Mixed methodology: A pragmatic approach to investigating complexity in radiography research.

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Mixed methodology: A pragmatic approach to investigating complexity in radiography research☆

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ABSTRACT

Objectives: Mixed methodology research designs are used to investigate and evaluate complexity in healthcare, yet the integration or mixing of qualitative and quantitative data in these studies is still considered a major methodological challenge. This article is the first to review the utilisation of mixed methods studies in radiography, with a particular emphasis on research design and evidence of integration. The paper presents a contemporary case study to explore advanced framework integration and concludes with recommendations for radiography mixed methods researchers.

Key findings: A search of three radiography journals (2013–2025) identified 26 mixed methods studies, mainly focusing on workforce research questions. At design level, only 14 studies were explicit about integration. Most studies were two-phase designs, with five studies deploying advanced frameworks. Convergent and explanatory sequential designs were prevalent, with data collection primarily through surveys, interviews and focus groups. Integration at the methods and reporting levels was rarely documented. The majority adopted a narrative integration reporting style, though few explicitly discussed qualitative and quantitative findings together. Only three articles explicitly defined meta-inferences, the new insights that emerge from the mixing of qualitative and quantitative data.

Conclusion: The adoption of mixed methodologies in radiography is limited but is increasingly used to investigate complex workforce research questions. While the individual quantitative and qualitative components are invariably well-described, a lack of meaningful integration potentially compromises the attainment of the true benefits of a mixed methods design.

Implications for practice: At the onset of the study, researchers are advised to justify the mixed methods design, clearly articulating the methods of integration at all study stages. Researchers should utilise appropriate tools that encourage reporting of quality criteria to ensure trustworthiness.

Introduction

Policymakers and research funders in healthcare are often looking for detailed exploration of a 'real world' policy, service or intervention, including the extent (quantitative) and nature (qualitative) of a problem and how they are inter-related. A mixed methods research design is an approach to collecting, analysing and mixing both qualitative and quantitative data in a single study; individually the qualitative and quantitative elements do not address the research question. These complex studies often include several workstreams, requiring considerable resources in terms of time and funding, and a research team with shared expertise in both qualitative and quantitative methods *and* how to combine them. These significant resource requirements may be prohibitive, contributing to the relatively low adoption of mixed methods studies in disciplines securing limited funding.

Mixed methodologies have their origins in the late 20th Century[1,2] with two landmark texts in 2003 heralding mixed methods as a novel philosophical approach,[3,4] and the next evolutionary trend.[3] However, in 2008 a review of mixed methods studies in

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healthcare highlighted concerns in their design, delivery and reporting,[5] with many describing only the individual components (qualitative or quantitative elements) of a study and failing to attempt any integration. The term integration refers to the intentional mixing of quantitative and qualitative approaches at any point in the mixed methods study,[6] with the aim of generating new insights or a deeper contextual understanding than is likely from researching the quantitative and qualitative components in isolation.[6–8]

In the two decades since publication of these landmark texts,[3,4] the methodologies and methods have become better defined, yet the integration of data in mixed methods studies is still considered a major methodological challenge.[6] Several systematic reviews have indicated a lack of meaningful engagement and explicit reporting of integration in many contemporary mixed methods studies.[6,9–15] Given the significance of integration in this type of research, Dupin & Borglin express concern that the topic has yet to receive proper attention from researchers.[6] To address this concern, this article is the first to review the utilisation of mixed methods studies in radiography, with a particular emphasis on research designs and evidence of integration at the design, methods and reporting levels. The paper will commence with clarification of relevant terminology, then will review design and integration features of radiography mixed methods studies, using a case study to explore integration in more detail. The article will conclude with key learning points to address in future radiography mixed methods studies.

Clarification of terminology

In research publications the terminology applied to mixed methods research is frequently confusing, often used interchangeably with the term 'multimethod'.[16] In a multimethod study, a series of complementary methodologies (not necessarily qualitative and quantitative methods) are employed to address a common overall research goal, however the data and findings are not integrated as they are within a mixed methods study.[16] Some form of mixing or interrelating the data provides a better insight into the research question than either collecting only quantitative or qualitative data or collecting both forms but not integrating them.[4] Further confusion arises from the use of the term 'mixed methods systematic review'. This does not imply a review of mixed methods research studies, rather it is a review which may include both qualitative and quantitative primary studies. Nevertheless, a rigorous convergent approach to combining the qualitative and quantitative evidence is required in a mixed methods systematic review,[17] not dissimilar to that undertaken within a mixed methods study. Similarly, the term 'mixed methods surveys' is often used inappropriately to refer to a questionnaire which gathers numeric data alongside limited text-based data sourced from 'open ended' text boxes. While valuable for expanding on some quantitative responses, these text boxes are unlikely to produce the richness of data required in a qualitative study. Researchers should instead refer to a quantitative survey with additional free text options that may be analysed through content analysis.

Mixed method approaches

The quantitative and qualitative phases of a mixed methods study are opposing in their epistemological and ontological approaches, yet researchers need to demonstrate which underpinning philosophy supported them to frame, address and provide answers to the research questions.[18–20] Fourteen philosophies underpinning mixed methods research are highlighted by Onwuegbuzie & Corrigan,[21] including the four major paradigms of pragmatism, critical realism, transformative-emancipatory, and dialectical pluralism[22,23]; pragmatism is the most commonly cited philosophical approach.[18] The aim of this paper is not to describe the respective philosophies, however a most recent publication,[24] provides a useful table that compares the philosophical assumptions and stances of the most common mixed methods research-based philosophies.

Mixed methods frameworks incorporate one of three 'basic' designs: triangulation (also known as convergent parallel), explanatory sequential, and exploratory sequential,[19] displayed in Fig. 1 with illustrative examples from radiography practice. The basic designs can be embedded into more complex advanced frameworks; often larger studies with multiple phases which may incorporate case studies or interventions into their design. These advanced frameworks facilitate more complex real-world investigations.

Mixed methods design in radiography

To explore the adoption of mixed methodologies in radiography, a search of the three international radiography journals which publish both therapeutic and diagnostic radiography research (*Radiography; Journal of Medical Radiation Sciences; Journal of Medical Imaging and Radiation Sciences*) was undertaken. The keywords and truncation "mixed method*" (inclusive of mixed method(s) and mixed methodology) was used to search titles and abstracts of papers published between January 2013 to October 2025. This was not intended to be a systematic search for all published mixed methods papers; any radiography mixed methods studies published outside these disciplinary journals will be excluded.

The search identified 28 articles. Two papers were subsequently excluded, having used the term mixed methods in the title to refer to a survey with open and closed questions.[25,26] Twenty-six articles were submitted for full text review,[27–52] with twelve (44 %) specifically referring to mixed methods in the title. The key features of the 26 mixed methods designs are displayed in Table 1. This analysis showed that many author teams were large (mean of 5), though 3 articles were single authored.[39,43,45] The studies were drawn from both therapeutic radiography (n = 11, 42 %) and diagnostic radiography (n = 15, 57 %) settings. Ten of the articles (38 %) indicated the study had received funding, though several appeared to be small internal grants. The focus of the studies was varied but all could be categorised into one or more of the following topics: workforce (n = 16, 61 %), clinical (n = 7, 27 %), and education (n = 7, 27 %).

Exploration of the study designs highlighted that the majority (n = 18, 69 %) included two data collection elements (one qualitative, one quantitative). Two of the studies included only qualitative[37] or quantitative[48] data collection; these studies are more appropriately framed as multimethod designs. Surveys and questionnaires were the most deployed quantitative methods, though validated outcome measures[36] and quantitative scales[41,43,48,52] also featured. Two innovative quantitative approaches included the collection of time-motion data in a study of imaging assistants,[35] and a national mapping exercise,[47] also focussing on Assistant Practitioners. The most deployed qualitative methods were interviews and focus groups, with one study reviewing posts on a discussion forum.[49]

Fourteen (54 %) of the articles explicitly referred to integration at the design level; those that did not were sometimes challenging to categorise. The most common integration designs were convergent (11, 42 %) and explanatory sequential (13, 50 %); only one study[37] used an exploratory sequential design, and one study

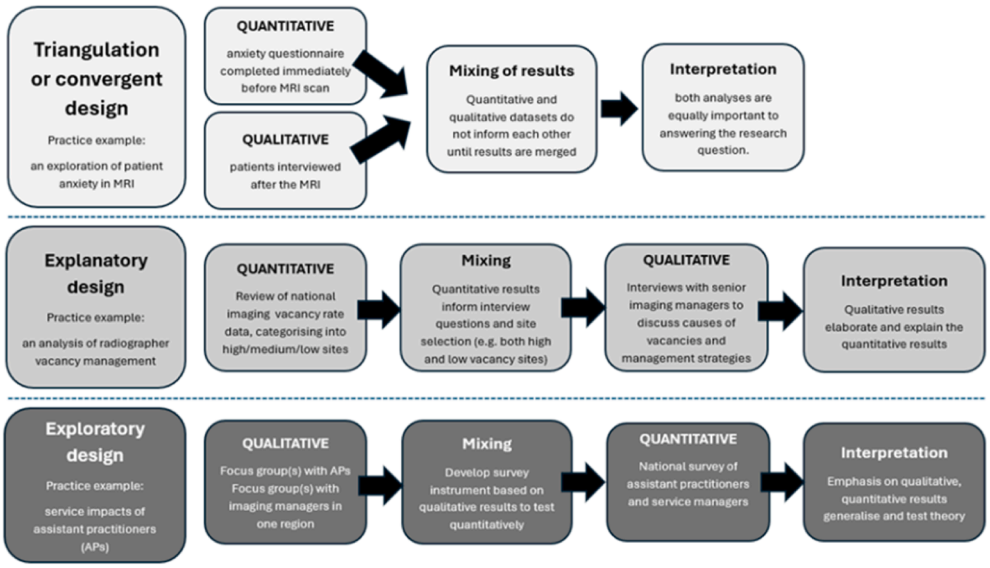

Figure 1. The basic mixed methods designs are illustrated with fictitious radiography research examples. Adapted from Plano–Clark et al. (2008).[23]

an exploratory embedded design.[31] Five studies also appeared to include advanced frameworks in their design, including one participatory design,[29] and four intervention designs.[36,41,43,48] With the exception of one of these studies which had a single author,[43] studies employing these more advanced designs had a minimum of three authors which corresponds with the expected greater complexity of these designs.

Integration and inference quality in mixed methods studies

Researchers often collect quantitative and qualitative data but do not explain how their findings are integrated[53]; meaningful integration (mixing) allows the realization of the true benefits of a mixed methods design.[54] Researchers therefore need to demonstrate how the quantitative and qualitative paradigms are integrated at various stages of the study through triangulation, complementarity and development in a multi-strategy approach.[3,53] Fetters et al.[8] outlines key integration principles at three levels (design, methods and interpretation and reporting) and provides illustrative examples of how it is achieved (Table 2).

Integration at the design level will depend on the type of basic or advanced design used to address the research question, with method level integration linking data collection methods and analysis from one study stage to another.[8] Integration at the interpretation and reporting levels is most frequently achieved through narrative reporting, but also in innovative designs using data transformation or joint display, where quantitative and qualitative findings are simultaneously displayed.[8] The 'themes-by-statistics' table is the most used approach, typically reporting categorical data (e.g. high/medium/low quantitative scores) to organize the presentation of themes or quotes.[54] Readers requiring a more detailed overview of integration may wish to explore a comprehensive virtual special issue on this topic in the Journal of Mixed Methods Research edited by Guetterman et al.[55]

In a mixed methods report or article, best practice is to include an integration section to describe the approach and any insights and inferences gained through the mixing of data.[54] An inference is a conclusion reached on the basis of evidence and reasoning; three inference processes may occur (quantitative inferences, qualitative inferences and integrated meta-inferences), each requiring transparent consideration of aspects of rigour such as validity and credibility that are suitable for the methods used.[54] Younas et al. define meta-inferences as the *"overall conclusions drawn from the merging of qualitative and quantitative inferences that reveal unique insights which could not be achieved by either approach alone"*[56,p2]. These meta-inferences have the potential to represent the "added value" of mixed methods research; they are not simply summaries of quantitative or qualitative findings but rather synthesized conclusions that connect or integrate both strands of the research.[56]

Integrative frameworks were recommended by Tashakkori and Teddlie as an effective way to describe the inference quality of mixed methods research, whereby good inference implies that the mixed methods used are credible.[57] A contemporary framework by Younas et al. classifies meta-inferences into two broad types (global and specific) and five sub-types (relational, predictive, causal, comparative, and elaborative),[56] and this may support researchers to better articulate meta-inferences gained during analysis.[56] Greater inference credibility arises where findings from both types of data confirm each other, known as confirmation or concordance, or findings may diverge but contribute additional understanding of the phenomenon under investigation.[8] Discordant findings, however, occur when the two types of data are *"inconsistent, incongruous, contradict, conflict, or disagree with each other"*,[8,p2144] requiring further action such as additional data gathering, re-analyses or seeking explanations from theory.

Guidelines for reporting mixed methods studies

An assessment of mixed methods rigour and inference quality may be required by journal or funding panel reviewers, by researchers assessing inclusion of a study within a systematic review, and by practitioners and policy makers considering adoption of findings into practice. However, Guetterman et al. note that for mixed methods studies *"a unified and common set of quality criteria remains elusive"*.[58],p6 Currently there are no published appraisal tools specifically designed for mixed methods appraisal in the collections of toolkits commonly accessed by researchers (e.g. JBI, CASP, EQUATOR),[59–61] although the Consolidated Checklist for Reporting Mixed Methods Research (CORMIX) by Jaam et al.[62] is currently under development. Useful quality criteria by O'Cathain et al., 2008[5] and Hong et al.[63] are available currently to guide

Table 1
Examples of radiography mixed methods designs. Key * DR= Diagnostic Radiography; TR=Therapeutic Radiography; W=Workforce and services; E=Education; C=Clinical.

Publication and citation	Author no.	Funding	Radiography Focus	MM in title	Phase no.	Methods	Integration - Design				
			* DR / TR / W / E / C	Present? Y/N			Explicit? Y/N	Triangulation/ Convergent	Exploratory sequential	Explanatory sequential	Advanced frameworks
Wright et al., 2014[27]	4	N	Fitness to practice TR, W, E	Y	2	Focus group, frequencies	N		X		
Carlier et al., 2023[28]	4	N	Autistic patients DR, C	N	2	Survey, interviews	N			X	
Probst et al., 2014[29]	4	Y	Developing resilience TR, W	N	3	Survey, interviews workshops	Y	X			Participatory
Cooke et al., 2025[30]	5	Y	Education CPD needs TR, W, E	Y	3	Survey, interviews, focus group	Y			X	
Nightingale et al., 2022[31]	6	Y	Gender influences TR, E	Y	2	Focus groups, survey	Y		X		
Lewis et al., 2025[32]	5	N	Research careers DR, W	Y	2	Survey, interviews	Y	X			
Hudson & Heales, 2023[33]	2	N	MRI staff perspectives DR, C	Y	2	Survey, focus group	Y	X			
Pallin et al., 2022[34]	8	Y	Public health resources TR, W, E	Y	2	Survey, interviews	Y			X	
Pinson et al., 2023[35]	6	N	Role of assistants DR, W	Y	2	Time motion data, interviews	Y			X	
Lundin et al., 2025[36]	3	Y	Radiotherapy masks RT, C	Y	3	Outcome measures questionnaire, interviews	Y	X			Intervention RCT
McBride et al., 2024[37]	10	Y	Mammogram participation DR, C	N	2	Systematic review, interviews (no quant)	Y	X			
Coleman et al., 2024[38]	3	Y	Sonographer supervision DR, W	Y	2	Survey, focus groups	N			X	
Turner, 2019[39]	1	N	Awareness of Sexual health TR, W	Y	2	Questionnaire, focus groups	N			X	
Huang et al., 2025[40]	11	Y	Radiology image sharing DR, W	Y	2	Surveys, interviews	N			X	
Karimi et al., 2025[41]	3	N	Simulation design DR, E	Y	3	? scales, interviews, focus groups	N	X			Intervention
Sundland et al., 2024[42]	2	N	Mobile services DR, W	N	2	Dataset analysis, interviews	Y	X			
Shiner, 2019[43]	1	N	Simulation preparedness DR, E	N	? 4	? scales, focus groups, questionnaire, interviews	N	X			Intervention
Lemon et al., 2023[44]	8	N	Staff resilience DR, W	N	2	Questionnaire, interviews	Y	X			
Vils Pedersen, 2022[45]	1	N	Research motivation DR, W	N	2	Survey, focus group	N	?			
O'Connor et al., 2023[46]	4	N	Clinical Educator retention DR, W	N	3	Survey, focus groups, interviews	Y			X	
Stewart-Lord et al., 2013[47]	3	N	Assistant practitioner DR, W	N	3	Mapping, survey, interviews	N			X	
Butlin et al., 2015[48]	4	N	Anxiety Coaching TR, W, E	N	4	Scale, questionnaire x 3 (no qual)	N			?	Intervention
Kobe et al., 2018[49]	3	Y	Critical incidents TR, W	N	2	Survey, discussion forum	N			?	
Gadeka & Esena, 2019[50]	2	N	Quality of care DR, C	N	2	Questionnaire, interviews	N			X	
Brown et al., 2021[51]	3	Y	Prostate patient care TR, C	N	2	Questionnaire, interviews	Y			X	
Nixon et al., 2018[52]	8	N	Mask anxiety TR, C	N	2	Quant scale, interviews	Y	X			

Table 2
Approaches to integration of mixed methods studies, adapted from Fetters et al.[8]

Level	Approach	Type	Description
Design	Explanatory design	Early	Early integration allows the qualitative phase to build on the initial quantitative phase
	Exploratory design	Early	Early integration allows the quantitative phase to build on the qualitative phase
	Triangulation	Late	Late integration of both datasets to compare results
	Advanced frameworks	Variable	Integration may be embedded at different stages throughout these more complex designs
Methods	Connecting	–	Data linked through sampling
	Building	–	One data collection method informs the other
	Merging	–	Data is collated for analysis (e.g. framework analysis)
	Embedding	–	Analysis is linked at multiple points
Interpretation and reporting	Narrative	Weaving	Qualitative and quantitative findings reported together on a theme-by-theme basis
		Contiguous	Presentation of findings within a single report, but the qual and quant findings are reported in different sections
		Staged	Often occurs in multistage mixed methods studies results of each step reported in stages as the data are analysed and published separately.
	Data Transformation	Two stages	1. One type of data must be converted into the other type of data (i.e., qual into quant or quant into qual). 2. The transformed data are then integrated with the data that have not been transformed. (e.g. content analysis to count codes or participants).
	Joint displays	Visual	Bringing data together through a visual means to draw out new insights beyond the information gained from the separate quant/qual. e.g. a figure, table, matrix, or graph which combines both qualitative and quantitative analysis.

mixed methods appraisal, alongside a field-specific reporting tool for use in rehabilitation settings.[64] No reporting or appraisal tool is available for the radiography field.

Integration and reporting in radiography mixed methods studies

Further analysis of the 26 radiography studies[27–52] enabled evidence of integration to be displayed in Table 3. Fourteen (54 %) of the articles were explicit about integration at design level, yet integration at the methods (n = 8, 31 %) and reporting levels (n = 2, 8 %) was rarely documented; it was challenging to identify and categorise where integration occurred. At the methods level, one third of the studies did not appear to integrate, however there was some evidence, albeit limited in many cases, of connecting (n = 8, 31 %), building (n = 6, 23 %) and merging (n = 7, 27 %) in the remaining articles. Only one study appeared to use an embedding method, with qualitative data the primary focus.[27] Articles presenting a larger number of data collection phases[29,43] lacked clarity on the order in which these phases occurred and how one phase impacted upon the next.

At the reporting level of integration, the majority adopted limited features of narrative integration, though few explicitly discussed qualitative and quantitative findings together. No study attempted data-transformation and only one study (Pinson et al.)[35] presented a joint display in the form of a 'side by side' table. Pinson's study[35] was the most explicit about integration processes, perhaps resulting from the adoption of a mixed methods reporting tool.[5] This suggests that the use of specific guidelines may raise the quality of mixed methods reporting.

Meta-inferences are the new insights that emerge from the mixing of qualitative and quantitative data. Only three articles (12 %) were explicit about any meta-inferences,[30–32] although some displayed features of convergence (n = 9, 35 %), expansion (n = 6, 25 %) and complementarity (n = 4, 15 %), with just one study suggestive of divergence.[44] Without explicit highlighting of meta-inferences, authors are missing an opportunity to demonstrate the new insights that have been gained from merging the qualitative and quantitative data; this is the essence of mixed methods research. With these limitations in mind, the following case study highlights the potential benefits of integration and meta-inferences in radiography mixed methods research.

A case study example from radiography research

Driven forwards by the on-going workforce shortages in imaging settings, the 'I-SWAP' study (Imaging Support Workers and Assistant Practitioners)[65] was implemented in the National Health Service in England to answer the following research questions:

- *What models of deployment of the support workforce exist within diagnostic imaging departments?*
- *What service, hospital, regional and national factors may encourage or inhibit implementation of these models?*

With an absence of published evidence to draw upon, the study was realist[66] and exploratory in nature, with the primary justification for selecting a mixed methods design being a clear need for both quantitative and qualitative elements to answer the research questions. The research team needed first to quantify how many imaging support workers were employed within the NHS, at what grade, in which modalities, and importantly what proportion of the imaging workforce they constituted. Building on this support workforce modelling, qualitative work packages explored the different models of deployment, why they were used, what worked and what didn't work in different settings, and what factors might encourage or inhibit transformation of the support workforce. Sufficient funding was secured to resource a 27-month study,[67] establishing at the outset a research team incorporating qualitative, quantitative and mixed methods expertise which strengthened rigour in each research phase.

Integration at the design level was achieved through a multistage advanced framework, incorporating an explanatory sequential basic design which enabled qualitative workstreams to enrich the understanding of an initial quantitative data workstream (Fig. 2). One of the workstreams, focusing on imaging service managers, included a more complex embedded or 'nested' design[8]; this phase was primarily qualitative, but incorporated quantitative support workforce data collection, for example headcounts and grades. This workforce data was discussed within the interviews, enabling a deeper understanding of the service

Table 3
Reporting of integration within radiography mixed methods studies.

Publication	Radiography Focus	Integration - Methods					Integration - Reporting				Meta-inferences				
	DR = Diagnostic radiography TR=Therapeutic radiography W=Workforce/services E = Education C=Clinical	Explicit? Y/N	Connecting	Building	Merging	Embedding	Explicit? Y/N	Narrative	Data trans-formation	Joint display	Explicit? Y/N	Convergence	Divergence	Complemen-tarity	Expansion
Wright et al., 2014[27]	Fitness to practice TR, W, E	N				X	N	X			N	?			
Carlier et al., 2023[28]	Autistic patient services (DR)	Y	X	X			N	X			N	X			
Probst et al., 2014[29]	Developing resilience (TR)	Y			X		N	?			N				
Cooke et al., 2025[30]	Education CPD needs (TR)	Y	X		X		N	X			Y	X			X
Nightingale et al., 2022[31]	Gender influences (TR)	Y		X			N	X			Y	X		?	
Lewis et al., 2025[32]	Research careers (DR)	Y			X		N	?			Y	X			
Hudson & Heales, 2023[33]	MRI staff perspectives (DR)	N					N	?			N	X			
Pallin et al., 2022[34]	Public health resources (TR)	N					N				N				
Pinson et al., 2023[35]	Role of assistants (DR)	Y	X		X		Y	X		X	N	X			X
Lundin et al., 2025[36]	Experience of RT masks (RT)	N					N	X			N	X			X
McBride et al., 2024[37]	Mammogram participation (DR)	N			?		N	?			N			X	
Coleman et al., 2024[38]	Sonographer supervision (DR)	N	X				N				N				
Turner, 2019[39]	Awareness of Sexual health (TR)	N		X	X		N	X			N	X			
Huang et al., 2025[40]	Radiology image sharing (DR)	N					N	X			N	?			
Karimi et al., 2025[41]	Simulation preparation (DR)	N			?		N	X			N	?			
Sundland et al., 2024[42]	Mobile services (DR)	N			X		Y	X			N			X	
Shiner, 2019[43]	Simulation preparedness (DR)	N	X	X			N	X			N			X	
Lemon et al., 2023[44]	Staff resilience (DR)	N					N	X			N		X		X
Vils Pedersen, 2022[45]	Research motivation (DR)	N			?		N	X			N	?			
O'Connor et al., 2023[46]	Clinical Educator retention (DR, W)	N	X				N	X			N				X
Stewart-Lord et al., 2013[47]	Assistant practitioner (DR)	Y	X	X			N				N				
Butlin et al., 2015[48]	Anxiety Coaching (TR)	N			?		N	X			N			?	
Kobe et al., 2018[49]	Critical incidents (TR)	N		X			N	X			N				
Gadeka & Esena, 2019[50]	Quality of care (DR)	N					N				N	?			
Brown et al., 2021[51]	Prostate patient care (RT)	Y	X		X		N	X			N	X		X	
Nixon et al., 2018[52]	Mask anxiety (RT)	N					N				N				X

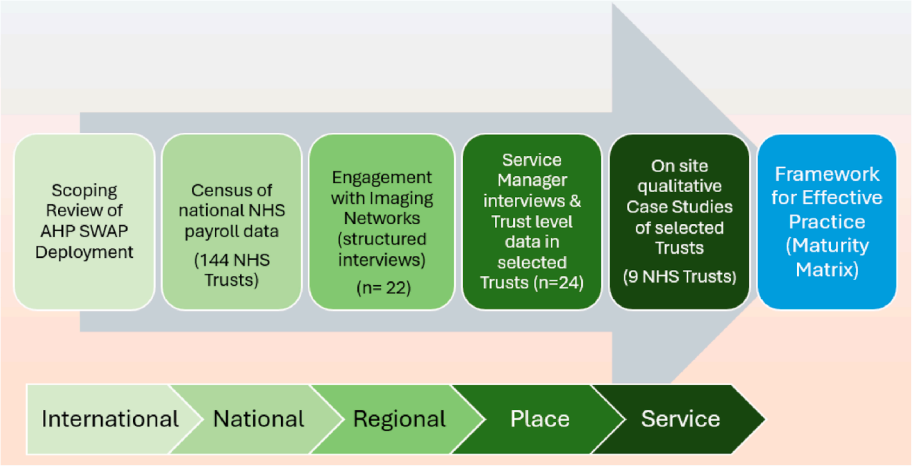

Figure 2. I-SWAP multi-phase explanatory sequential mixed methodology design. Adapted from Nightingale et al., 2025.[65] The workstreams gradually narrow down from a broad international perspective through to a more nuanced service perspective. Key: AHP = Allied Health Professions; SWAP = Support Worker and Assistant Practitioner.

level approach to deployment. Analysis of these two components was undertaken simultaneously by extracting both datasets into a matrix following a framework analysis approach.[68] This nested design enabled a much richer understanding of deployment decisions.

Integration at the methods level included building and connecting,[8] incorporated into the study design at the outset (Fig. 3). The scoping review[69,70] and payroll census[71] findings shaped the interview questions for imaging network representatives and service managers (building).[72] Similarly, findings from these service managers shaped the design of the question schedules for the qualitative case studies,[73] ensuring that the 'golden threads' captured in early workstreams were embedded throughout the entire study and were not lost in the latter stages. Integration was also achieved through connecting the workstreams via their sampling strategies (Fig. 3). Analysis of the payroll census data[71] enabled the team to rank organisations based on the level of deployment of support workers. This ranking system created an evidence-informed sampling frame for stratified sampling of 24 sites for the service manager phase, ensuring that selected sites reflected the full range of potential deployment approaches. The sampling frame was used again to impartially identify nine representative case study sites for the final data collection phase. This sampling frame reduces selection bias when compared to convenience or purposeful sampling strategies[74] such as requesting sites to volunteer their participation.

As is commonplace in large-scale multi-stage studies, findings from three of the workstreams were published separately (narrative staged approach[8]) enabling timely dissemination of findings. Two workstreams were published together in a single article as the use of framework analysis[68] highlighted significant overlap in the qualitative findings.[72] The findings from each workstream were then integrated using O'Cathain's Mixed Methods Matrix approach[75] to create a determinant framework,[76] a visual representation of the headline findings which supports easier interpretation. This framework was reviewed by the lead investigator alongside a health policy researcher, independent of the research team, to encourage unbiased reporting. Fifteen critical determinants were identified, these being causal factors which control or influence the likelihood of effective imaging support worker deployment. The determinant framework was developed into a Maturity Matrix, a model for assessing and improving the maturity of health care services,[77] presenting a series of discrete iterative steps that represent a desired evolutionary path towards

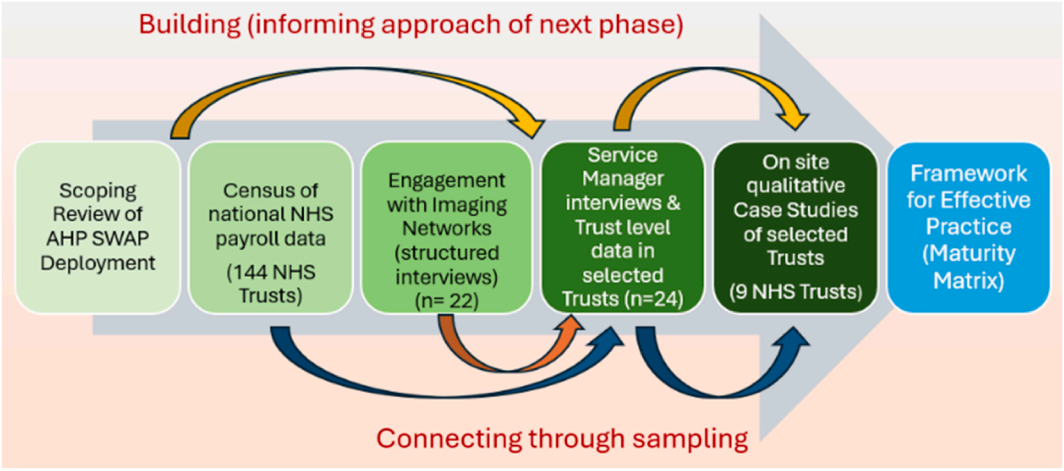

Figure 3. Mixed methodology integration approaches embedded within the research design. Adapted from Nightingale et al., 2025.[65] Yellow arrows indicate the building of earlier findings into the design of subsequent data collection instruments. Blue arrows indicate how earlier phase findings influence the sampling strategy (site selection) for later phases. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

excellence or effectiveness. The matrix design was the culmination of the mixed methods study, supporting imaging leaders to understand, explain and predict influences on effective support workforce deployment in their setting.

In summary, the I-SWAP mixed methods study adopted an explanatory sequential basic design incorporated into a multistage advanced framework. This complex design efficiently addressed the research questions, enabling the 'golden threads' identified at each stage of the study to be captured and explored through a range of integration strategies embedded throughout the study. While quantitative and qualitative findings were published separately, the findings were subsequently presented in a combined report[65] following best practice reporting guidelines[5,78] with the integrated findings developed into an actionable tool to support strategic workforce planning.

Recommendations for future radiography mixed methods studies

In this paper, we identified 26 radiography mixed methods studies for further analysis, highlighting limitations in design, methods and reporting, including a distinct lack of integration. The radiography profession is not alone in failing to achieve rigour in mixed methods studies; systematic reviews in nursing,[6,9,11] and education[14] have also highlighted a lack of meaningful engagement and explicit reporting of integration. In a 2024 bibliometric analysis of three radiography journals, mixed methods studies had the lowest prevalence (5 %) of all research types.[79] This lower adoption of mixed methods studies may be because they are complex to design and conduct and require significant resource in terms of personnel, knowledge and expertise, time and funding. Only ten of the 26 studies had received any funding, and these appeared to be small external grants (less than £10,000) or internal awards; securing funding for radiography research is known to be challenging.[80,81] This is likely to be insufficient to properly resource researcher time for a mixed methods study. Appropriate knowledge and methodological expertise is more likely to be found within a larger research team, including those with specific research training. Radiography pre-registration and post-registration awards, while introducing both qualitative and quantitative research, are unlikely to focus on mixed methods designs. Similarly, radiographers embarking upon doctoral level study may elect to follow either a qualitative or a quantitative approach, with fewer electing a mixed methodology. This suggests that radiography researchers will need to upskill through continuing professional development, and this paper has signposted researchers to recommended literature on how to successfully conduct and report mixed methods studies. The following recommendations summarise the approaches outlined above, signposting to examples of further reading where relevant:

- Radiography researchers seeking an initial introduction to mixed methods research are signposted in the first instance to articles providing helpful overviews.[82,83] For those requiring a more detailed understanding, core texts[18,22] will be informative when read alongside methodology papers previously highlighted.[8,23,55]
- Ensure a coherent philosophical underpinning of mixed methods studies[23] that enables the researcher to frame appropriate study aims and research questions that may be effectively answered through a mixed methods approach.
- Justify and clearly articulate the specific mixed methods design and methods of integration[8,55] at the onset of the study and ensure the study aims align with the selected mixed methods design.
- Make explicit the way in which integration was applied at design, data collection, data analysis and reporting stages of the study.[8]
- When reporting mixed methods studies, utilise appropriate tools[5,63,64] that make clear the quality criteria and how this enhanced the study to ensure trustworthiness.

Limitations

The search strategy did not intend to be a systematic search for all published mixed methods radiography studies. Caution should be applied as this search probably under-estimates the use of mixed methods studies in radiography. Any radiography mixed methods studies published outside the three selected disciplinary journals are excluded. Similarly, publications featuring the individual qualitative and quantitative components without specific reference to mixed methods in the title, abstract and keywords, would be unlikely to be identified. A single researcher conducted data extraction; the lack of clarity in many articles required judgements to made that may not be fully representative of each study. A full systematic search and review could be a useful follow-on study.

Conclusion

Mixed methodology research designs have been used successfully for over three decades to investigate and evaluate complexity in healthcare. While adoption in radiography has been limited, explanatory sequential and convergent/triangulation designs are increasingly being used to investigate a range of workforce and education research questions. Exploratory designs (qualitative followed by quantitative workstreams) and mixed methods advanced frameworks appear to be rarely undertaken by radiography researchers. While the individual quantitative and qualitative components in radiography mixed methods studies are invariably well-described, a lack of meaningful integration potentially compromises the attainment of the true benefits of a mixed methods design.

Generative AI use

Not applicable.

Ethics approval and consent to participate

This research did not require Institutional Review Board approval because it is a narrative review. The research cited within has been previously published elsewhere and cited accordingly.

Availability of data

Not applicable, this is a narrative review. No results are published.

Author contributions

JN: Conceptualisation; Methodology; Writing - Original Draft; Writing - Review & Editing; Visualisation.

ASL: Methodology; Writing - Review & Editing; Visualisation.

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Conflict of interest statement

JN is an Honorary Editor and ASL is an Associate Editor for Radiography, however, as authors of this submission they had no role in or visibility of the handling of the manuscript through the editorial or peer review process.

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