinic processes. Participants recommended that staff seeking to implement the model would need to take a very organised and planned approach to the clinic, and would need to be prepared to review and adapt processes as implementation continued. Implementation of the model required all members of the team to be aware of their role in the clinic and to perform their work to a high standard so that the model could operate well. Learning from the experiences of other sites, seeing how the model operated at other sites and incorporating practice runs were suggested by several participants as part of the implementation process. Some suggestions for improvement included starting a clinic earlier or having the remote radiologist join later to help with time pressures, and incorporating a results review meeting that included all members of the team to support providers' learning needs.

<u>Workforce</u>

Participants reported that it was imperative to the success of the remote radiology model that the team had strong professional relationships with each other that had been formed by working together during onsite clinics, generating high levels of trust. The importance of experienced health

professionals as team members was highlighted. In particular, remote radiologists reported that they should know the skill level of the sonographer or ultrasound operator, and be entirely comfortable in working with them remotely. Medical officers with skills in biopsy procedures, particularly ultrasound guided biopsies, were also considered necessary for clinics considering implementing the model. More guidelines on the potential roles of various health professionals as part of the team were suggested. A requirement for remote radiologists to be experienced in breast work was also reported. Participants advised that assessment services should not attempt to use the remote radiology model unless optimal service delivery was occurring during onsite clinics.

Some participants advised that for the model to be sustainable, forward planning was required to ensure that appropriately qualified and experienced clinicians would continue to be available. Participants also advised that maintaining an awareness of remote radiologists' availability was helpful in the event of late changes to their schedule. Training supported by providers well experienced in using the remote radiology model was suggested as important for new team members. Continuing to support the learning needs of all providers was also an important consideration suggested by some participants.

Technology and equipment

Participants advised that reliable telehealth connections needed to be in place for the remote radiology model to run smoothly. Early communication with telehealth and technology experts was strongly recommended for clinics looking to implement the model. Participants reported a need for timely technical support to be available during clinics, especially during the first few remote radiology assessment clinics where technical hitches were most likely to arise. Additionally, some members of the onsite team, and the remote radiologist, needed to have some expertise in troubleshooting connection issues. To help with reliable and timely transmission of imaging, some participants reported the need for sonography equipment to be updated, requisition of appropriate numbers of assessment monitors at the remote site, and availability of onsite PACS equipment that matched remote site PACS equipment. The use of tomosynthesis was also reported to be a technology that may improve assessment clinics.

Access to technology that would facilitate better communication was an improvement that some participants suggested. Suggested improvements included technology that would allow images to be marked on the screen without the need to refresh the screen, an ongoing video-link so that providers could see each other and converse, and fit-for-purpose teleconferencing equipment. Participants advised that staff should use communication that was suitable for the team, fit local workflow and allowed contact with the remote radiologist at any time.

The use of a client information system that was compatible across jurisdictions was reported to offer better access to client information. Such a system would reportedly reduce time and effort spent in sharing client information in other ways, thereby reducing double handling of client information and preparation required for remote radiology assessment clinics.

7.7 Summary

The views of 55 service providers involved in the implementation and operation of the remote radiology assessment model for service delivery provided insight into the processes of establishing the model, the challenges and enablers of successful implementation and operation of the model, and factors important in the provision of a model that is safe and acceptable for service providers. Overall, service providers were satisfied with the remote radiology model including how it operated at their service, their roles within the model and the impact of the model on timeliness of the

service. Service providers were passionate about providing a safe and quality service to clients in a timely manner, and supported the remote radiology model in the absence of local radiological workforce that could meet service demand.

The remote radiology model operated slightly differently at each site (whilst remaining within NQMC guidelines) and was adapted at each service, over time for some aspects, to suit local workflows and service provider preferences. In addition to this important flexibility, enablers of the remote radiology model were strong team functioning, effective communication and reliable technology.

The majority of participants reported that the remote radiology model was as safe as the onsite model, in part due to the continued reflection and communication about quality involved in implementing the model. Some potential risks that were identified around the use of telehealth related to radiologist supervision of a clinic and the potential for changed biopsy behaviour. Both of these potential risks were reported to be lessened through strong working relationships between onsite and remote staff where knowledge and trust in each other's skills was well established. The quality of imaging through synchronous telesonography required expert input to ensure that imaging transmitted using telehealth was diagnostically acceptable. Participants also suggested improvements of the remote radiology model and offered advice for services seeking to implement the model. These mostly focused on guidelines, processes, workforce, and technology and equipment.

8. Cost assessment study

The research team has approved the removal of the contents of this chapter from this version (version 2) of the final report. The chapter contents have been removed as requested by BreastScreen Australia and the Australian Government Department of Health for the purposes of public dissemination. The chapter described the findings of the cost assessment study.

9. Discussion

Overall, this evaluation of the remote radiology assessment model following the remote radiology assessment trial has demonstrated reassuring findings in terms of the quality and safety of this format of assessment clinic, in terms of clinical outcomes (notably likelihood of cancer detection), timeliness, cost, client perceptions and acceptance, and the perspectives of health professionals and other stakeholders involved with governance and implementation of the model.

To conduct this assessment we had access to a large database cataloguing 21,117 visits to assessment clinics across three jurisdictions, including 3,904 assessment visits conducted under the remote radiology model, ensuring adequate power for confidence in the findings. We also conducted surveys with 144 women attending remote radiology assessment clinics in all three jurisdictions, and conducted semi-structured interviews with 55 service providers representing a wide range of health care providers, managers and regional stakeholders involved in the provision of the model. A cost study was also conducted at the jurisdictional level.

9.1 Summary of main findings

These figures suggest that the remote radiology assessment model is as effective at detecting cancer as the radiologist onsite model. There were no statistically significant differences in the agestandardised likelihood of cancer detection (any cancer, invasive cancer or small invasive cancer) between assessment visits conducted under the remote radiology assessment model and the onsite assessment model. There was a small but significant increase in cancer detection (any cancer or invasive cancer) using an adjusted model when the time after the implementation of the remote radiology model at each site was compared with pre-implementation. However, this likely to be contributed to by simultaneous work being done by jurisdictions to reduce radiologist variability and particularly decrease unnecessary recalls for assessment over the same time frame, rather than an effect of implementation of the model per se.

There were significant improvements in timeliness of assessment, and pro-equity changes in attendance at assessment visits for women from more remote locations and lower socioeconomic status. The introduction of the model resulted in highly significant reductions in timeliness of assessment -the time taken from screen date until date of first attendance at assessment clinic (AOR 0.21, 95% CI 0.20-0.24, p<0.001) and remote radiology assessment visits had significantly shorter times from screen date until assessment recommendation, and date from first attendance until assessment recommendation. Again, this needs to be contextualised in terms of the fact communicated by our service colleagues that extra assessment clinics to cater for need are almost always implemented using the remote radiology model and thus will improve the timeliness outcomes. Despite this we can be confident that implementation of the model contributes to more timely assessment and diagnosis for women, particularly those in most disadvantaged settings.

Surprisingly, women attending a remote radiology assessment clinic were significantly less likely to require more than one assessment visit to obtain an outcome (AOR 0.49; 95% CI 0.33-0.71, p<0.001) a factor particularly important for those from remote areas. Whilst an unexpected finding, when triangulated with the qualitative findings this makes sense, due to the increased likelihood of going on and conducting required biopsies on the same day under the remote radiology assessment model, and possibly changes in availability of skilled staff on site and less travel time for radiologists.

There were also no statistically significant differences in uncertainty (equivocal assessment recommendations) for women not diagnosed with cancer between the remote radiology and onsite

models, or when comparing the pre-implementation and post-implementation time period (where equivocal assessment recommendations were compared for early review versus return to routine rescreening, and routine rescreen in one year versus routine rescreen in two years). Whilst there were considerable variations by jurisdiction in terms of strategy for dealing with the small number of equivocal results, this suggests overall that the remote radiology model does not change levels of uncertainty in assessment recommendations.

Slightly higher numbers of mammograms per assessment visit were reported for the remote radiology assessment model compared with the onsite model, even after adjusting for the underlying temporal trend. This means that there may be slightly more radiation exposure for women assessed under the remote radiology model, however the absolute levels of this are extremely unlikely to pose any clinical risk. Extra exposure from X-ray guided biopsy figures were not included in this analysis. It is possible that as providers become more experienced and comfortable with the model that these numbers may reduce over time, however monitoring is recommended. The use of Computed Radiography (CR) mammography machines at some screening sites was associated with higher numbers of mammograms performed at assessment clinics in one jurisdiction. CR machines are known to produce images that are poorer quality than those produced by Digital Radiography machines (121), increasing the likelihood for repeat imaging to be required at assessment. The more widespread introduction of tomosynthesis for diagnostic purposes may also impact on these numbers. There were no significant differences between the remote radiology and onsite models in number of assessment visits where biopsies were performed, although open biopsies (small in number) were not included.

The purpose of the costing assessment was to attempt to determine differences in the relative costs of each model, not to calculate or determine the total cost of each model. It has not been possible to give a total, comprehensive cost for each, as many cost data were not available. [*The rest of this paragraph has been removed in this version of the final report for the purposes of public dissemination*].

Overall, women accessing the remote radiology assessment clinics were extremely satisfied with the service provided. The majority of women did not expect to experience any differences in care between the assessment models, and a small proportion of women reported a preference for a radiologist to be onsite, most commonly due to their perceptions of equitable access to health care services in rural and regional areas, a shorter waiting time at an onsite assessment clinic or ability to discuss questions and results with the radiologist. Women were accepting of the remote radiology model for their care. Although only 25% of women recalled being advised of the remote radiology model during the phone call to book their assessment visit, it is quite likely that this was artificially low given what a stressful time it is in women's lives and the influence of recall bias. For women, satisfaction with their clinic experience appeared to centre on positive interactions with, and characteristics of service providers (frequently described as friendly, helpful, comforting, compassionate and professional), rather than whether the radiologist was onsite.

Health care providers across the sites also reported high satisfaction with the remote radiology assessment clinic processes overall, and provided thoughtful responses about the implementation process, and factors important to the successful and safe operation of the model. These factors related to teamwork and trust, the technology or equipment, and strong processes, training and governance support required to support the model. The stakeholder interviews reflected support for the remote radiology model overall, given the benefits of increasing access to timely care for women in rural and remote areas. The actual process of implementing a new model itself might support quality care through stimulating greater focus on teamwork and communication, and

continuing critical reflection of procedures and outcomes. A balance between programmatic support and guidelines to govern safe practice, and some flexibility to operationalise the model in a way optimal to local needs was viewed as important.

9.2 Factors important for implementation of a high quality and safe service using the remote radiology assessment model

Service provider interviews highlighted that the remote radiology assessment model is not intended to replace the radiologist onsite model, or facilitate any flow-on effects such as deskilling of available local health professionals. Rather, implementation and use of the remote radiology model is to ensure a continuous and accessible assessment service for regional, rural and remote women when local radiology options are not available.

Three main categories of findings were consistently reported that are important to ensure that the model delivers a high quality and safe service: 1) workforce factors, particularly teamwork and trust; ii) technology factors; and iii) system factors including monitoring, processes and governance. Each of these are discussed below, and they form the basis for the recommendations outlined in Chapter 10. These three categories of findings map very closely to the three main factors identified by Chang and others' 2015 model for evaluating telemedicine initiatives (112). Chang suggests that there are six main areas to consider in terms of implementing a safe and effective telemedicine model, grouped into three main areas: i) human factors (service provider factors and patient/client factors); ii) system factors (organisational factors and technological factors); and iii) environmental factors (societal/financial factors and regulatory factors). Likewise, the RANZCR Teleradiology Standards, released in 2017, support regulation and credentialing of the workforce both onsite and remote, clear communication and the use of appropriate equipment (118).

9.2.1 Workforce, teamwork and trust

Assembling an appropriate team is vital, with some efforts required to ensure cohesiveness, skill coverage and unity with a shared goal of supporting increased access to quality care. This team will include suitably trained and credentialed staff in the regional or rural location for: i) imaging (radiographer, sonographer, nurse where applicable); ii) clinical management (medical officer with appropriate training or breast physician, breast nurse); iii) data management and technical staff; and iv) appropriate reception and support staff (including Indigenous liaison staff). In addition, suitably trained and supported radiologists, both local (where available) and remote are required. Planning in terms of the competencies required to provide a safe and effective service and those available may be more fruitful than producing narrow definitional roles of particular health professions that may limit flexibility at various sites. Processes to ensure ongoing adequate credentialing in Australian settings are important, along with a continuing focus on skill maintenance and upskilling.

Processes for developing and maintaining trust and good team functioning were developed at all sites and viewed as important. These included regular onsite clinics as well as remote radiology assessment clinics (although there was no consensus either in the literature or our data about how often was optimal), face to face training sessions in which all staff participate, and more explicit team building sessions. Recruiting a project manager to cover the transition period to implementing a remote radiology assessment model at a particular site was recommended by a number of interviewees, as was the maintenance of sufficient flexibility to make small adjustments to the operation of the model to suit local context in terms of workforce availability, skill sets and competencies.

9.2.2 Technology

The main concerns raised with the remote radiology assessment model related to the technology, and the need to have equipment that meets technical specifications in place and tested, with immediate technical support available prior to implementation of the model and during service delivery. Testing the fidelity of image transmission at intervals is an important component, as highlighted in the RANZCR guidelines (118). Naturally, this included equipment for the storing and transmission of images and data, but in addition, technology for real time communication (verbal and written) between remote and onsite staff was viewed as vital and sometimes relatively neglected. In general, a tension was identified between the need for guidelines and protocols to provide sufficient detail for guidance, for BreastScreen Australia assessment services establishing a remote radiology assessment program, and the need to retain sufficient flexibility to account for the rapid evolution of technology and site-specific variations in availability of equipment and skills.

9.2.3 Governance, monitoring, systems and processes

The interviewees in our study all stressed the importance of careful planning and governance support and guidelines for implementation, technical specifications and workforce credentialing. This included ensuring that appropriate systems were in place for data management and recording, including longitudinal monitoring for quality and safety outcomes. Whilst in some jurisdictions there was considerable strength in programmatic guidance and support, across the trial sites, considerable ingenuity and innovation was displayed by implementing sites in terms of building solutions to communication and record-keeping challenges in their local context. The communication of individual client level data between remote radiologist and onsite clinical staff was an area where some duplication occurred, that may be strengthened in future by shared electronic medical records accessible across sites. Harmonisation of the processes and variables used for monitoring across jurisdictions emerged as another area for potential action.

9.3 Limitations of the remote radiology assessment model

As stressed by many interviewees, the intention of the remote radiology assessment clinic has never been to either replace onsite radiologists in assessment clinics at regional and rural locations, or to save money. Rather, the motivation has been to address shortages in availability of the local radiologist workforce through a model that can provide a safe, high quality service, whilst facilitating timely access for regional, rural and remote dwelling women to breast assessment services closer to home. Locum radiologists are one solution, yet as expressed they also lack consistency and do not address the issues of team functioning that has been demonstrated as so vital to safe operation of an assessment model.

The remote radiology assessment model addresses only a local shortage of supply of radiologists. However, in regional and rural areas, there are considerable workforce shortage issues across a range of other health professionals, for example sonographers, that are not addressed by this model. Ensuring that any available local workforce is not de-skilled through operation of the remote radiology model is important, and an appropriate balance needs to be struck (and periodically reviewed) according to the situation in each location.

There are slightly increased numbers of mammographic images under the remote radiology model. These may be a teething issue related to increased caution about remote radiology model amongst staff (particularly remote radiologists) and the rates of both mammograms and biopsies appeared to vary between different radiologists. Given the data provided, we were unable to confidently assess the difference in rates of mammograms or biopsies requested by individual radiologists under the remote radiology model compared with the onsite model. Monitoring is needed over time to see whether the small increase in imaging requested and apparently unchanged biopsy behaviour is a consistent finding or something that changes as all staff become comfortable with the remote assessment model. Care should be taken to adjust for various demographic and jurisdictional factors that influence biopsy rates when investigating individual radiologists' practice for equitable comparison.

Following this review of the quality and safety of service delivery under the model and stakeholder perceptions, there is an expectation that policies and processes will be reviewed as more clinics adopt the model to enable further consideration of resources and context.

9.4 Strengths and limitations of the study

A strong team, consistent engagement with stakeholders and a robust evaluation approach ensured that a comprehensive evaluation of the remote radiology assessment model has been possible. This incorporated: i) quantitative assessment of the quality and safety of the remote radiology assessment model (including cost comparison); ii) client satisfaction and acceptability; and iii) acceptability of the model and perspectives of service providers and managers. In addition to strong governance oversight through the Remote Radiology Assessment Research Governance Committee subgroup of NQMC Governance Committee, and ongoing liaison with implementation sites, detailed stakeholder engagement through the CJAG, ensured that inconsistencies in terminology and data systems could be resolved quickly and accurately. A consumer representative reviewed our client survey, however, despite persistent efforts, she was unable to commit to regularly attend meetings of the CJAG group.

The team were able to use our experience to navigate in a timely fashion the extremely burdensome separate human research ethics, research governance and public health approvals required across three jurisdictions to conduct this work. We were able to do some detailed mapping of the slight variations in the operation of the remote radiology assessment model at the four sites from which qualitative data was collected. Both our quantitative and qualitative data analysis plans were reviewed by national experts, with suggestions incorporated. We had access to a large quantitative dataset, enabling adequate power to be confident of the validity of the quantitative findings. Many of the findings (for example those relating to the likelihood of cancer detection for first and subsequent screens), align closely with figures published in contemporaneous BreastScreen Australia reports. The use of multiple data collection methods and approaches, and data and coding triangulation support the reliability and trustworthiness of our findings. In addition, strong participation in interviews from a wide range of service providers and managers across jurisdictions, and the addition of a client survey with both numerical and qualitative data about satisfaction and acceptability was a strength.

There were some limitations to our analysis and some of these factors have been reflected in recommendations. Given that a randomised-controlled trial design was not feasible, the study design chosen was able to describe and measure associations, but not ascribe causality. There were some issues with access to data and inconsistencies in datasets and terminology between jurisdictions with considerable amounts of missing data from some jurisdictions. For example, we were not able to identify Indigenous women from NSW for the purpose of this analysis due to additional ethics requirements. Furthermore, we needed to conduct some detailed mapping of variables, with input from technical experts and SCUs, to allow harmonisation and merging of

datasets between jurisdictions. Clinical outcomes were usually reported per assessment visit, rather than assessment episode, thus there may be some slight miscalculation based on double counting of women who had more than one assessment visit for an episode, although the absolute numbers of these were very low. In retrospect, refusal rates (with reasons) may have been a more accurate measure for assessing impact of the remote radiology assessment model on attendance rates, as women were generally booked into the next available assessment clinic regardless of the model used for service delivery.

[Two paragraphs relating to the cost assessment study have been removed in this version of the final report for the purposes of public dissemination].

A larger proportion of Aboriginal and Torres Strait Islander women in our client satisfaction survey sample would have strengthened this section.

9.5 Summary

Overall, these findings suggest that the remote radiology assessment model is at least as effective at detecting cancer as the radiologist onsite model. There were significant improvements in timeliness of assessment, and pro-equity changes in attendance at assessment clinics for women from more remote locations and lower socioeconomic status. Slight increases in the numbers of mammograms performed under the remote radiology assessment model should be monitored over time, and continued efforts made to strengthen participation of Aboriginal and Torres Strait Islander women in BreastScreen Australia programs (including assessment) more broadly. The findings demonstrated high acceptability and satisfaction of the remote radiology assessment model amongst clients, clinical, administrative and management staff. A range of suggestions were made about factors important for safe implementation and operation of the model into the future, with a focus on the team, technology and governance and monitoring.

10. Recommendations

This evaluation has provided strong evidence of the safety and acceptability of the remote radiology assessment model across three different jurisdictions. This evidence supports consideration of broader roll-out of the model, with the proviso that consideration should be given to recommendations for safe and sustainable operation of the model and monitoring of outcomes. Recommendations are drawn from the data collected and analysed for this evaluation. In keeping with the clear themes of the findings (including input from our expert stakeholders) these recommendations have been classified into three main groups: i) teamwork and trust; ii) technology; and iii) governance, monitoring, systems and processes.

1. Teamwork and Trust

The establishment of an appropriately skilled and credentialed team is vital to the success of the remote radiology assessment model. Team members need to develop effective working relationships, communication strategies and trust, and have opportunities to participate in professional development to obtain and maintain skills.

1.1 Assemble an appropriately skilled team of health professionals who have experience in teamwork, established relationships and have developed a high level of trust.

Team members with appropriate prior experience and skillsets are highly valued within assessment services. In implementing a remote radiology assessment model, onsite and remote providers should have worked together previously, ideally face-to-face. Service providers emphasised that opportunities to work together enhanced trust in each other's judgement and technical skills, and promoted effective, candid communication. A set minimum amount of time that providers have worked together is not identifiable or appropriate. It is recommended that service teams and remote providers should determine the trust levels and teamwork necessary for the safe implementation of the model.

1.2 Provide ongoing opportunities for the whole team to spend time together face-to-face to develop and maintain relationships.

Remote radiologists conducting an onsite clinic with team members on a regular basis will facilitate maintenance of working relationships and promote team cohesiveness. The frequency of onsite visits by remote radiologists required will vary depending on the stage of team development and retention of health professionals. Decisions around face-to-face work should consider the local needs and expectations of individual services and involve discussion with local staff including the designated radiologist.

1.3 Ensure that optimal means of communication during, and between, remote radiology assessment clinics are available to all onsite service and remote providers.

Significant preparatory work is required to organise and conduct a remote radiology assessment clinic. Additionally, effective and efficient communication is required during and following assessment clinics. Communication should be straightforward and easily accessible throughout the planning, delivery and finalisation of assessment clinics. Options identified in this evaluation included video-link and phone-link. Other options for consideration include secure online chat platforms, although it is necessary to ensure confidentiality and privacy is maintained. When and how communication happens during the delivery of a remote radiology assessment clinic should take into consideration the service processes and workflow implemented for delivery of the model, in the local context. Assessment services implementing the remote radiology model should be

prepared for methods of communication to change over time as service providers adapt the model to their local needs and preferences.

1.4 Facilitate opportunities for learning, professional development and upskilling for all team members.

Service providers value learning opportunities for professional development and participants commented on the learning opportunities that the remote radiology model presented for them. Some gained procedural skills while others valued the contact with radiologists who were highly experienced in breast work. Given the reliance on health professionals other than the radiologist to perform certain procedural work, giving priority to ensure health professionals receive relevant opportunities to obtain and maintain skills will nurture a skilled workforce.

Learning opportunities were not available to all service providers within the natural flow of the remote radiology model, and were reported by some to be limited in comparison to the onsite model. Opportunity for professional development is an important aspect of job satisfaction and performance. Learning needs and opportunities for health professionals should be identified and incorporated within, or adapted to, existing processes where possible. For instance, setting aside time following a remote radiology assessment clinic, possibly during regular case review meetings, for discussion of cases and queries between onsite and remote health professionals, could aid in ensuring learning opportunities are available for all health professionals.

1.5 Ensure that training is provided for new team members, and for succession planning.

The remote radiology model requires team members to be well aware of the clinic processes for the day, and their role in these processes and within the team. New team members will likely be unfamiliar with all the processes of the remote radiology model, and may experience uncertainty and stress as a result. Training for new team members should be well supported by other team members who are experienced in their role and in delivering services under the remote radiology model. New team members should be involved in face-to-face meetings with remote staff, and be appropriately supported until they, and the team, have built up the appropriate levels of trust and teamwork. Training of potential new team members should be considered for succession planning, so that they may gain experience in the remote radiology model and ensure the continuation of high quality and safe care.

Importantly, succession planning may also include training less experienced team members in procedural work and preparing radiologists for remote service provision, as appropriate within jurisdictions. Identifying needs in terms of succession planning should ideally include input from service providers at services when implementing the remote radiology model, together with remote radiologists and SCUs.

1.6 Monitor appropriate competencies and credentialing for all health professionals, with regular review.

The clinical skills of all health professionals involved in provision of the remote radiology model are of utmost importance in assuring the safety and quality of the model. This is particularly true for sonographers, radiographers, medical officers and breast physicians due to the likely requirements for additional procedural work in the remote radiology model. As indicated in recommendation 1.4, health professionals should be supported in obtaining and maintaining the appropriate

competencies and credentialing needed for them to safely and confidently apply the necessary skills. Competencies and skills required in the remote radiology model could be detailed in guidelines and these requirements should be reviewed regularly.

2. Technology

2.1 Strengthen best-practice guidelines for quality assurance of the technology associated with synchronous telesonography used in remote radiology assessment.

The RANZCR have guidelines for teleradiology, however guidelines and technical specifications for the use of synchronous telesonography for diagnostic assessment for breast cancer are not currently available. Development of guidelines to aid in quality assurance of the remote radiology assessment model at implementation, and at regular intervals, will facilitate timely and efficient implementation of the model. Such guidelines will also provide advice on optimal standards that are considered safe. Given the innovative use of synchronous telesonography for breast cancer assessment, a collaborative approach to development of guidelines is recommended. There is already considerable expertise in each jurisdiction through the implementation of the remote radiology assessment model trial. Drawing on the expertise of these key stakeholders as well as others using telesonography in diagnostic health applications would be beneficial. Networks may be identified through the RANZCR, from Hospital and Health Service Districts and international forums in the fields of telehealth and medical physics.

2.2 Provide and maintain fit-for-purpose equipment at both sending and receiving sites.

Further investigation of minimum technical specifications and compatibility issues for equipment used in the remote radiology assessment model may enhance interoperability of system components into the future. Equipment and available resources vary amongst jurisdictions, and regular testing of fidelity and quality of image transmission is important. A collaborative approach in sharing equipment and technical specifications currently in use, will aid in guiding implementation at other assessment services and jurisdictions.

Provision of fit-for-purpose equipment to facilitate effective communication between onsite and remote providers should be prioritised, given the importance of ensuring precise exchanges of information required for assessment clinics. Likewise, provision of assessment stations and software that supports the most efficient means of communicating through the PACS is ideal and may improve the efficiency of remote radiology clinics.

2.3 Ensure that onsite and remote providers have access to immediate technical support.

Given the reliance of the remote radiology assessment model on technology, onsite and remote providers should have access to immediate technical support. This is particularly pertinent during the early implementation phase, when technical problems are more likely. Advising telehealth providers, in the relevant jurisdiction, of remote assessment clinic dates may ensure that support is quickly available to service staff if needed. Furthermore, consideration should be given to contractual arrangements or agreements with telehealth providers to ensure that constant support is available for service staff and remote providers. Contact details for telehealth providers should be

easily accessible by service staff and remote providers together with procedural guidelines in the event of major technological issues impacting the conduct of a planned clinic. Troubleshooting guides, set out in a brief step-by-step format, should be accessible by onsite and remote providers, and ideally displayed near the relevant equipment.

2.4 Provide training for onsite and remote providers regarding operation of equipment and other technological aspects required for the remote radiology model.

Implementation of the remote radiology model should include training for onsite and remote providers in the use of equipment and telehealth for delivering the service, as relevant to their specific roles in the model. Training for new team members should also occur, as appropriate (see also recommendation 1.5). Guidelines for use, including troubleshooting, should be provided during training and also displayed near the relevant equipment (see also recommendation 2.3).

3. Governance, monitoring, systems and processes

3.1 Governance and monitoring

3.1.1 The BSA NQMC has a role in developing and continuously reviewing best-practice guidelines to support the safe and high quality provision of remote radiology assessment services in appropriate circumstances. High level oversight of safety and quality outcomes is an important part of their role.

The BSA NQMC has an essential role in ensuring that the remote radiology assessment model is provided by highly skilled service staff and remote radiologists, and only in the case of identified shortfall of appropriate local radiological workforce. Service provider interviews highlighted that the remote radiology assessment model is not intended to replace the radiologist onsite model, or facilitate any potential flow-on effects such as deskilling of available local health professionals. Rather, implementation and use of the remote radiology model is to ensure a continuous and accessible assessment service for regional, rural and remote women when local radiology options are not available.

National best-practice guidelines, should be reviewed in consultation with relevant stakeholders, with consideration for the RANZCR Teleradiology Standards (118), as well as the findings and recommendations made in this evaluation report. National-level guidelines for remote radiology assessment should be broad to cover best-practice and account for potential jurisdictional differences, but provide strong guidance for SCUs wherever appropriate.

3.1.2 SCUs have a continuing role in monitoring clinical outcomes, quality and safety of remote radiology assessment models within their jurisdictions.

SCUs have an essential role in ensuring that the remote radiology assessment model is implemented according to quality and safety standards. Jurisdictional processes should be grounded in BSA NQMC national guidelines (see also recommendation 3.1.1). Ideally, these processes should be open for feedback and regular review from assessment services both using the model, and those services considering implementation of the model. Open consultation and review will ensure that program support and processes remain responsive to contextual factors, and continue to promote the sustainable and safe provision of the model.

Guidelines around service processes should allow some flexibility. Participants in this evaluation indicated that flexibility and ability to adapt over time was necessary to account for local contextual differences. It is important to note that local contextual differences also occur with onsite models, for example, some assessment services use locum sonographers or breast physicians. Understanding how new roles fit within the interdisciplinary health care team may require further work in the future.

Roles of service staff should be clearly defined at the jurisdictional level in consultation with onsite and remote providers. This will address issues associated with cross-jurisdictional differences in role names and descriptions.

Given the relatively recent implementation of the remote radiology model, SCUs should continue to monitor the clinical outcomes for clients assessed using the remote radiology model. After a longer implementation period and as experience working in the model develops further research should be undertaken to explore any potential changes in rates of imaging and biopsy rates under the remote model.

3.1.3 Continued monitoring of outcomes in terms of quality, safety and timeliness of assessment services is important when considering requests to further implement the remote radiology assessment model.

Ensuring that women who participate in the BreastScreen Australia program are able to access timely assessment services is an important aspect of the BSA NAS. Where there is identified need due to inadequate access to local radiological workforce and poor timeliness outcomes for clients, this evaluation has shown that the remote radiology model is a safe and quality service model. In the case that the remote radiology model is available for other assessment services to consider for service provision in the future, availability of workforce resources requires early planning. Attracting and training remote radiologists to participate in the model will likely require significant periods of time and effort (to build skills and team cohesion), and succession planning may help ensure that the model can continue to be provided safely. Working with local service providers including the designated radiologist, medical officer, radiographer, sonographer, managers and data managers is important to define roles locally, discuss processes and ensure good communication between team members.

3.1.4 Work to refine client information and data monitoring systems so that they use consistent data fields across jurisdictions that in turn align with the BSA Data Dictionary.

This evaluation drew on extensive client information accessible from jurisdictional datasets. Considerable effort was required to harmonise and merge variables for analysis. We recommend that SCUs and services continue to work towards consistent use of variables as described in the BSA Data Dictionary. Consistent use of variables will facilitate appropriate sharing of clinical information between sites as needed, and information-sharing for the purposes of quality and safety management and monitoring.

3.1.5 Assessment services have a responsibility to undertake continuous self-monitoring on remote radiology assessment clinics and review processes as appropriate.

Onsite and remote providers' monitoring and review of the conduct of remote radiology assessment clinics is especially important during the early phases of implementation. Discussion of what worked well and potential improvements should occur, and changes incorporated as appropriate. Review of service processes for the model should occur at regular intervals (every one to two years) even after the model has become established to ensure that the model continues to operate as safely and efficiently as possible. The usual processes and delegations for maintaining high quality service provision that apply for radiologist onsite assessment, including involvement of the services' designated radiologist, continue to apply.

3.1.6 Jurisdictions consider mechanisms to accurately gather cost data for assessment visits performed under remote radiology and radiologist onsite models.

Affordability and sustainability of the remote radiology assessment model may be an increasingly important consideration in the future if the model continues to be rolled out at other assessment services. With this in mind, mechanisms to accurately gather cost data on aspects of assessment including, but not limited to, imaging, biopsies, ultrasounds, clip markers, consumables, pathology and tomosynthesis and to include equipment maintenance costs in the model would enable more comprehensive assessment of the cost of assessment clinics. The ability to differentiate between onsite assessment clinics with a locum or locally based radiologist would also facilitate accurate identification of cost differences between models and their implications.

3.2 Systems and processes for planning and implementation

3.2.1 Consider designation of a project officer to coordinate change management processes in preparation for the remote radiology assessment model.

Change process management should be actively considered when planning implementation of the remote radiology assessment model. A project officer assigned specifically to facilitate implementation of the model at an assessment service may assist by coordinating the process and providing advice, training in relevant technology and serve as a point of contact for troubleshooting. Having the assessment service team on board involved in the planning stages should promote acceptance of changes and new processes, thereby aiding in a smooth transition. This could be accomplished by informing the team about the motivation for implementing the model, and sharing experiences of other assessment services and the lessons learned from them. Additionally, an inclusive approach that involves the service team and potential remote providers in discussions about how the model should work locally, offers the advantage of drawing on local team experience to identify possible problems and solutions, while also promoting teamwork.

3.2.2 Jurisdictions and services planning to implement the remote radiology assessment model should consult widely with telehealth and biomedical professionals, medical physicists and access advice and support from existing users of the model.

Medical physicists, biomedical experts and telehealth professionals are essential partners to consult when planning to implement the remote radiology assessment model. These professionals can:

ensure that access to secure internet networks occurs, appropriate bandwidth is available for transmission of quality images, equipment is appropriate and compatible for the intended application, and that the system is optimised for reliable transmission of quality imaging.

Jurisdictions and health services currently delivering the remote radiology assessment model can provide valuable advice and insight regarding their experiences of implementing the model. SCU staff, service staff and radiologists can all share valuable contextual experiences to inform early discussions, and should ideally be involved in early and continuing discussions to inform the development of models at other services.

3.2.3 Client information systems that facilitate effective and efficient sharing of client information between local and remote service providers should ideally be available.

Electronic systems already facilitate the sharing of images and data. System improvements to enable sharing of information and data currently recorded on paper would assist in sharing of all clinical details in a timely manner and promote accuracy. Sharing client information is currently hampered by cross-jurisdictional differences in client information systems which results in paperwork and process duplications. Use of a system that allows all team members to access current information and assessments would be ideal.

3.2.4 Duties specific for the efficient operation of remote radiology assessment clinics for onsite and remote staff should be clear.

Some extra duties, or changes in how duties were carried out, were identified for some roles within the remote radiology model. Duties identified that facilitate efficient operation of the remote radiology model include:

- Planning dates for remote assessment clinics by service staff and SCUs: ensuring availability of appropriately skilled onsite and remote staff (clinical and technical)
- Booking and consenting clients: ensuring experienced service staff have confirmed clients are appropriate for inclusion in the remote radiology assessment clinic considering expected procedures required, and that the clients are aware of the remote model of service delivery in the clinic they will be attending
- Preparing for clinics: including a team member designated to coordinate with the remote service providers and also test equipment

3.2.5 Processes used for remote radiology assessment clinics should facilitate optimal service provision for the local context.

Governance guidelines are important in ensuring that assessment services undertaking the remote radiology assessment model for service delivery continue to deliver safe and quality services. Likewise, there may be guidance from established remote radiology assessment clinics that would prove helpful for service implementation. However, there may be local conditions or context that need to be considered for optimal delivery of the model at a new service. Any significant factors that would facilitate better provision of the remote radiology assessment model should be shared with SCUs and be progressed to the BSA NQMC as appropriate. Service processes should suit local workflows and be agreeable to both onsite and remote providers.

Summary

In summary, JCU has undertaken an independent evaluation of the remote radiology assessment service model operating in BreastScreen Australia clinics. Data was collected to evaluate the efficacy, safety, quality and acceptability of the remote radiology assessment model. There were no statistically significant differences in the age-standardised likelihood of cancer detection between assessment visits conducted under the remote radiology assessment model and the onsite assessment model. Significant improvement in the timeliness of assessment visits and assessment recommendations and no increase in equivocal assessment outcomes were found. A slight increase in the number of mammograms performed under the remote radiology assessment model should be monitored over time.

It was found that the model has many benefits for both service providers and patients and enabled services to meet accreditation standards for timeliness of assessment. Further research is required to develop guidelines and technical specifications for the use of synchronous telesonography. Future monitoring of clinical outcomes data over time is also recommended to explore trends in the numbers of images and biopsies undertaken within the remote assessment model.

Recommendations are made for ongoing use and future implementation of the remote radiology model in BreastScreen Australia clinics. These recommendations are drawn from analysis of data for this evaluation and may be helpful in ensuring continuing high standards of care provided via the remote radiology assessment model.

References

- 1. Australian Institute of Health and Welfare. (2019). Cancer in Australia 2019. Cancer series no. 119. Cat. No. CAN 123. Canberra: AIHW.
- 2. Australian Institute of Health and Welfare. (2018). BreastScreen Australia monitoring report 2018. Cancer series no. 112. Cat. no. CAN 116. Canberra: AIHW.
- 3. Australian Institute of Health and Welfare. (2013). Medical Workforce 2011. National health workforce series no. 3. Cat. no. HWL 49. Canberra: AIHW.
- 4. Larkins, S. & Evans, R. (2014). Greater support for generalism in rural and regional Australia. Australian Family Physician, 43(7): 487-490.
- 5. Leung J, McKenzie S, Martin J, McLaughlin D. Effect of rurality on screening for breast cancer: a systematic review and meta-analysis comparing mammography. Rural and Remote Health (online) 2014; 14: 2730. http://www.rrh.org.au/articles/subviewnew.asp?ArticleID=2730
- 6. Mitchell KJ, Fritschi L, Reid A, McEvoy SP, Ingram DM, Jamrozik K et al. Rural–urban differences in the presentation, management and survival of breast cancer in Western Australia. Breast 2006; 15(6): 769-776.
- 7. Bettencourt BA, Schlegel RJ, Talley AE, Molix LA. The breast cancer experience of rural women: a literature review. Psycho-Oncology 2007; 16(10): 875-887.
- 8. Australian Institution of Health and Welfare. (2008) Rural, regional and remote health Indicators of health system performance, AIHW: Canberra
- Department of Health and Ageing. Rural and Regional Health Australia: National strategic framework for rural and remote health. (Internet) 2015. Available: http://www.ruralhealthaustralia.gov.au/internet/rha/publishing.nsf/Content/NSFRRHhomepage (Accessed 16 2016).
- Bradford NK, Caffery LJ, Smith AC. Telehealth services in rural and remote Australia: a systematic review of models of care and factors influencing success and sustainability. Rural and Remote Health (online) 2016. 16:3818 http://www.rrh.org.au/articles/showarticlenew.asp?ArticleID=3808
- Jhaveri D, Larkins S, Kelly J and Sabesan S (2016) Remote chemotherapy supervision model for rural cancer care: perspectives of health professionals. European Journal of Cancer Care, 25 (1). pp. 1-6
- 12. Chan B, Larkins S, Evans R, Watt K and Sabesan S (2015) Do teleoncology models of care enable safe delivery of chemotherapy in rural towns? Medical Journal of Australia, 203 (10). pp. 1-6
- Sabesan S (2015) Specialist cancer care through telehealth models. Australian Journal of Rural Health, 23. pp. 19-23
- 14. Australian Safety and Quality Framework for Health Care. 2010. Australian Commission on Safety and Quality in Health Care. <u>https://www.safetyandquality.gov.au/wp-</u>content/uploads/2012/01/32296-Australian-SandQ-Framework1.pdf
- 15. BreastScreen Queensland. BreastScreen Queensland: quality standards, protocols and procedures manual. Brisbane: Queensland Government; n.d.
- 16. Cancer Screening Unit BreastScreen Queensland. Remote assessment operating procedures manual. Brisbane: Queensland Health; 2017.
- 17. Australian College of Rural and Remote Medicine. College submission: RANZCR draft Teleradiology Standards. Brisbane: ACRRM; 2017.
- 18. US Food and Drug Administration. Mobile Medical Applications: Guidance for Industry and Food and Drug Administration Staff. Siver Spring. MD: Food and Drug Administration; 2015.
- 19. Bashshur R, Shannon G, Krupinski E, Grigsby J. The Taxonomy of Telemedicine. Telemedicine and e-Health. 2011;17(6):484-94.

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- 20. Bashshur RL, Krupinski EA, Thrall JH, Bashshur N. The Empirical Foundations of Teleradiology and Related Applications: A Review of the Evidence. Telemedicine and e-Health. 2016;22(11):868-98.
- 21. Raza T, Joshi M, Schapira RM, Agha Z. Pulmonary telemedicine--a model to access the subspecialist services in underserved rural areas. Int J Med Inf. 2009;78(1):53-9.
- 22. Brown J, Holland B. Successful Fetal Tele-Echo at a Small Regional Hospital. Telemedicine and e-Health. 2017;23(6):485-92.
- 23. Crowe B, Maraj A, Thatcher M, Parrish S, Rogers K. Development of a combined telemedicine and Picture Archiving and Communications System for a tertiary hospital group. Journal of Telemedicine and Telecare. 2007;13(SUPPL. 3):35-6.
- 24. Huang T, Moon-Grady AJ, Traugott C, Marcin J. The availability of telecardiology consultations and transfer patterns from a remote neonatal intensive care unit. Journal of Telemedicine and Telecare. 2008;14(5):244-8.
- 25. Kreutzer J, Akutsu H, Fahlbusch R, Buchfelder M, Nimsky C. Teleradiology in neurosurgery: experience in 1024 cases. J Telemed Telecare. 2008;14(2):67-70.
- 26. Mrak G, Paladino J, Dzubur A, Desnica A. Telemedicine in neurosurgery: teleradiology connections in the Republic of Croatia. J Telemed Telecare. 2009;15(3):142-4.
- Audebert HJ, Schwamm L. Telestroke: Scientific results. Cerebrovasc Dis. 2009;27(SUPPL. 4):15-20.
- 28. Demaerschalk BM, Bobrow BJ, Raman R, Ernstrom K, Hoxworth JM, Patel AC, et al. CT interpretation in a telestroke network: agreement among a spoke radiologist, hub vascular neurologist, and hub neuroradiologist. Stroke. 2012;43(11):3095-7.
- 29. Nagao KJ, Koschel A, Haines HM, Bolitho LE, Yan B. Rural Victorian Telestroke project. Internal Medicine Journal. 2012;42(10):1088-95.
- 30. Fong WC, Ismail M, Lo JW, Li JT, Wong AH, Ng YW, et al. Telephone and Teleradiology-Guided Thrombolysis Can Achieve Similar Outcome as Thrombolysis by Neurologist Onsite. J Stroke Cerebrovasc Dis. 2015;24(6):1223-8.
- 31. Sørensen T, Dyb K, Rygh E, Salvesen R, Thomassen L. A qualitative description of telemedicine for acute stroke care in Norway: Technology is not the issue. BMC Health Serv Res. 2014;14(1).
- 32. Dharmasaroja PA, Muengtaweepongsa S, Kommarkg U. Implementation of telemedicine and stroke network in thrombolytic administration: Comparison between walk-in and referred patients. Neurocritical Care. 2010;13(1):62-6.
- 33. Spokoyny I, Raman R, Ernstrom K, Demaerschalk BM, Lyden PD, Hemmen TM, et al. Pooled assessment of computed tomography interpretation by vascular neurologists in the STRokE DOC telestroke network. J Stroke Cerebrovasc Dis. 2014;23(3):511-5.
- 34. Martinon A, Le Pogam MA, Boublay N, Ganne C, Ben Cheikh A, Buron C, et al. Teleradiology saves times in cases of vital emergencies: A comparative study with on-call radiology in two urban medium-sized French hospitals. European Research in Telemedicine. 2014;3(4):151-60.
- Matsumoto M, Koike S, Kashima S, Awai K. Geographic Distribution of Radiologists and Utilization of Teleradiology in Japan: A Longitudinal Analysis Based on National Census Data. PLoS ONE. 2015;10(9):e0139723.
- 36. Lundberg N, Wintell M, Lindsköld L. The future progress of teleradiology-An empirical study in Sweden. Eur J Radiol. 2010;73(1):10-9.
- 37. Hasegawa T, Murase S. Distribution of telemedicine in Japan. Telemed J E Health. 2007;13(6):695-702.
- 38. Sass M, Feko A. The emergence of telemedicine and e-health in Hungary. Telemedicine and e-Health. 2011;17(5):388-95.

- 39. McCrossan BA, Sands AJ, Kileen T, Cardwell CR, Casey FA. Fetal diagnosis of congenital heart disease by telemedicine. Arch Dis Child Fetal Neonatal Ed. 2011;96(6):F394-7.
- Friedman AC, Downing D, Chino J, Krupinski E, Kilian C, Lance P. Feasibility of remote CT colonography at two rural Native American medical centers. AJR Am J Roentgenol. 2010;195(5):1110-7.
- 41. de Paredes ES, Lopez FW, Strickland Jr WJ, Grizzard Jr WS, Zedler PA, Roberts KM, et al. Telemammography: Interfacing between primary physicians and experts. Applied Radiology. 2007;36(9):26-30.
- 42. Duchesne JC, Kyle A, Simmons J, Islam S, Schmieg JRE, Olivier J, et al. Impact of Telemedicine Upon Rural Trauma Care. The Journal of Trauma: Injury, Infection, and Critical Care. 2008;64(1):92-8.
- 43. Ashkenazi I, Zeina AR, Kessel B, Peleg K, Givon A, Khashan T, et al. Effect of teleradiology upon pattern of transfer of head injured patients from a rural general hospital to a neurosurgical referral centre: follow-up study. Emerg Med J. 2015;32(12):946-50.
- 44. Dario C, Scannapieco G, Scienza R, Carraro MG, Saccavini C, Vio E, et al. The Neurosurgical Telecounseling Network in the Veneto Region: 4 Years of Experience of HEALTH OPTIMUM. Telemedicine and e-Health. 2014;20(11):19-1014.
- 45. Jacobs JJ, Jacobs JP, van Sonderen E, van der Molen T, Sanderman R. Fracture diagnostics, unnecessary travel and treatment: a comparative study before and after the introduction of teleradiology in a remote general practice. BMC Fam Pract. 2015;16:53.
- 46. McGill A, North J. An analysis of an ongoing trial of rural videoconference fracture clinics. J Telemed Telecare. 2012;18(8):470-2.
- 47. McGill AF, North JB. Teleconference fracture clinics: a trial for rural hospitals. ANZ journal of surgery. 2012;82(1-2):2-3.
- 48. Kennedy S, Bhargavan M, Sunshine JH, Forman HP. The effect of teleradiology on time to interpretation for CT pulmonary angiographic studies. J. 2009;6(3):180-9.e1.
- 49. Weber JE, Ebinger M, Rozanski M, Waldschmidt C, Wendt M, Winter B, et al. Prehospital thrombolysis in acute stroke: results of the PHANTOM-S pilot study. Neurology. 2013;80(2):163-8.
- 50. Huffman RI, Lewis RS, Forman HP, Sunshine JH. The performance of outside readings by radiology practices. AJR Am J Roentgenol. 2010;195(5):1159-63.
- 51. Hohmann J, de Villiers P, Urigo C, Sarpi D, Newerla C, Brookes J. Quality assessment of out sourced after-hours computed tomography teleradiology reports in a Central London University Hospital. Eur J Radiol. 2012;81(8):e875-9.
- 52. Sutherland JE, Sutphin HD, Rawlins F, Redican K, Burton J. A comparison of telesonography with standard ultrasound care in a rural Dominican clinic. Journal of Telemedicine and Telecare. 2009;15(4):191-5.
- 53. Oliveira TC, Bayer S, Gonçalves L, Barlow J. Telemedicine in Alentejo. Telemedicine and e-Health. 2014;20(1):90-3.
- 54. Sharma S, Bohn D, Mikroyiannakis I, Trowbridge J, Thompson D, Bell R, et al. Development of a multi stakeholder partnership to improve access to and delivery of neurosurgical services in Ontario. Health Policy. 2017;121(2):207-14.
- 55. Latifi R, Gunn JKL, Bakiu E, Boci A, Dasho E, Olldashi F, et al. Access to Specialized Care Through Telemedicine in Limited-Resource Country: Initial 1,065 Teleconsultations in Albania. Telemedicine and e-Health. 2016;22(12):1024-31.
- 56. Mair F, McClusky C, Wilsgaard T, Wootton R. The added value of video for consultations in telemedicine for minor injuries work. J Telemed Telecare. 2011;17(8):427-31.

- 57. Moya M, Valdez J, Yonas H, Alverson DC. The impact of a telehealth web-based solution on neurosurgery triage and consultation. Telemedicine journal and e-health : the official journal of the American Telemedicine Association. 2010;16(9):945-9.
- 58. Whiteman C, Kiefer C, D'Angelo J, Davidov D, Larrabee H, Davis S. The use of technology to reduce radiation exposure in trauma patients transferred to a level I trauma center. W V Med J. 2014;110(3):14-8.
- 59. Crocker M, Cato-Addison WB, Pushpananthan S, Jones TL, Anderson J, Bell BA. Patient safety and image transfer between referring hospitals and neuroscience centres: could we do better? Br J Neurosurg. 2010;24(4):391-5.
- 60. Schwamm LH, Holloway RG, Amarenco P, Audebert HJ, Bakas T, Chumbler NR, et al. A review of the evidence for the use of telemedicine within stroke systems of care: A scientific statement from the American heart association/American stroke association. Stroke. 2009;40(7):2616-34.
- 61. Garg R, Sevilla A, Garberich R, Fleishman CE. Remote delivery of congenital cardiac magnetic resonance imaging services: a unique telemedicine model. Pediatr Cardiol. 2015;36(1):226-32.
- 62. Zennaro F, Neri E, Nappi F, Grosso D, Triunfo R, Cabras F, et al. Real-Time Tele-Mentored Low Cost "Point-of-Care US" in the Hands of Paediatricians in the Emergency Department: Diagnostic Accuracy Compared to Expert Radiologists. PLoS ONE. 2016;11(10):e0164539.
- 63. Adams SJ, Burbridge BE, Badea A, Langford L, Vergara V, Bryce R, et al. Initial Experience Using a Telerobotic Ultrasound System for Adult Abdominal Sonography. Can Assoc Radiol J. 2016.
- 64. Adambounou K, Farin F, Boucher A, Adjenou KV, Gbeassor M, N'Dakena K, et al. Preliminary experience with tele-sonography and tele-mammography in Togo. Diagn Interv Imaging. 2012;93(7-8):639-42.
- 65. Dyer D, Cusden J, Turner C, Boyd J, Hall R, Lautner D, et al. The clinical and technical evaluation of a remote telementored telesonography system during the acute resuscitation and transfer of the injured patient. Journal of Trauma Injury, Infection and Critical Care. 2008;65(6):1209- 16.
- 66. Popov V, Popov D, Kacar I, Harris RD. The feasibility of real-time transmission of sonographic images from a remote location over low-bandwidth Internet links: a pilot study. AJR Am J Roentgenol. 2007;188(3):W219-22.
- 67. Martinov D, Popov V, Ignjatov Z, Harris RD. Image quality in real-time teleultrasound of infant hip exam over low-bandwidth internet links: a transatlantic feasibility study. J Digit Imaging. 2013;26(2):209-16.
- 68. Fatehi M, Safdari R, Ghazisaeidi M, Jebraeily M, Habibi-koolaee M. Data standards in teleradiology. Acta Informatica Medica. 2015;23(3):165-8.
- 69. DICOM Standards Committee.
- 70. The Royal College of Radiologists. Standards for the provision of teleradiology within the United Kingdom.
- 71. Sanita ISd. Guidelines for quality assurance and technical requirements in teleradiology. English translation and revision of Rapporti ISTISAN 10/44. Roma: Istituto Superiore di Sanita; 2013.
- 72. European Society of Radiology. ESR white paper on teleradiology: An update from the teleradiology subgroup. Insights into Imaging. 2014;5(1):1-8.
- Silva E, 3rd, Breslau J, Barr RM, Liebscher LA, Bohl M, Hoffman T, et al. ACR white paper on teleradiology practice: a report from the Task Force on Teleradiology Practice. J. 2013;10(8):575-85.
- Zhai Y-k, Zhu W-j, Hou H-l, Sun D-x, Zhao J. Efficacy of telemedicine for thrombolytic therapy in acute ischemic stroke: a meta-analysis. Journal of Telemedicine and Telecare. 2015;21(3):123-30.
- 75. Acosta L, Ruibal Faral K. Diagnostic Imaging Integrated Network: A Teleradiology Pilot in Public Hospitals in Uruguay. Stud Health Technol Inform. 2015;216:923.
- Shiferaw F, Zolfo M. The role of information communication technology (ICT) towards universal health coverage: the first steps of a telemedicine project in Ethiopia. Glob Health Action. 2012;5:1-8.
- 277. Lewis RS, Sunshine JH, Bhargavan M. Radiology practices' use of external off-hours teleradiology services in 2007 and changes since 2003. AJR Am J Roentgenol. 2009;193(5):1333-9.
- 78. Lefere P, Silva C, Gryspeerdt S, Rodrigues A, Vasconcelos R, Teixeira R, et al. Teleradiology based CT colonography to screen a population group of a remote island; at average risk for colorectal cancer. Eur J Radiol. 2013;82(6):e262-7.
- 79. Watson JJ, Moren A, Diggs B, Houser B, Eastes L, Brand D, et al. A statewide teleradiology system reduces radiation exposure and charges in transferred trauma patients. Am J Surg. 2016;211(5):908-12.
- 80. Fridell K, Aspelin P, Felländer-Tsai L, Lundberg N. The effect of PACS on the practice of orthopaedic surgeons. Journal of Telemedicine and Telecare. 2011;17(3):137-41.
- 81. Agrawal A, Agrawal A, Pandit M, Kalyanpur A. Systematic survey of discrepancy rates in an international teleradiology service. Emerg. 2011;18(1):23-9.
- 82. Platts-Mills TF, Hendey GW, Ferguson B. Teleradiology interpretations of emergency department computed tomography scans. J Emerg Med. 2010;38(2):188-95.
- 83. Otto C, Shemenski R, Scott JM, Hartshorn J, Bishop S, Viegas S. Evaluation of tele-ultrasound as a tool in remote diagnosis and clinical management at the Amundsen-Scott South Pole Station and the McMurdo Research Station. Telemed J E Health. 2013;19(3):186-91.
- 84. Salazar AJ, Aguirre DA, Ocampo J, Camacho JC, Díaz XA. DICOM gray-scale standard display function: Clinical diagnostic accuracy of chest radiography in medical-grade gray-scale and consumer-grade color displays. American Journal of Roentgenology. 2014;202(6):1272-80.
- Salazar AJ, Aguirre DA, Ocampo J, Diaz XA, Camacho JC. Diagnostic Accuracy of Digitized Chest X-Rays Using Consumer-Grade Color Displays for Low-Cost Teleradiology Services: A Multireader–Multicase Comparison. Telemedicine and e-Health. 2014;20(4):34-311.
- 86. Eklf H, Radecka E, Liss P. Teleradiology uppsala-sydney for nighttime emergencies: Preliminary experience. Acta Radiol. 2007;48(8):851-3.
- 87. Segura J, Roldán C, Galera J, Naval J. What do Spanish physicians believe and expect about telemedicine? Results of a Delphi-based survey. Telemedicine and e-Health. 2008;14(1):42-8.
- 88. Coppola F, Bibbolino C, Grassi R, Pierotti L, Silverio R, Lassandro F, et al. Results of an Italian survey on teleradiology. Radiol Med (Torino). 2016;121(8):652-9.
- Ranschaert ER, Boland GW, Duerinckx AJ, Barneveld Binkhuysen FH. Comparison of European (ESR) and American (ACR) white papers on teleradiology: Patient primacy is paramount. J. 2015;12(2):174-82.
- 90. European Society of Radiology. ESR teleradiology survey: results. Insights into Imaging. 2016;7(4):463-79.
- 91. Ranschaert ER, Binkhuysen FHB. European Teleradiology now and in the future: Results of an online survey. Insights into Imaging. 2013;4(1):93-102.
- 92. Petik B, Sirik M, Çolak D, Duman T. The use of teleradiology in Turkey: Current situation and attitudes of radiologists. Turkiye Klinikleri Journal of Medical Sciences. 2015;35(4):225-32.
- 93. Al-Kadi A, Dyer D, Ball CG, McBeth PB, Hall R, Lan S, et al. User's perceptions of remote trauma telesonography. J Telemed Telecare. 2009;15(5):251-4.
- 94. Mozhgan K, Sadat GSPS, Malekeh M, Kahouei M. The survey of residents and radiologists' attitudes about access to patient information in Teleradiology in Iran. Journal of Engineering and Applied Sciences. 2012;7(2):155-8.

- 95. Kim JE, Song YM, Park JH, Lee JR. Attitude of korean primary care family physicians towards telehealth. Korean Journal of Family Medicine. 2011;32(6):341-51.
- 96. Lester N, Durazzo T, Kaye A, Ahl M, Forman HP. Referring physicians' attitudes toward international interpretation of teleradiology images. AJR Am J Roentgenol. 2007;188(1):W1-8.
- 97. Jacobs JJ, Ekkelboom R, Jacobs JP, van der Molen T, Sanderman R. Patient satisfaction with a teleradiology service in general practice. BMC Fam Pract. 2016;17:17.
- 98. Rosenberg C, Kroos K, Rosenberg B, Hosten N, Flessa S. Teleradiology from the provider's perspective-cost analysis for a mid-size university hospital. Eur Radiol. 2013;23(8):2197-205.
- Stroetmann KA, Jones T, Dobrev A, Stroetmann VN. An evaluation of the economic impact of ten European e-health applications. Journal of Telemedicine and Telecare. 2007;13(SUPPL. 1):62-4.
- 100. Whitacre BE. Estimating the economic impact of telemedicine in a rural community. Agricultural and Resource Economics Review. 2011;40(2):172-83.
- 101. Whitacre BE, Hartman PS, Boggs SA, Schott V. A community perspective on quantifying the economic impact of teleradiology and telepsychiatry. Journal of Rural Health. 2009;25(2):194-7.
- 102. Dattakumar A, Gray K, Jury S, Biggs B-A, Maeder A, Noble D, et al. A unified approach for the evaluation of telehealth implementations in Australia. University of Melbourne, Institute for a Broadband-Enabled Society; 2013.
- 103. Sangare M, Tanner L, Voss S, Laureys F, Hollow D, Toure M. A national teleradiology programme in Mali: implementation and results. J Telemed Telecare. 2015;21(3):131-8.
- 104. Legido-Quigley H, Doering N, McKee M. Challenges facing teleradiology services across borders in the European union: A qualitative study. Health Policy and Technology. 2014;3(3):160-6.
- 105. Gabriel MH, Jones EB, Samy L, King J. Progress and challenges: implementation and use of health information technology among critical-access hospitals. Health Aff (Millwood). 2014;33(7):1262-70.
- 106. Fruehwald-Pallamar J, Jantsch M, Pinker K, Hofmeister R, Semturs F, Piegler K, et al. Teleradiology with uncompressed digital mammograms: clinical assessment. Eur J Radiol. 2013;82(3):412-6.
- 107. Griggs R, Andronikou S, Nell R, O'Connell N, Dehaye A, Boechat MI. World Federation of Pediatric Imaging (WFPI) volunteer outreach through tele-reading: the pilot project in South Africa. Pediatr Radiol. 2014;44(6):648-54.
- 108. Ferreira AC, O'Mahony E, Oliani AH, Araujo Júnior E, Da Silva Costa F. Teleultrasound: Historical perspective and clinical application. International Journal of Telemedicine and Applications. 2015;2015:1-11.
- 109. Demiris G, Charness N, Krupinski E, Ben-Arieh D, Washington K, Wu J, et al. The role of human factors in telehealth. Telemedicine and e-Health. 2010;16(4):446-53.
- 110. Leader JK, Hakim CM, Ganott MA, Chough DM, Wallace LP, Clearfield RJ, et al. A multisite telemammography system for remote management of screening mammography: An assessment of technical, operational, and clinical issues. J Digit Imaging. 2006;19(3):216-25.
- 111. Weinstein RS, López AM, Barker GP, Krupinski EA, Descour MR, Scott KM, et al. The innovative bundling of teleradiology, telepathology, and teleoncology services. IBM Systems Journal. 2007;46(1):69-84.
- 112. Chang H. Evaluation Framework for Telemedicine Using the Logical Framework Approach and a Fishbone Diagram. Healthcare Informatics Research. 2015;21(4):230-8. Available at https://e-hir.org/journal/view.php?id=10.4258/hir.2015.21.4.230
- 113. NVivo qualitative data analysis software, QSR International Pty Ltd. Version 12, 2018.

- 114. Queensland Government. 2018-2019 Annual Report Townsville Hospital and Health Service. 2019. THHS.
- 115. Queensland Government. 2018-2019 Annual Report Central Queensland Hospital and Health Service. 2019. CQHHS.
- 116. Northern Territory Government. 2017-2018 Annual Report Department of Health. 2018. Northern Territory Government.
- 117. NSW Government website. Southern NSW. Accessed on 10/10/2019 at https://www.health.nsw.gov.au/lhd/Pages/snswlhd.aspx
- 118. Royal Australian and New Zealand College of Radiologists. Teleradiology Standards. 2017. RANZCR.
- Australian Institute of Health and Welfare 2015. BreastScreen Australia data dictionary: version
 Cancer series no. 92. Cat. no. CAN 90. Canberra: AIHW.
- 120. Australian Institute of Health and Welfare 2014. BreastScreen Australia monitoring report 2011–2012. Cancer series no. 86. Cat. no. CAN 83. Canberra: AIHW.
- 121. BreastScreen Australia website. Computed Radiography (CR) mammography compared with screen film mammography and Digital Radiography (DR) mammography. Accessed on 5th November at

http://www.cancerscreening.gov.au/internet/screening/publishing.nsf/Content/cac-drmammography

	Publication	Country setting	Discipline	Type of article	Description of teleradiology	Outcomes measured	Insight into quality, safety, implementation
	Teleradiology for se	ervice provis	ion in less resourd	ed and well res	ourced settings		
1	Acosta and Faral, 2015	Uruguay	Hospital systems	Program description	Region wide implementation of a management system for exchange of imaging studies between centres (pilot)	NA	Resistance to change addressed with provision of information, training opportunities and continued improvement to usability. Outsourcing will require agreements.
2	Adambounou et al., 2012	Togo	Telemammogra phy	Pilot	When internet sufficient, remote radiologist guides sonographer at local site in real-time and makes a diagnosis after imaging complete. When internet insufficient, remote radiologist guides sonographer using images previously sent, communicating throughout-near real-time.	Mean speed of connection Quality of transmissions	Issues with internet speed – back up plan involved viewing of images stored and transferred through Dropbox.
3	Adams, et al., 2016	Canada	Robotic sonography	Prospective study	Robotic arm with ultrasound probe controlled by remote sonographer. Patient assistant at local site. Remotely guided in real-time	Duration of examination Visualisation of images Reporting Patient survey Service provider survey	Equipment compatibility. Differences in visualisation and measurement may be due to user dependency of sonography. Awareness of how to optimise system during operation.
4	Ashkenazi et al., 2015	Israel	Trauma, neurosurgery	Case series	Head imaging transmitted from hospital to Level 1 trauma centre. Trauma surgeon at local site consults with remote neurosurgeon and make treatment decision.	Injury severity score Abbreviated injury scale	Clinical information and CT scan available for decision making. Injury severity score Abbreviated injury scale Safe to admit a patient at Level 2 centre following consult using teleradiology.
5	Audebert and Schwamm, 2009	NA	Telestroke	Review	Review of status of telemedicine in acute management of stroke care	NA	Interpretation of brain imaging by a remote expert is equivalent to on-site evaluation if original data are transmitted and viewed on monitors of sufficient resolution.
6	Bashshur, 2016	NA	Teleradiology and related applications	Review	NA	NA	Teleradiology valid and reliable for detecting a variety of health problems.

Appendix 1. Summary of literature for desktop review

	Publication	Country setting	Discipline	Type of article	Description of teleradiology	Outcomes measured	Insight into quality, safety, implementation
7	Brown and Holland, 2017	United States	Tele- echocardiograph y, antenatal	Retrospective chart review	Sonographers perform scan at local site and transmit to paediatric cardiologist at remote site. Interpreting cardiologist discussed finding on phone with referring provider.	Identify foetuses with congenital heart disease and mild defects	Postnatal scan confirmed high accuracy of model. Asynchronous preferred for better workflow and efficiency.
8	Cenname et al., 2013	Multiple countries	Military, neurosurgery	Case series	Digitised imaging transmitted from military theatre to military hospital by local radiologist and technician.	Diagnostic accuracy	Devices comply with DICOM standard and compatible. Improvement will be direct connection with acquisition system and RIS-PACS at military hospital-patient details shared.
9	Choi, 2013	Korea	Dentistry	Retrospective study	Dentists can submit images, clinical information and enquiries to a website. Professors (radiologists) of oral and maxillofacial radiology respond.	Disease classification Correlations with patient chief complaint Image modality Number of dentists using the service	Differential diagnosis of common disease in demand. Differential diagnosis of common disease in demand. Service not well used.
10	Coulburn et al., 2012	Malawi	Teleradiology	Feasibility study and evaluation	Used photos of Xrays saved as JPEG files to transmit de- identified tricky CXR images to US radiologist - report emailed back and discussed at clinical meeting.	Concordance of diagnoses (70.9%), image quality 86% good (only 4 repeats); 36 patients had a finding that changed management.	Teleradiology can improve tuberculosis diagnosis and case management, especially if criteria to identify the patients most suitable for referral are developed and the radiologist is conversant with local resources and health problems. Designating a clinical focal point for teleradiology ensures sustainability. Staff need time to adapt to a new teleradiology programme.
11	Crowe, et al., 2007	Australia	Hospital systems	Program description	Hospital group planning teleconsultation service to QLD and northern NSW for teleradiology (store and forward) and telecardiology.	NA	Integration of PACS, clinical information systems, patient administration system, clinical portal system.
12	Dario et al, 2014	Italy	Trauma, Neurosurgery	Program description	Local physician transmits request for consultation with imaging to remote neurosurgeon. Interaction	Clinical satisfaction Volume of activity Time to outcome	Digital signature ensure security over encoded channels. Integration of systems using international standards.

	Publication	Country setting	Discipline	Type of article	Description of teleradiology	Outcomes measured	Insight into quality, safety, implementation
					with neuroradiology at remote site.		Key objective included common standards in technological infrastructure and clinical processes. Consulting form facilitated shared diagnosis Training important for usability.
13	De Paredes et al., 2007	Unites States	Telemammogra phy	Program description	Images acquired on digital units, checked for quality by technologist and transmitted via encrypted data circuits to archive for breast imagers. Breast imagers work with soft copies on workstations. Recall for diagnostic mammograms occasionally directed by radiologist remotely for remote facilities.	NA	Remote interpretation require secure, redundant, efficient and resilient network. Worked out minimum bandwidth requirements - no compression required. Archive backed up on separate offsite archive. Physicians can access RIS. Computerised reporting. Systems integrated.
14	Demaerschalk et al., 2012	United States	Telestroke	RCT	Telestroke	CT based contraindication to thrombolytic treatment Localisation of lesion, presence of prior stroke, oedema, haemorrhage, neoplasm, hyperdense artery sign	Agreement excellent and no significant differences between the different teleprofessionals and the traditional model.
15	Dharmasroja et al., 2010	Thailand	Telestroke	Evaluation	Telephone consultation and teleradiology for patients with acute ischaemic stroke. Stroke fast-track activated if presumptive diagnosis of acute stroke within 3hrs of onset. If no on-call neurologist at bedside, CT scan assessed remotely and patient referred to hub for tPA if no contraindications.	Modified Rankin scale at discharge and 3 months after stroke onset Symptomatic intracerebral haemorrhage after thrombolysis compared with 'walk-in' patients	tPA administration occurred at hub - so about need for urgent transfer. Stroke education and training for service providers.
16	Duchesne et al., 2008	United States	Trauma	Retrospective review	Remote expertise access by emergency physician through videoconferencing and sharing of radiology images.	LOS Number patients transferred to tertiary centre Transfer time Mortality Cost	Cost-effectiveness for improving access to trauma services

	Publication	Country setting	Discipline	Type of article	Description of teleradiology	Outcomes measured	Insight into quality, safety, implementation
17	Dyer et al., 2008	Canada	Trauma	Pilot	Bidirectional videoconferencing for viewing imaging conducted in real- time and used to consult with remote trauma surgeons	NA	Costly Technical issues with delay in sonographic image transmission and freezing early on.
18	Elkf et al., 2007	Australia and Sweden	Radiology	Pilot	Local site in Sweden transmitted imaging studies to remote radiologist in Australia	Download time Report turnaround time	Time to download studies at remote site was a major challenge.
19	Ferreira et al., 2015	NA	Teleultrasound	Review	NA	NA	Debate about diagnostic accuracy and image quality Asynchronous may result in missing or inaccurate information. Real-time transmission perceived to be high cost Training important.
20	Fong et al., 2015	Hong Kong	Telestroke	Prospective study	Remote (off-site) neurologist interprets imaging remotely. Discuss with internist at local site to determine treatment decision	Functional outcome at 3 months Door to needle time Symptomatic intracranial haemorrhage	Achieved similar safety and efficacy as on-site model as on-site model. Teleradiology with telephone consultation safe.
21	Friedman et al, 2010	United States	Colorectal cancer	Retrospective study	CTC technologist trained by author (a radiologist?) in performing a CTC examination. PHC providers could order CTC for screening or diagnostic purposes. Images transmitted via teleradiology server to remote radiologist.	Image quality	Data transmission not a workflow problem. Self- study training module for new technologist being developed
22	Fruehwald- Pallamar et al, 2013	Austria	Telemammogra phy	Pilot	NA	Image quality Diagnostic accuracy	PACS have high storage capacity and capacity for high transmission rates Uncompressed digital mammograms can be transmitted without loss of information. No significant difference in image quality or diagnostic accuracy of lesions.
23	Garg et al., 2015	United States	Cardiology, MRI	Retrospective study	MRI physicians at local site performed CMRI in real-time and guided by expert in CMRI at remote site. Local physician available if required.	Number patients requiring medication or sedation. Study duration	Physician at local site important for coordination of patient are within hospital, in case of emergency or medication administration, bridge between remote physician and patient. Communication and instructions good. One incident of technical failure.

	Publication	Country setting	Discipline	Type of article	Description of teleradiology	Outcomes measured	Insight into quality, safety, implementation
24	Griggs et al., 2014	South Africa	Paediatrics	Pilot	Digital Xrays JPEG store and transfer capture and reading of paediatric Xrays	Indications for referral, patient demographics, number and type of Xray, reviewer characteristics, burden of disease	Sustainability Issues with bandwidth requires image compression but may lead to poor image quality. User friendliness
25	Hasegawa and Murase, 2007	Japan	Telemedicine	Review	Use of telemedicine in Japan	NA	37% of 1006 telemedicine projects identifies involved teleradiology. Radiologist in demand
26	Hohmann, et al., 2012	United Kingdom	Hospital systems	Retrospective study	Outsourced teleradiology for after-hours services (one provider with offices in UK and Australia). All consultants registered radiologists. Reports done in one hour and sent back via secure email. Telephone consultation between health professional and radiographer possible.	Level of agreement with report from category 5 = no disagreement to category 4 = definite omission or misinterpretation with serious threat to life	0.8% of reports were definite misinterpretations with moderate likelihood of morbidity but no threat to life. Accredited radiologists.
27	Huang et al., 2008	United States	Cardiology, congenital heart disease	Retrospective study	Real-time, guided sonography involving sonographer at local site and cardiologist at remote site if required. Otherwise through store- and-forward. Recommendations for medical care or transfer communicated via videoconference to patient and neonatologist.	Number of transfers avoided	Unit designated as level III nursery with telemedicine as means of cardiologist staff.
28	Huffman, 2010	United States	Outsourcing	Cross- sectional descriptive	Findings from survey of sample of ACR members	NA	 11% of workload for practices that provide outside services. 4% of total workload of US radiologists consisted of outside readings Proportions differ according to type of practice, size and location to metropolitan area

	Publication	Country setting	Discipline	Type of article	Description of teleradiology	Outcomes measured	Insight into quality, safety, implementation
29	Jacobs et al., 2015	Nether- lands	Orthopaedics, General practice	Retrospective study	Xray taken by trained radiographer at general practice. Interpreted by remote radiologist. Consult with remote surgeon and treatment decision made.	Fracture diagnositcs Number unnecessary transfers Treatment Number of Xrays	Changed role for GP-increased ability to treat with supervision of surgeon. Increase in number of X-rays conducted- uncertain cases returning for reassessment. Facilitated safe treatment at home
30	Kennedy et al., 2009	United States	Pulmonary	Retrospective study	Designated teleradiology hours for imaging for diagnosis of acute pulmonary embolism. Clinicians can access interpretations of imaging studies from specific computer stations through the hospital.	Proportion of time-critical CT pulmonary angiographic studies Time to report	Improvement in workflow noted-faster report turnaround.
31	Kierkegard, 2015	Denmark	Telemedicine	Retrospective study	NA	NA	Diagnostic teleradiology used in two of five regions of Denmark
32	Kifle et al., 2010	Ethiopia	Telemedicine	Cross- sectional descriptive	Overview of telemedicine use in Ethiopia	Perceived ease of use, usefulness, anxiety and a range of other constructs influencing intention to use according to a predetermined model.	The reactions of the end-users need to be considered when implementing telemedicine interventions.
33	Kreutzer et al., 2008	Germany	Neurosurgery	Retrospective study	Analogue set up allowing local hospital to transmit imaging to remote neurosurgical hospital	Cost of patient transport Cost of imaging	Expensive systems require technical servicing to ensure image quality, have compatibility issues and data security issues. Seen to be a barrier to implementation.
34	Lam and Poropatich, 2008	NA	Military	Cross- sectional, descriptive	Deployment of telemedicine in the NATO military forces	NA	Teleradiology frequently deployed using asynchronous workflow.
35	Latifi et al., 2016	Albania	Telemedicine	Retro- spective study	Evaluate new telemedicine program in Albania	Patient demographics, discipline, technology, outcome.	70% used asynchronous store and forward. Most radiology, then stroke and neurotrauma. Between 20-23% of people transferred - much more likely with synchronous than asynchronous review. Questions about remuneration and sustainability.
36	Lefere et al., 2013	Portugal	Colorectal cancer	Prospective trial	CT colonography performed by local radiographer supervised by local radiologist. Imaging sent to expert radiologist in CTC interpretation.	Diagnostic accuracy	CTC radiographers and local radiologist with no experience in interpretation therefore teleradiology implemented.

	Publication	Country setting	Discipline	Type of article	Description of teleradiology	Outcomes measured	Insight into quality, safety, implementation
37	Lewis et al., 2009	United States	Outsourcing	Cross- sectional descriptive	Patterns of use of external after- hours teleradiology Services by practices in 2007 and changes since 2003.	NA	Almost half of all radiology practices use outsourced services About half of all radiologists were in practices using outsourced services
38	Lewis, et al., 2012	NA	Trauma	Review	Reviews worldwide trends in development and adoption of telemedicine for acute injury management	NA	NA
39	Lundberg et al., 2010	Sweden	Hospital systems	Program description	Describes design and implementation of a regional network for teleradiology	NA	Stakeholder consultation essential Access to clinical information for diagnostic work. Integration of systems Uniformity of coding and descriptions for radiology Agreements for collaboration between hospitals and departments Security
40	Maher et al., 2007	Ireland	Telemedicine	Cross- sectional descriptive	,NA	NA	Teleradiology most common form of telemedicine in Ireland
41	Mair et al., 2010	Scotland	Trauma	Quasi randomised using pre- recorded sessions.	Teleradiology used to consult with remote physican by telephone with PACS and videoconferencing with PACS	Decision to transfer	Videoconferencing, with use of teleradiology where required, more supportive in decision making than telephone.
42	Martinon, et al., 2014	France	Hospital systems	Quasi-experi- mental, prospective controlled study	Emergency physician sends request to teleradiologist via secure data centre. If accepted, teleradiology send protocol to onsite radiology technician who proceeds according to the protocol. Images sent to teleradiologist for interpretation and report back. Available by phone to talk with doctor if needed.	Average turnaround report time Events that might affect report time Availability and conformity of exam requests to practice guidelines Staff satisfaction	Communication better with teleradiology Technicians perceived training and supervision to be better with teleradiology that on-site radiology. Teleradiology requests compliant with quality measures more often than on-site requests.

	Publication	Country setting	Discipline	Type of article	Description of teleradiology	Outcomes measured	Insight into quality, safety, implementation
43	Matsumoto et al., 2015	Japan	Radiology	Cross- sectional	NA	Number radiologists	Caution about commercial teleradiology due to quality concerns and compliance with standards.
44	McCrossan et al., 2011	United Kingdom	Antenatal, congential heart disease	Prospective	Obstetric sonographer guided in real-time at local site by remote foetal cardiologist.	Quality of images for diagnosis Diagnostic decisions Radiographer perceptions before and after study including; rating own skills; supervision by specialist; the technology	Diagnostic accuracy Radiographers' confidence and satisfaction increased with time. Upskilling of radiographer Costly Not time consuming
45	Mrak et al., 2009	Croatia	Neurosurgery	Program description	CT units at 18 small regional medical centres connected with national referral centre in Zagreb	NA	Most valuable for decisions about proper and effective patient treatment. Rapid and reliable phone consultations therefore early initiation of therapy.
46	Nagao et al.,	Australia	Telestroke	Retrospective study	Remote neurologist connects to videoconference and reviews CT images and clinical info - final decision by local physician.	Proportion of thrombolysed patients Rates of symptomatic intracerebral haemorrhage Door to CT time	Technical issues prevented 20% of the telestroke group from undergoing full telestroke activation. Benefits include unnecessary patient transfer, neurosurgical procedures identified rapidly and upskilling of rural physicians.
47	Norum et al., 2007	Norway	Telemedicine	Retrospective study	NA	NA	Essential for regional services for neurosurgery, trauma, orthopaedics, vascular surgery, coronary heart surgery, oncology and radiotherapy.
48	Oliveria, 2014	Portugal	Telemedicine	Program description	Used for highly dispersed population. Network consists of 20 primary care units and 5 hospitals over 4 districts	NA	Reduce cost of care Increase accessibility
49	Otto, 2013	Antarctic	Sonography	Retrospective study	Imaging performed by physicians, physician assistant or ultrasound technician at local site and transmitted to radiologist or cardiologist at remote site.	Image quality Concordance of diagnosis Treatment outcomes	Real-time link not feasible. Would require coordination due to time-zones and coordination with satellite connectivity (available for limited hours) Context specific training for local physician important.
50	Popov, 2007	Serbia and United States	Sonography	Pilot	Remote sonologist (in US) guides sonographer (in Serbia) via real- time low resolution video and	Image quality Preferred image Identify organ Attempt diagnosis	Costly to implement – this was low cost solution. Negotiated low bandwidth with use of low resolution video and remote, expert guided

	Publication	Country setting	Discipline	Type of article	Description of teleradiology	Outcomes measured	Insight into quality, safety, implementation
					pictures taken and sent in real- time to US. Occurs in two steps: 1. Low resolution real-time video at low frame rate to area of interest. Slowed to optimise image and then frozen for recording. 2. Still images recorded by both users. Then scan continues.	Quality of images also assessed using Mean Gray Value software to determine amount of image loss.	sonography to instruct when to slow down for better transmission of potential pathologies.
51	Raza, 2009	United States	Pulmonary	Retrospective study	Telemedicine consultation with transmission of imaging studies as needed. Patent and nurse or respiratory technologist at local site and pulmonary physician at remote site.	Access to care Clinical decision making Patient disposition	90% of patients diagnosed at first consultation. Saved travel distance and patient work days. Patients satisfied with telemedicine. Integrated computerised medical record and existing network of hospitals and clinics an advantage for implementation.
52	Sangare, 2015	Mali	Teleradiology	Retrospective study	Store and forward radiology review between peripheral hospitals and central hospital	Usage patterns over times/sites, diagnoses/diagnostic agreement, missed diagnoses, staff perceptions	Network was successful in increasing diagnoses and reducing misdiagnoses. Successful implementation depended on local ownership of a network, which was developed in close collaboration with hospital leadership, national radiologists and other healthcare personnel. Barriers mostly related to technical issues and support and popular amongst clinical staff.
53	Sass, 2011	Hungary	Telemedicine	Cross- sectional descriptive	Teleradiology most common form of telemedicine. Acute shortage of radiologists.	NA	Obstacles for telemedicine include IT infrastructure, interoperability, lacking IT skills, legal and technical issues.
54	Sharma, 2017	Canada	Hospital systems	Program description	A region wide network was developed to improve access to emergency neurosurgical care.	NA	Continued collaboration between all stakeholders during design and implementation. Implementation informed by previous experience. Education component to help physician identify when neuroconsult indicated.
55	Shiferaw and Zolfo, 2012	Ethiopia	Telemedicine (teleradiology,	Descriptive case study	Store and forward radiology review between peripheral hospitals and central hospital	Computer literacy, implementation factors,	Implementation does not depend on technological readiness, rather e-government

	Publication	Country setting	Discipline	Type of article	Description of teleradiology	Outcomes measured	Insight into quality, safety, implementation
			telepathology, teledermatology)			satisfaction, perceptions of barriers and enablers	readiness, policies, multisectoral development and capaciity development. Programs need to be modified for local context.
56	Sørensen et al., 2012	Norway	Neurosurgery, stroke	Program description	Presents an overview of the status of telestroke in Norway	NA	Physician involved feel up to date with the field. Requires motivated staff, a common radiology network Unclear responsibility for communication lines. Room for equipment an issue. Demand must be perceived for implementation
57	Spijker et al., 2014	LMICS where Medicins Sans Frontieres operate	Teleradiology	Retrospective study	Various types of store and forward - computerised (digital) and film radiology	Quality of film (and variations by site or film type); diagnostic or non-diagnostic. Concordance between raters	Traditional films significantly more non-diagnostic images than computerised films. Planned teleradiology services and training were associated with better quality at CR services. Training for radioographer important
58	Spokoyny et al., 2014	United States	Telestroke	RCT	Telestroke	Ability of different specialists involved in Telestroke to determine if rt-PA needed for acute stroke.	Reading can be carried out by a specialist other than a radiologist
59	Sutherland et al., 2009	Dominican Republic	Sonography	Prospective	Imaging for clinical investigation in primary care setting transmitted to radiologists in the United States for interpretation	Time to report Time to return for results Quality of transmitted images	Teleradiology showed improvements in speed and number of reports returned. Need to continue to refine data manipulation and transmission methods in this setting. Fear of overuse of imaging.
60	Swerdlow et al., 2017	NA	Robotic sonography	/Review	NA	NA	Advantage of real-time is reduction in recall for reassessment. Reduce physical strain on sonographers. Unskilled personnel at local site.
61	Vladzymyrskyy et al., 2014	Ukraine	Pulmonary, tuberculosis	Program description	Videoconference meeting between experts and sometimes patients to confirm diagnosis of TB. Teleradiology involved as required.	NA	Diagnosis changed in 21% of cases.
62	Watson, 2016	United States	Hospital systems	Retro- spective study	Implemented teleradiology for transfer of patient information and imaging between hospitals	Reduction in repeat CT Cost savings Length of stay	Secure transfer over VPN required legal agreement between organisations and billing agreement.

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						Spared radiation	Existing wireless access at hospitals enabled statewide adoption. Software compatible with existing radiology workstations.
63	Weber et al., 2013	Germany	Pre-hospital trauma	Prospective piloi study	Stroke Emergency Mobile Unit consisting of neurologist, paramedic, radiographer and CT machine. CT image transmitted from the field to remote radiologist. Radiologist consults with local neurologist and treatment decision made with remote senior neurologist.	Data from prehospital sources 3 month follow up telephone survey and interview to determine Rankin score.	Issue with technical failure – CT malfunction and delayed CT image transmission in emergency situation.
64	Whiteman et al. 2014	United States	Hospital systems	Retrospective study	An imaging archiving system was implemented at hospitals and replaces the use of CDs for patient transfers.	Number of repeat CT scans performed	Important to reduce repeat imaging and radiation exposure. Teleradiology enables better workflows for exchange of imaging during patient transfer.
65	Zennaro et al., 2016	Angola	Digital radiology	Pilot	Digital Xrays with potential for store and forward	Number of films, Xray quality, number unsatisfactory, use of teleradiology under new system and impact on diagnosis	Local technicians with training were able to generate excellent quality digital images. These worked well for teleradiolgoy.
66	Zennaro et al., 2013	Italy	Paediatrics, emergency	Clinical trial	Point of care ultrasonography performed by emergency paediatrician at local site under real-time, remote guidance from paediatric radiologist.	Diagnostic accuracy Examination duration Number technical issues Video/audio quality	Minimal delay in image transfer Low cost equipment and open source applications Training of physician at local site important
67	Zhai et al., 2015	NA	Neurosurgery, stroke	Meta-analysis	compared telestroke with in-person care at a medical facility	Favourable modified Rankin score Incidence of intracranial haemorrhage Mortality	Management of acute ischaemic stroke with telemedicine safe in hospitals with limited experience with tPA therapy.
	Readiness/impleme	ntation issue	S				
68	Crocker et al., 2010	United Kingdom	Teleradiology	Evaluation	NA	NA	Hospitals without PACS experience added mean delay of 5.8hrs on decision making. Reliable teleradiology is needed not only to identify patients who need rapid transfer but also

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							to prevent unnecessary transfer of patients who do not need neurosurgical intervention.
69	Demiris et al., 2010	United States	Telemedicine	Review	NA	NA	Important for technical designers to understand end users; need more understanding of how telehealth is integrated into workflow training essential; usability and patient provider relationship is not compromised.
70	Gabriel et al., 2014	United States	Telemedicine	Cross- sectional	Teleradiology most commonly used telehealth application.	NA	Challenges include workflow and staffing issues, security and privacy. Important that necessary resources and support is available to assist with adoption of new technologies.
71	Hartvigsen et al., 2007	Norway	Telemedicine	Review	Teleradiology increasingly important for regional clinical coordination	NA	Telemedicine is well integrated into routine health service provision. Benefits include economic and qualitative - time for other tasks, patient access.
72	Jarvis-Selinger et al., 2008	Canada	Telemedicine	Review	NA	NA	Key strategies for readiness include change management and training, understanding costs and development of protocols
73	Johnson, 2010	United States	Teleradiology	Review	NA	NA	Technical aspects well understood but political licensing and credentials and legal issues limiting
74	Junca-Lapace- Valageas et al., 2015	France	Teleradiology	Prospective	A teleradiology service set up in Lorraine region	NA	Highlighted the need for afterhours teleradiology
75	Legare et al., 2010	Canada	Telemedicine	Review	Review of readiness assessment tools	NA	More research needed to determine validity and psychometric qualities of all readiness assessment tools
76	Legido-Quigley et al., 2014	Europe	Teleradiology	Qualitative	NA	NA	Obstacles included uncertainty about liability, registration, data security and data quality. Also highlighted the need for EU wide legal framework.
77	Van Dyk, 2014	South Africa	Telemedicine	Review	Compare existing frameworks for the implementation of telehealth services that can contribute to the success rate of future endeavours	NA	Nine frameworks available. In some cases theoretical frameworks were used - diffusion of innovation, technology acceptance, ereadiness and system lifecycles. Review indicated that a holistic implementation approach is needed. Theories can assist with the implementation for other services.

	Publication	Country setting	Discipline	Type of article	Description of teleradiology	Outcomes measured	Insight into quality, safety, implementation
	Quality assurance						
78	Agrawal et al., 2011	United States	Teleradiology	Descriptive	Radiology technologists of client hospitals submitted a requisition for radiology read to the group's operations center in Bangalore, India using either fax or electronic radiology information system (RIS) entry. The images were transferred over VPN to a web- based PACS (eRAD, Greenville, South Carolina) and downloaded from there to the individual radiologist's workstation using lossless JPEG transfer. A firewall and site to site virtual private networks were used to secure the data. Some studies were read directly from the client hospital's radiology viewing software. Preliminary reports were faxed back to clients.	Error rate and clinical significance of error	International teleradiology services are associated with very low rates of clinically significant errors. Due to limited feedback, particularly for minor errors, an internal review is important – Attention required for issues such as inadequate history and additional clinical information.
79	Di Paolo et al., 2009	Italy	Forensics	Case series	In two cases of death following road accident, death was due to the failure to obtain radiological reports of the x-rays performed in the ED and diagnosis could have been established if teleradiological service was activated	NA	Highlight the risk of excluding the radiologist from the management of patients whose images are transmitted via teleradiology system
80	Giansanti et al., 2007	Italy	Telemedicine	Evaluation	Several applications were examined: telediagnosis in telecardiology, telepathology and teleconsultation, hospital nursing management teleeducation and telerehabilitation	NA	Findings highlight the need for a set of guidelines for quality control in telemedicine within the context of Italy

	Publication	Country setting	Discipline	Type of article	Description of teleradiology	Outcomes measured	Insight into quality, safety, implementation
81	Platts-Mills et al., 2010	United States	Teleradiology	Prospective	Films sent from ED to teleradiology group between 7pm and 7am. Images were compressed and they had the same ability to manipulate images as in-house teleradadiology. Clinical information was provided by physician. Interpretations were made available by fax orvia website. Also available for teleconsult. Compared with in- house radiology group who had the same information however in- house rad had opportunity to access additional information and discuss with other care providers	Proportion of major, minor or no discrepancy	Major discrepancies were identified in 32 of 550 scans. Minor discrepancies were identified in 116 of 550 scans. 8 of the major discrepancies were attributed to misinterpretations by teleradiologist and 9 by in-house radiologists. Findings support the cautious use of teleradiology interpretations for ED decision making. Further study needed to better define the sensitivity of teleradiology interpretations
82	Ross et al., 2010	Czech Republic, Denmark, Estonia, Finland, Lithuania Netherlan ds	Teleradiology	Qualitative	Radiology service connecting 200 hospitals across N Europe into one dedicated secure IP based network. A web based viewing and reporting platform was used. Examinations were sent from local archiving to intermediate archive. Second service was a consultation portal for buying and selling of imaging related telemedicine services.	NA	Cross border teleradiology service did not develop into routine practice in any of the participating hospitals. Lack of integration between the teleradiology platform and local systems. Language was the biggest barrier to overcome. Special attention required in areas of clinical quality and trust. Clinical acceptance is a pre-requisite for cross- border teleradiology. Cross border tele radiology can be used to make radiology more available and improve services.
83	Tie and Koczwara 2004	Australia, United States	Teleradiology	Review	NA 	NA	Teleradiology provides opportunities for quality improvement in radiology including education, audit and benchmarking. Can also improve access to services and sharing of expertise. Consideration should be given to development of quality improvement initiatives.

	Publication	Country	Discipline	Type of article	Description of teleradiology	Outcomes measured	Insight into quality, safety, implementation
84	Martinov et al., 2013	Serbia and United States	Sonography	Pilot	Remote expert monitors ultrasound in real-time via teleconferencing module. Can record and review still ultrasound images. Remote saving of imaging for use at both sites.	Image quality Mean Gray Value	Technical issues with audio. Used Skype as a backup. No clinical differentiation between original and transmitted images.
85	Parsai et al., 2012	Switzerlan d	Sonography	Prospective	Video clip forwarded with imaging for interpretation.	Image quality	Video clip forwarded increased accuracy of image interpretation compared with still images alone for hepatic and extrahepatic pathologies.
86	Salazar et al., 2014	Colombia	Imaging			ROC curves Perceived image quality	Image interpreters perceived differences in image quality between monitors however reported to be due to variability between radiologists.
87	Salazar et al., 2014	Colombia	Imaging	Prospective	Images printed and digitised prior to transmission.	Diagnostic accuracy using consumer and medical grade monitors.	No significant differences in diagnostic accuracy between displays and calibrations.
88	Leader et al., 2007	USA	Telemammogra phy	Descriptive and clinical simulation study	*Almost real-time" tele- mammography with interpretation by central radiologist	Telemammography and clinical agreement Reduction in % of women recalled	First proof of concept study for telemammography. Reduction in rate of unnecessary recall but only 66.1% agreement with clinical assessment. In 2007 technical quality issues were limiting effectiveness.
89	Weinstein et al., 2007	Arizona, USA	Teleradiology and telepathology	Program description	Packaging of telemedicine services around breast cancer screening (radiology, pathology and oncology)	Timeliness of diagnosis	First commercialised bundling of telemedicine services. Allowed increased service efficiency (same-day processes), but low quality study.
	Security						
90	Fatehi et al., 2015	Iran	Security	Professional paper	Review of data standards for teleradiology	NA	Data interchange, document and terminology standards Harmonisation of standards needed for interoperability.
91	Nyeem et al., 2013	Australia	Security	Review	Review about medical image watermarking for teleradiology	NA	Danger of tempering or theft Requires policy for teleradiology and security measures Watermarking for medical images not well accepted yet. Confidentiality, reliability, and availability needed in teleradiology

	Publication setting	Country	Discipline	Type of article	Description of teleradiology	Outcomes measured	Insight intoquality, safety, implementation
	Economic evaluation	າ					
92	Dattakumar et al., 2013	Internation al	Telehealth	Review	NA	Externally validated instruments, frameworks and guidelines are not utilised; generally hard to make comparisons between studies due to diverse outcome measures used	Important to design studies to ensure that results are comparable with other studies in the field
93	McGill., 2012	Australia	Orthopaedics	Cost analysis	Videoconference fracture clinics	Cost savings to health service	No outcomes assessed, only estimated cost reductions to the health service
94	Rosenberg., 2013	Germany	Teleradiology	Cost analysis	Cost of providing a clinic using teleradiology	Cost	Cost of providing service estimated under different pricing assumptions
95	Stroetmann et al., 2007	Europe	Telehealth	Cost benefit analysis	NA	Cost	
96	Whiteacre, 2011	United States	Telemedicine	Cost benefit analysis	NA	Cost	
97	Whiteacre et al., 2009	United States	Telemedicine	Cost benefit analysis	NA	Cost	
	Views of users of t	eleradiolog	у				
98	Al-Kadi et al., 2009	Canada	Sonography	Cross- sectional descriptive	Piloted tele-ultrasound between rural resuscitating centre and a tertiary referral centre to facilitate tele-mentoring during acute trauma resuscitations	user satisfaction; perception of patient benefit; perceived improvement in collegiality between remote and referral centre staff; perception of personal ultrasound skill improvement; perception of system as better teaching or clinical tool.	Clinical users were satisfied with the system and felt it improved collegiality and skills. Though not thoroughly tested, the study also suggested that the system may have benefit for teaching trainees.
99	Coppola et al., 2016	ltaly	Radiology	Cross- sectional descriptive	Survey of opinions about teleradiology	PACS availability in their hospital/practice; routine use of TR in clinical practice; method of transmitting reports and accessing patient data; important requirements for TR implementation; usage of TR;	Most Italian radiologists have favourable perceptions about teleradiology but have concerns for the systems to be impersonal for patients and disrupting communication between clinicians.

	Publication	Country setting	Discipline	Type of article	Description of teleradiology	Outcomes measured	Insight into quality, safety, implementation
		J				perceived advantages and threats of using TR; etc.	
100	European Society of Radiology, 2016	Europe	Radiology	Cross- sectional descriptive	Survey of use of teleradiology	1st survey: focus on in- and out- sourcing; 2nd survey: impact and user dimensions (e.g. in vs out sourcing, dis/advantages, QA etc.); financial aspects, informed consent, legislation, guidelines	Few responses from national radiology societies indicating a perceived positive impact of outsourcing. Notably, individuals perceived the main advantage to be greater availability of radiologists, the main disadvantage to be inability for offsite radiologists to participate in multi team meetings, but there was overall a high rate of perceived satisfaction. Little information from patients - only doctors' perception. General reluctance towards teleradiology may stem from fear of deteriorating hospital-based radiology and commoditisation of low cost external services.
101	Fridell et al., 2011	Sweden	Orthopaedics	Qualitative	Use of PACS	Qualitative themes derived via grounded theory process - professional role, work practice & technology.	PACS provides great opportunities for facilitating better team-working; there is potential for other health care professionals to take over the work traditionally done by radiologists but also opportunity for radiologists to take on more specialised skills.
102	Jacobs et al., 2016	Netherlan ds	General practice	Cross- sectional descriptive	x-rays taken in island-based general practice and interpreted at mainland hospital	Patient satisfaction	High patient satisfaction with a teleradiology service based in primary care and in partnership with a hospital on the mainland. Noted importance of being seen and treated on the island close to home and opportunity for relational continuity.
103	Kim et al., 2011	Korea	General Practice	Cross- sectional descriptive	Survey of use of teleradiology	Attitudes towards revised telehealth legislation; opinions re: anticipated outcomes in medical environment; thoughts re: how to adopt telehealth.	The majority of respondents are not in support of the revised telehealth legislation allowing doctor- patient teleconsults. The majority agreed with the negative consequences of telehealth - legal issues, patient shifting, fee setting, and concerns about protecting patient privacy. However, a many indicate that they would be willing to utilise telehealth in some format in the future. Overall, shows a need for policy makers to consult and work with physicians re: implementation of telehealth services.

	Publication	Country setting	Discipline	Type of article	Description of teleradiology	Outcomes measured	Insight into quality, safety, implementation
104	Lester et al., 2007	United States	Multidisciplinary	Cross- sectional descriptive	Teleradiology (local vs international, images sent for interpretation) - excludes nighthawk services	Preference for local or international radiologist services	When all things are equal, referring physicians prefer local radiological services. There was no clear age relationship between willingness to refer to international radiology services but indications that university-based academic physicians would be more willing to use international services than private practice or community hospital-based counterparts.
105	Mozhagan et al., 2012	Iran	Teleradiology	Mixed methods	Teleradiology broadly	Attitudes towards teleradiology and access to patient data	Access to patient data in teleradiology services can be improved to enhance patient care.
106	Petik et al., 2015	Turkey	Teleradiology	Mixed methods	Use of teleradiology	Level of teleradiology knowledge; format of data 105transmission; disadvantages of teleradiology	Positive attitudes towards teleradiology spread in Turkey but concerns about patient privacy (informed consent to teleradiology and transmission of data) as well as quality of care when patient data and radiologist contact was diminished.
107	Ranschaert, et al., 2013	Europe	Teleradiology	Cross- sectional descriptive	Teleradiology broadly	Usage, opinions and future visions	Across Europe: wide variety of applications, implementation mainly in countries with good PACS networks, limited use of commercial services, language is limiting factor for further spread of teleradiology, need for pan-European legislation, price regulation and quality assurance framework.
108	Sadoughi, et al., 2017	Iran	Radiology	Cross- sectional descriptive	Teleradiology broadly	Knowledge and opinions of teleradiology	Radiologists themselves were more optimistic re: teleradiology usage than managers and underscores the need to work with all users & address variety of concerns in implementation of new teleradiology service.
109	Segura et al., 2008	Spain	Telemedicine	Cross- sectional descriptive	Telemedicine – not focussed specifically on teleradiology	Beliefs and opinions of telemedicine - and future intentions re: usage	Little mention specifically of teleradiology but does highlight cultural concerns about value of physical patient-physician contact/attendances.

Appendix 2. Analysis plan for clinical outcomes

National Research Project on Remote Radiology Assessment Service Delivery Model Preliminary data analysis plan v4 Primary Outcomes

Outcome variables: Cancer detection

1) Presence of any cancer (coded as yes/no)

2) Presence of invasive cancers (coded as yes/no)

3) Presence of small invasive cancers (coded as yes/no)

Comparison Groups

Remote vs onsite assessment, pre-implementation vs post-implementation of intervention

Potential confounders

Age, remoteness, ethnicity, first/subsequent screen, service within jurisdiction, CALD, SEIFA, year of assessment episode.

Proposed Data Analysis

Given the binomial nature of the cancer outcomes, plan is to conduct binomial logistic regression analysis with comparison groups and potential confounders included as predictors of the respective outcomes.

Outcome variables: Timeliness

 Timeliness of assessment – quantified as time (days) from Screen Date until Date of First Attendance at assessment clinic. This timeframe will then be collapsed into 3 groups: ≤28 days, 29-35 days, 36+ days.

2) Timeliness of recommendation – quantified as time (days) from Screen Date until Assessment Recommendation. Same group comparisons as above.

3) Time between Date of First Attendance at assessment clinic and Assessment Recommendation. Timeframe will be 3 groups: ≤15 days, 16-22 days, ≥23 days.

Comparison Groups

Pre-implementation vs post-implementation of intervention (outcomes 1, 2, 3), Remote vs onsite assessment (outcomes 2 and 3)

Potential confounders

Age, remoteness, ethnicity, service within jurisdiction, SEIFA, year of assessment

Proposed Data Analysis

Given the 3 levels of the categorical ordinal outcome, plan ordinal regression with comparison groups and controlling for potential confounders.

Potential issues

Need to consider outliers here, as current max value is 1987 days. Data expert suggested that clients more than 137 days from their screen date should be excluded.

Secondary Outcomes

Outcome variable

Proportion of women requiring more than one assessment visit to obtain an outcome

Comparison Groups

Remote vs onsite assessment, pre-implementation vs post-implementation of intervention

Potential confounders

Age, remoteness, service within jurisdiction.

Proposed Data Analysis

Logistic regression with comparison groups and controlling for confounders.

Potential issues

This is hard to quantify. Currently thinking that it is individuals with the same EpisodeID, but different AttendanceIDs. Data expert suggested looking at date of attendance as a way to distinguish between unique attendances.

Outcome variables

Attendance at assessment clinics amongst women in target range. Age, remoteness, ethnicity, CALD, SEIFA.

Comparison groups

Remote vs onsite assessment, pre-implementation vs post-implementation of intervention, service within jurisdiction.

Proposed Data Analysis

Descriptive analyses

Outcome variables: Variations in number of procedures requested by remote radiologist.

Under consideration

1) Number of core biopsies per assessment episode <u>Comparison groups</u>

Remote vs onsite assessment, pre-implementation vs post-implementation of intervention

Proposed Data Analysis/Potential Issues

2) Number of FNA biopsies per assessment episode <u>Comparison groups</u>

Remote vs onsite assessment, pre-implementation vs post-implementation of intervention

Proposed Data Analysis/Potential Issues

3) Number of core/FNA biopsies (combined total) per radiologist per assessment episode <u>Comparison groups</u>

Remote vs onsite assessment, pre-implementation vs post-implementation of intervention

Proposed Data Analysis/Potential issues

Descriptive analyses

Outcome variable

Number of mammography images required for work up at assessment - total.

Comparison groups

Remote vs onsite assessment, pre-implementation vs post-implementation of intervention

Potential confounders

Age, remoteness, service within jurisdiction.

Proposed Data Analysis

As outcome is a count, and likely to be non-normally distributed, would look at doing a Poisson with comparison groups and controlling for confounders.

Outcome variable

Proportion of women who are not diagnosed with cancer and have an outcome of early review vs all other outcomes; 1 year versus 2 years.

Comparison groups

Remote vs onsite assessment, pre-implementation vs post-implementation of intervention.

<u>Potential confounders</u> Age, remoteness, service within jurisdiction.

Proposed Data Analysis

Logistic regression with comparison groups and controlling for confounders.

Inclusion/Exclusion Criteria for all outcomes <u>NT</u> <u>AXATT</u> Include in analysis: 1. Attended BXRS

Exclude from analysis:2. Attended Elsewhere3. Decline call back invitation4. Failed to attend8. Other

<u>AXL1Clinic</u> Include in analysis: DAR - Darwin Assessment Remote DAX - Darwin Assessment

Exclude all other clinic types from analysis: SDD - Step Down Darwin SDA - Step Down Alice Springs AAX-NT BreastScreen Central Australia OUT - outside NT BreastScreen Program AAR - Alice Springs Assessment Remote AAX - Alice Springs Assessment

<u>QLD</u>

Conducted by Include in analysis: 1. BSA service

Exclude from analysis:

- 2. Private facility
- 3. Other BSA Service
- 4. Unknown
- 5. Declined
- 6. GP
- 7. Other

<u>NSW</u>

All clients in database were assessed in NSW although some clients may have screened outside NSW. Include all clients.

Appendix 3. Client survey

Client survey for Townsville, Rockhampton and Queanbeyan

Town names were substituted as appropriate for each site. The Darwin site has some wording changes to reflect the slightly different way that the remote radiology model operates at this site.

PROJECT: Remote Radiology Assessment Model Evaluation

Service User Survey

Evaluation of the Remote Radiology Assessment Model of Service Delivery

You are invited to take part in a research study evaluating the Remote Radiology Assessment Model of Service Delivery. This service has been implemented by BreastScreen Australia at the Townsville BreastScreen clinic. The remote radiology service allows this BreastScreen clinic to continue providing regular assessment clinics and services via telehealth technology when radiologists are not available to attend this clinic in person. This research study will investigate the safety and acceptability of the remote radiology assessment service for service users, service providers and the organisation. The study is being conducted by Professor Sarah Larkins and a team of researchers at the College of Medicine and Dentistry, James Cook University for the Australian Government Department of Health.

Information about the Remote Radiology Assessment Model of Service Delivery

The remote radiology assessment service involves BreastScreen doctors, nurses and imaging staff here in Townsville working with a radiologist based at another location. Radiologists are the specialist doctors who review your mammograms and provide reports about what the mammograms mean for your health. The radiologist takes part in your care by using telehealth technology. Telehealth uses information and communication technologies to provide health services from a distance.

What does participation involve?

We invite you to take part in this study about the remote radiology service by completing a survey. The survey asks about your satisfaction with the remote radiology service, your confidence in the service and if you have a preference in terms of the radiologist's location.

The survey will take about 10 to 20 minutes to complete. Identifying information will not be collected from you. This means that you cannot be identified from your responses to the survey. This also means that once you have completed the survey, we cannot remove your survey answers from the rest of the data. Taking part in this study is completely voluntary. The care that you receive at this service, or any other service, will not be affected by your choice to take part, or not take part, in this study.

The data from the study will be used in research publications such as journal articles, and in reports for the Department of Health. You will not be identified in any way in these publications.

If you have any questions about the study, please contact Sarah Larkins or Karen Johnston.

Principal Investigator:
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Co-Investigator: Professor Sabe Sabesan Medical Oncology Townsville Cancer Centre Phone: 7 478 14957 Email: sabe.sabesan@jcu.edu.au Co-Investigator: Karen Johnston College of Medicine and Dentistry James Cook University Phone: 7 4781 5385 Email: karen.johnston@jcu.edu.au

If you have any concerns regarding the ethical conduct of the study, please contact: Ethics Coordinator Townsville Hospital and Health Service Human Research Ethics Committee Phone: (07) 4433 1440 (<u>TSV-Ethics-Committee@health.qld.gov.au</u>) Ethics Approval: HREC/17/QTHS/76

Or: Human Ethics, Research Office James Cook University, Townsville, Qld, 4811 Phone: (07) 4781 5011 (<u>ethics@jcu.edu.au</u>) Ethics Approval: H7082

Is this visit for screening or assessment?

(Assessment clinic is when you have been recalled after a screening mammogram)

- O Screening (Disqualification statement: Thank you for considering this survey. No further responses are needed)
- O Assessment (recalled after a screening mammogram). *Please go to Q1.*

Q1. Do you consent to complete this survey?

- O Yes
- O No

Please note:

By continuing to complete this survey, you agree for your survey answers to be used in this research study.

By continuing to complete this survey online, you are also consenting to the storage of your responses off-shore until the survey is closed.

Q2. How old are you?

- O 40-49
- O 50-59
- O 60-69
- O 70-74
- O 75 and over

Q3. Do you identify as Australian Aboriginal or Torres Strait Islander?

- O No
- O Yes
 - O Australian Aboriginal
 - O Torres Strait Islander
 - O Australian Aboriginal and Torres Strait Islander
- O I don't want to answer this question

Q4. When you are at home, do you usually speak a language other than English?

- O No
- O Yes

Q5a. How satisfied were you with your clinic experience today?

Please rate your level of satisfaction. Choose one option only.

1	2	3	4	5
Very	A bit	Neither	Quite satisfied	Extremely
Dissatisfied	dissatisfied	satisfied or		satisfied
		dissatisfied		
0	0	0	0	0

Q5b. Please outline a reason for your choice.

A radiologist is a doctor who reviews your mammograms and reports on what they mean for your health

Q6. Did you know that the clinic today uses a radiologist who is working from another location?

O No

O Yes

If yes: How did you know that today's clinic was a remote radiology clinic?

(You may choose as many responses as apply)

- O staff told me on the phone when making this appointment
- O when completing the consent form
- O staff told me this morning
- O other

Sometimes the assessment service involves a radiologist who is present here at the clinic.

Or

In *the remote radiology assessment service* the radiologist is at another location and can see your images (via telehealth) while communicating with a doctor and health staff here.

- Q7. Do you think the care you receive today in a *remote radiology assessment service* would be different to the care you might receive with the radiologist physically present here at the clinic?
 - O No
 - O Yes

Please outline a reason for your choice.

Q8a. Do you prefer the radiologist present here or the remote radiology assessment service?

Please rate your level of preference. Choose one option only.

Radiologist	No preference	Remote	l don't have a
present		radiology	preference as this is my
preferred		assessment	first visit to the
		service	assessment clinic.
		preferred	
0	0	0	Ο

Q8b. Please outline a reason for your choice.

	asses	Is there anything else you would like to add about the remote radiology assessment service?							
210.	Have you had any other experience of telehealth? Telehealth uses information and communication technologies to provide health services from a distance. For example, you may visit your family doctor and talk with a specialist doctor on a screen.								
	0	No							
	0	Yes							
211.	How many times have you attended (or visited) a BreastScreen clinic altogether (either screening or assessment clinic)? Please choose one option only.								
	0	2 – 5 times							
	0	6 – 9 times							
	0	10 times or more							
212.	How	far did you travel to access this service?							
	0	less than 20km							
	0	21-50km							
	0	51-100km							
	0	more than 100km							
213.	What	is your postcode of residence?							
214.	What	is your suburb of residence?							
	Thar	nk you very much for taking the time to complete our survey!							

Darwin Client Survey

PROJECT TITLE: Remote Radiology Assessment Model Evaluation

PRINCIPAL INVESTIGATOR: Professor Sarah Larkins [*MBBS, BMedSci, MPH& TM, PhD, FRACGP, FARGP, GAICD*] College of Medicine and Dentistry, James Cook University, Townsville, QLD

Client Survey

Evaluation of the Remote Radiology Assessment Model of Service Delivery

You are invited to take part in a research study evaluating the Remote Radiology Assessment Model of Service Delivery. This service has been implemented by BreastScreen Australia at the Casuarina BreastScreen clinic, and at other clinics in Queensland and New South Wales. The remote radiology service allows this BreastScreen clinic to continue providing regular assessment clinics and services via telehealth technology when radiologists are not available to attend this clinic in person. This research study will investigate the safety and acceptability of the remote radiology service for service users, service providers and the organisation. The study is being conducted by Professor Sarah Larkins and a team of researchers at the College of Medicine and Dentistry, James Cook University for the Australian Government Department of Health.

Information about the Remote Radiology Assessment Model of Service Delivery

The remote radiology assessment service involves BreastScreen doctors and nurses here in Darwin working with a radiologist based in Sydney. Radiologists are the specialist doctors who review your mammograms and provide reports about what the mammograms mean for your health. The radiologist takes part in your care by using telehealth technology. Telehealth uses information and communication technologies to provide health services from a distance.

What does participation involve?

The researchers invite you to take part in this study about the remote radiology service by completing a survey. The survey asks about your satisfaction with the remote radiology service, your confidence in the service and if you have a preference in terms of the radiologist's location.

The survey will take about 10 to 20 minutes to complete. Identifying information will not be collected from you. This means that you cannot be identified from your responses to the survey. This also means that once you have completed the survey, we cannot remove your survey answers from the rest of the data. Please note, if you choose to complete the survey online you are consenting for your responses to be stored off-shore.

Taking part in this study is completely voluntary. The care that you receive at this service, or any other service, will not be affected by your choice to participate, or not participate, in this study.

The findings from this research study will provide the government with information about how effective the new model is for meeting the needs of people living outside cities and how it can be improved.

The data from the study will be presented in aggregated form. This means that individual responses will not be reported. The data from the study will be used in research publications such as journal articles, and in reports for the Department of Health. You will not be identified in any way in these publications. If you have any questions about the study, please contact Sarah Larkins or Karen Johnston.

Principal Investigator:

Professor Sarah Larkins College of Medicine and Dentistry James Cook University Phone: 7 4781 3139 Email: sarah.larkins@jcu.edu.au

Co-Investigator:

Karen Johnston College of Medicine and Dentistry James Cook University Phone: 7 4781 5385 Email: <u>karen.johnston@jcu.edu.au</u>

This study has been approved by the Human Research Ethics Committee (HREC) of the Northern Territory.

If you have any concerns or complaints regarding the ethical conduct of the study, you are invited to contact:

Ethics Administration

Human Research Ethics Committee of the Northern Territory Department of Health and Menzies School of Health Research Phone: (08) 8946 8687 or (08) 8946 8692 Or email: <u>ethics@menzies.edu.au</u> Ethics Approval: 2017-2893

Or: Human Ethics, Research Office James Cook University, Townsville, Qld, 4811 Phone: (07) 4781 5011 (<u>ethics@jcu.edu.au</u>) Ethics Approval: H7082

Is this visit for screening or assessment?

(Assessment clinic is when you have been recalled after a screening mammogram)

- O Screening (Disqualification statement: Thank you for considering this survey. No further responses are needed)
- O Assessment (recalled after a screening mammogram). Please go to

Q1.

1. Do you consent to complete this survey?

- O Yes
- O No

Please note:

By continuing to complete this survey, you agree for your survey answers to be used in this research project.

By continuing to complete this survey online, you are also consenting to the storage of your responses off-shore until the survey is closed.

2. How old are you?

- O 40-49
- O 50-59
- O 60-69
- O 70-74
- O 75 and over

3. Do you identify as Australian Aboriginal or Torres Strait Islander?

- O No
- O Yes
 - O Australian Aboriginal
 - O Torres Strait Islander
 - O Australian Aboriginal and Torres Strait Islander
- O I don't want to answer this question

4. When you are at home, do you usually speak a language other than English?

- O No
- O Yes

5a. How satisfied were you with your clinic experience today? Please rate your level of satisfaction. Choose one option only.

1	2	3	4	5
Very	A bit	Neither	Quite satisfied	Extremely
Dissatisfied	dissatisfied	satisfied or		satisfied
		dissatisfied		
0	0	0	0	0

5b. Please outline a reason for your choice.

A radiologist is a doctor who reviews your mammograms and reports on what they mean for your health.

6. Did you know that the clinic today uses a radiologist who is working from another location (eg. Sydney or Brisbane)?

- O No
- O Yes

If yes: How did you know that today's clinic was a remote radiology clinic?

(You may choose as many responses as apply)

- O staff told me on the phone when making this appointment
- O when completing the consent form
- O staff told me this morning
- O other

Sometimes the assessment service involves a radiologist who is present here at the clinic

Or

In the *remote radiology assessment service* the radiologist is located in Sydney and can see your images (via telehealth) while communicating with a breast doctor here.

- 7. Do you think the care you receive today in a *remote radiology assessment service* would be different to the care you might receive with the radiologist physically present here at the clinic?
 - O No
 - O Yes

Please outline a reason for your choice.

8a. Do you prefer the radiologist present here or the *remote radiology assessment service*?

Please rate your level of preference. Choose one option only.

Radiologist present preferred	No preference	Remote radiology assessment service preferred	I don't have a preference as this is my first visit to the assessment clinic.
0	0	0	0

8b. Please outline a reason for your choice.
Ha r	ve you had any other experience of telehealth?
Tele	ehealth uses information and communication technologies to provide health
ser	vices from a distance. For example, you may visit your family doctor and talk
a sp	becialist doctor on a screen.
0	No
0	Yes
Ho ^r	w many times have you attended (or visited) a BreastScreen clinic
alte	ogether (either screening or assessment clinic)?
Plea	ase choose one option only.
Plea	ase choose one option only.
O	2 – 5 times
Plea	ase choose one option only.
O	2 – 5 times
O	6 – 9 times
Plea	ase choose one option only.
O	2 – 5 times
O	6 – 9 times
O	10 times or more
Plea	ase choose one option only.
O	2 – 5 times
O	6 – 9 times
O	10 times or more
Ho	w far did you travel to access this service?
Plea O O Ho	ase choose one option only. 2 – 5 times 6 – 9 times 10 times or more w far did you travel to access this service? less than 20km
Ple:	ase choose one option only.
0	2 – 5 times
0	6 – 9 times
0	10 times or more
Ho	w far did you travel to access this service?
0	less than 20km
0	21-50km
Ple:	ase choose one option only.
0	2 – 5 times
0	6 – 9 times
0	10 times or more
Ho	w far did you travel to access this service?
0	less than 20km
0	21-50km
0	51-100km
Ple: 0 0 0 Ho 0 0 0	ase choose one option only. 2 – 5 times 6 – 9 times 10 times or more w far did you travel to access this service? less than 20km 21-50km 51-100km more than 100km

Thank you very much for taking the time to complete our survey!

Appendix 4. Interview schedule

- 1. What is your current role in the remote radiology assessment clinics?
- 2. How long have you worked in remote radiology assessment clinics?
 - a. Have you been involved in any other types of teleradiology? (providing or receiving advice)
- Has your work changed since the remote radiology model has started here?
 a. If yes, how has your work changed?
- 4. Are there aspects of team functioning that have changed since implementation of the remote radiology assessment model?
- 5. Does the remote radiology assessment model affect how you access client information/records?
 - a. If yes, in what way?
 Probe, if required: could access to client data be improved?
 Do you see any problems with access to client data in the current remote radiology model? (i.e. probe security concerns, sufficiency concerns)
- 6. In your view, are there any benefits of the remote radiology model for service staff?
 - a. Probe further if required: How does this work?
 - b. Do you think there are any negative effects associated with the remote radiology model for BreastScreen staff or service providers?
 - i. Do you think that any of these negative effects could pose risks to staff or limit the service available?
 - Potential probe, if required: How does that work?
 - c. Check: what does this mean for service operation?
- 7. In your view, are there any benefits of the remote radiology model for clients?
 - a. Probe further if required: How does this work?
 - b. Do you think that any of these benefits specifically affect the quality and safety of care that clients receive?
 - c. Do you think there are any negative effects associated with the remote radiology model for clients?
 - i. Do you think that any of these negative effects influences the quality and safety of care that clients receive?
 - Potential probe, if required: How does that work?
 - Standards for teleradiology are currently being developed, but could you comment on how you think the remote radiology model here conforms to existing standards that guide radiology?
 Potential probe: PACS, image quality, environment
- 8. Thinking about the implementation or roll-out of the remote radiology model at this site, what worked well?
 - a. Probe, if required: What specific processes worked well?
- 9. Were there any challenges to implementation of the model at this site?
 - a. Probe, if required: what specific processes did not work well?

- b. Were the existing guidelines useful?
- c. What kind of support did you receive from organisations/units outside this clinic?
- d. Any opposition?
- 10. To what extent do you think service users/clients are aware of the new model of care?
 - a. Do you think that the remote radiology model affects client satisfaction with this service?
 - i. If yes: how so?
 - ii. If no: why not?
- 11. What could be done differently to improve the remote radiology assessment model at this site?
- 12. What advice would you provide to other sites seeking to implement the remote radiology assessment model?
- 13. Anything else you would like to add?
- 14. Brief demographics:
 - i) Role in the service; length of time in role <1 year; 1-5 years; > 5 years
 - ii) Age range 20-29, 30-39; 40-49; 50-59; 60+
 - iii) Gender male, female, other
 - iv) Postcode

iv) Australian Aboriginal Torres Strait Islander, Australian Aboriginal and Torres Strait Islander, none of these

Appendix 5. Economics analysis plan

Methodology

Descriptive statistics will be utilised to quantify the fixed and variable costs associated with care under the remote radiology and face to face models. Four distinct sources of cost are proposed for the remote radiology model:

- Equipment set-up costs, which included acquisition of equipment for teleconferencing and staff training;
- Ongoing equipment maintenance and technical support;
- Mammograms and tests for diagnosis;
- Remote radiologist time consulting for assessment clinic.

Three area of cost are proposed for the face to face model:

- Travel and accommodation costs for the radiologist travelling to and staying at the onsite location;
- Radiologist time travelling to and staying at the onsite location;
- Mammograms and tests for diagnosis.

If clinical difference detected:

Based upon the identified costs the hypothetical cost-effectiveness of treating 10,000 women with the remote radiology model compared to the on-site model will then be assessed using a decision-analysis model.

The model will cover time from initiation of assessment through to assessment result. Costs for each diagnosis state will be identified in the above analysis, the probability of detecting one cancer case for each of the two treatment arms will be taken from the clinical outcomes analysis of the study.

<u>Results</u>

Table 1: Set-up costs of the remote radiology model

Source of cost	Mean	SD
e.g. equipment purchase, installation, testing, staff training (related to remote model)		

- Additional notes for table 1:
 - We are looking for costs associated with setting up the site to provide the remote radiology model. For example, purchasing and installing new equipment and/or software to set up the remote radiology model. If you purchased any software, did staff require additional training to use this? etc
 - If the site already has access to and uses equipment as part of the previous model, please do *not* include this

	Table 2: Ongoing costs associated v	with the remote radiology model – fixed costs
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		j
Source of cost	Mean	SD

e.g. equipment maintenance, technical support, trouble shooting etc	

- Additional notes for table 2:
 - We are looking for ongoing costs associated with the remote radiology model. For example, maintaining equipment used for the remote radiology model etc

Table 3: Ongoing costs associated with remote radiology model and face-to-face model– variable costs associated with staff

Source of cost	Mean – <u>per patient</u>	SD
Remote model		
Face to face model		

- Additional notes for table 3:
 - We are looking for staff costs for the remote radiology model and the face-to-face model.

Table 4: Ongoing costs associated remote radiology model and face-to-face model – variable costs associated with imaging and tests

	Number of mammograms and other testsCosts of mammograms and other tests		mograms and • tests	
Model	Mean – <u>per</u> SD <u>patient</u>		Mean – <u>per</u> <u>patient</u>	SD
Remote model				
Face to face model				

- Additional notes for table 4:
 - The number of mammograms and other tests actually performed in the remote radiology model and onsite model will be determined from the clinical data provided by jurisdictions.
 - The actual mean number of mammograms and other tests will be calculated per assessment episode.
 - The cost of mammograms and other tests will be sourced from the jurisdictions if available, or a proxy costing measure will be used (MBS rebate fee).

Table 5: Fixed and variable costs for remote radiology and radiologist onsite (FIFO) models over the study period.

Jurisdiction	Total number of episodes	Total Fixed	Total variable cost – staffing and travel	Total variable – imaging and other tests	Total cost	Average (total) cost per episode*
Remote model						
Face to face model						

• Additional notes for Table 5:

• This table uses information from Table 1, 2, 3 and 4. This table uses the actual number of assessment episodes under each of the assessment models to estimate fixed and incremental costs per episode under each model.

If clinical difference not detected:

• Differences in cost will be assessed with generalised linear models, specifying a gamma distribution and a log link function.

Table 6. Cost differences of the remote radiology model compared to the onsite model.

	Remote radiology model	Onsite model
Cost ratio (95% CI)		

If clinical difference detected:

Table 5: Cost-effectiveness of the remote radiologist model compared to face to face model, hypothetical cohort of 10,000 women

	Remote model	Face to face model
Mean Cost (SD)	\$	\$
	()	
Mean number of cancer cases		
detected (SD)		
ICER		

Appendix 6. Uncorrected cancer detection rates

Overall, uncorrected cancer detection rates for assessment visits conducted under the remote radiology assessment model were 12.2 per 100 assessment visits whereas for assessment visits conducted under the radiologist onsite model they were 14.1 per 100 assessment visits. For invasive cancer (excluding DCIS), the rates were 10.2 per 100 assessment visits versus 12.0 per 100 visit, and for small invasive cancers 5.0 per 100 visits versus 6.8 per 100 visits, respectively. It is very important to note that these figures are not age standardised and do not take into account other demographic factors that are known to affect the rate of cancer detection. The logistic regression analysis takes these and other factors into account (Table 5.1), and demonstrates equivalence of cancer detection across all measures.

Assessment model	Cancer (any)⁺	Invasive Cancer ⁺⁺	Small Invasive Cancer ⁺⁺⁺
	n (%; 95% Cl)	n (%; 95% Cl)	n (%; 95% Cl)
Remote radiology	476	398	195
(N=3904)	(12.19; 11.08-13.13)	(10.19; 9.24-11.14)	(4.99; 4.31-5.67)
Onsite	947	805	454
(N=6705)	(14.12; 13.29-14.95)	(12.01; 11.23-12.79)	(6.77; 6.17-7.37)

Post-implementation data only: Uncorrected cancers detected with remote radiology assessment versus onsite assessment (N=10,609).*

⁺Cancer (any) consists of DCIS, and large and small invasive cancers.

⁺⁺ Invasive cancer consists of large and small invasive cancers.

***Small invasive cancer consists of small invasive cancers only.

*Uncorrected figures reported in this table are not age standardised and do not take into account other demographic factors that are known to affect the rate of cancer detection. The logistic regression analysis takes these and other factors into account (Table 5.1), and demonstrates equivalence of cancer detection across all measures.

	Cancer (any)⁺ n (%; 95% CI)	Invasive Cancer ⁺⁺ n (%; 95% Cl)	Small Invasive Cancer ⁺⁺⁺ n (%; 95% Cl)
Pre-implementation	1,373	1,115	674
(N=10,508)	(13.07; 12.43-13.71)	(10.61; 10.02-11.20)	(6.41; 5.94-6.88)
Post-implementation	1,423	1,203	649
(N=10,609)	(13.41; 12.76-14.06)	(11.3; 10.70-11.90)	(6.12; 5.66-6.58)

Uncorrected cancers detected pre-implementation versus post-implementation of the remote radiology assessment model (N=21,117).

⁺Cancer (any) consists of DCIS, and large and small invasive cancers.

⁺⁺ Invasive cancer consists of large and small invasive cancers.

***Small invasive cancer consists of small invasive cancers only.

% Proportion of assessment visits conducted in this time period that involved cancer detection.

Appendix 7. Supplementary material for likelihood of cancer detection (remote vs onsite)

Supplementary material for Table 5.1. Frequencies and proportions for cancer detection for regression model - assessment visits conducted using the remote radiology model versus the onsite model, post-implementation (final numbers included in the regression model; n=8,109).

Variable	Level	Cancer (any) ⁺	Invasive Cancer ⁺⁺	Small Invasive
		N (%)	N (%)	Cancer ⁺⁺⁺
				N (%)
Remote clinic	No	947 (66.5)	805 (66.9)	454 (70)
	Yes	476 (33.5)	398 (33.1)	195 (30)
Subsequent	No	240 (16.9)	208 (17.3)	88 (13.6)
screen	Yes	1,183 (83.1)	995 (82.7)	561 (86.4)
Age at screen			N/A	
CALD	No	1,352 (95)	1,148 (95.4)	622 (95.8)
	Yes	71 (5)	55 (4.6)	27 (4.2)
SEIFA	1-3	304 (28.4)	254 (28.3)	119 (24.4)
	4-6	464 (43.3)	398 (44.3)	226 (46.4)
	7-10	303 (28.3)	246 (27.4)	142 (29.2)
Indigenous	No	880 (61.8)	736 (61.2)	376 (57.9)
	Yes	33 (2.3)	27 (2.2)	15 (2.3)
	Unknown	510 (35.8)	440 (36.6)	258 (39.8)
Remoteness	RA1	33 (3.1)	23 (2.5)	14 (2.9)
	RA2	433 (40.3)	357 (39.6)	194 (39.6)
	RA3	558 (51.9)	486 (53.9)	267 (54.5)
	RA4	33 (3.1)	22 (2.4)	11 (2.2)
	RA5	18 (1.7)	14 (1.6)	4 (0.8)
Jurisdiction	1	509 (35.8)	439 (36.5)	257 (39.6)
	2	828 (58.2)	693 (57.6)	356 (54.9)
	3	86 (6)	71 (5.9)	36 (5.5)

Appendix 8. Supplementary material for likelihood of cancer detection (pre-implementation vs post-implementation)

Supplementary material for Table 5.2. Frequencies and proportions for regression model for proportions for cancer detection for regression model - pre-implementation of the remote radiology model versus post-implementation (final numbers included in the regression model; n=17,339)

Variable	Level	Cancer (any)⁺	Invasive Cancer**	Small Invasive
		N (%)	N (%)	Cancer ⁺⁺⁺
				N (%)
Pre Post	Pre	1,373 (49.1)	1,115 (48.1)	674 (50.9)
	Post	1,423 (50.9)	1,203 (51.9)	649 (49.1)
Subsequent	No	578 (20.7)	481 (20.8)	226 (17.1)
screen	Yes	2,218 (79.3)	1,837 (79.2)	1,097 (82.9)
Age at screen			N/A	
CALD	No	2,665 (95.3)	2,222 (95.9)	1,275 (96.4)
	Yes	131 (4.7)	96 (4.1)	48 (3.6)
SEIFA	1-3	534 (23.2)	446 (23.4)	240 (21.8)
	4-6	1,018 (44.3)	865 (45.4)	515 (46.7)
	7-10	745 (32.4)	595 (31.2)	348 (31.6)
Indigenous	No	1,169 (41.8)	957 (41.3)	506 (38.2)
	Yes	47 (1.7)	39 (1.7)	23 (1.7)
	Unknown	1,580 (56.5)	1,322 (57)	794 (60)
Remoteness	RA1	85 (3.7)	70 (3.7)	35 (3.2)
	RA2	961 (41.7)	781 (40.8)	454 (41)
	RA3	1,163 (50.4)	992 (51.9)	580 (52.4)
	RA4	65 (2.8)	49 (2.6)	29 (2.6)
	RA5	32 (1.4)	21 (1.1)	9 (0.8)
Jurisdiction	1	1,578 (56.4)	1,320 (56.9)	792 (59.9)
	2	1,015 (36.3)	839 (36.2)	442 (33.4)
	3	203 (7.3)	159 (6.9)	89 (6.7)

Appendix 9. Supplementary material for timeliness of assessment (pre-implementation vs post-implementation)

Timeliness of assessment and assessment recommendations between pre-implementation and postimplementation periods of the remote radiology model (final numbers included in the regression model; n=17,386). Remoteness of clients' residence grouped to account for relatively smaller numbers of women residing in both RA1 and RA5. There was no difference in the outcomes.

Variable	Level	Time from screen date until date of first attendance AOR (95% CI)	Time from screen date until assessment recommendation AOR (95% CI)	Time from date of first attendance until assessment recommendation AOR (95% CI)
Pre-post	Pre		REF	
	Post	0.22 (0.20-0.24)***	0.28 (0.26-0.31)***	0.82 (0.66-1.01)
Age at screen		1.00 (1.00-1.01)*	1.01 (1.00-1.01)**	1.00 (0.99-1.01)**
Jurisdiction	1		REF	
	2	1.30 (1.16-1.45)**	1.33 (1.20-1.46)**	2.30 (1.84-2.90)***
	3	2.33 (2.07-2.62)***	2.15 (1.92-2.40)***	0.88 (0.59-1.29)
Remoteness of	RA1+2		REF	
residence of	RA3	1.28 (1.18-1.38)**	1.11 (1.03-1.20)*	0.52 (0.44-0.62)***
woman	RA4+5	3.07 (2.61-3.59)***	2.39 (2.05-2.78)	0.41 (0.24-0.67)***
*p<0.05, **p<0.01	, ***p<0.001			
AOR: Adjusted odd	s ratio			
CI: Confidence inte	rval			

Appendix 10. Proportion of women requiring more than one assessment visit to obtain an outcome (pre-implementation vs post-implementation)

Likelihood of women requiring more than one assessment visit to obtain an outcome post-implementation of the model compared with pre-implementation (final numbers included in the regression model; n=15,397).

Variable	Level	AOR (95%CI)
Pre-post	Pre	REF
	Post	1.04 (0.83-1.28)
Age at screen		1.01 (1.00-1.02)
Jurisdiction	1	REF
	2	0.75 (0.58-0.96)**
Remoteness	RA1	REF
	RA2	1.04 (0.70-1.59)
	RA3	0.86 (0.58-1.33)
	RA4	0.20 (0.03-0.68)***
	RA5	0.45 (0.02-2.20)
**p<0.01		
***p<0.001		
AOR: Adjusted odd	ls ratio	
CI: Confidence inte	erval	

Appendix 11. Number of mammography images required for work up at assessment (pre-implementation vs post-implementation)

Number of mammography images required for work up at assessment clinics pre- versus postimplementation of the remote radiology model (final numbers included in the regression model; n=17,461).

Variable	Level	Ratio of means
		(95%CI)
Pre-post	Pre	REF
_	Post	1.12 (1.10-1.15)***
Age at screen		1.00 (1.00-1.00)
Jurisdiction	1	REF
	2	0.70 (0.68-0.72)***
	3	1.24 (1.20-1.28)***
Remoteness	RA1	REF
_	RA2	0.95 (0.90-0.99)*
_	RA3	0.91 (0.87-0.96)**
_	RA4	0.88 (0.82-0.95)***
_	RA5	0.91 (0.84-0.99)**
*p<0.05, **p<0.01, ***	*p<0.001	
CI: Confidence interval		
Assumption: missing da	ata coded as '()' number of
mammograms for som	e assessment	visits in the pre-

implementation period of Jurisdiction 2.

Appendix 12. Assessment recommendations (pre-implementation vs post-implementation)

Likelihood of women not diagnosed with cancer who received equivocal assessment recommendations at assessments conducted pre- and post-implementation of the remote radiology model (final numbers included in the regression model; n=14,859).

Variable	Level	AOR (95%CI)		
		Early Review vs Rescreen	Rescreen 1 year vs Rescreen 2	
			years	
Pre-post	Pre		REF	
	Post	1.26 (0.84-1.91)	0.97 (0.84-1.11)	
Age at screen		1.01 (0.99-1.02)	0.99 (0.98-1.00)*	
Jurisdiction	1	REF		
	2	10.59 (6.43-18.08)***	0.36 (0.31-0.42)***	
	3	11.37 (6.45-20.36)***	0.32 (0.27-0.39)***	
Remoteness	RA1		REF	
	RA2	1.58 (0.48-9.76)	1.06 (0.74-1.47)	
	RA3	1.00 (0.30-6.16)	1.00 (0.70-1.39)	
	RA4	0.44 (0.08-3.29)	1.18 (0.74-1.85)	
	RA5	0.65 (0.13-4.70)	1.54 (0.93-2.59)	
*p<0.05				
***p<0.001				
AOR: Adjusted odds	ratio			
CI: Confidence inter	val			

Appendix 13. Assessment visits where core biopsies performed (preimplementation vs post-implementation)

Likelihood of a core biopsy being performed at an assessment visit in the pre-implementation period compared with the post-implementation period.

Variable	Core bio	opsy performed
	Yes	No
	n (%)	n (%)
e-implementation =10,508)	1,083 (10.3)	9,425 (89.7)
ost-implementation I=10,609)	1,736 (16.4)	8,873 (83.6)