Development of the radiography evidence base:

An examination of advancing practice

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Keywords

Radiography; advanced practice; evidence-based practice; image interpretation; reporting; consultant practice

Abstract

Radiography has seen most development over the last 30 years with the evolution of new technologies, but perhaps more significantly changes in education models and radiographer roles. The development of advanced and consultant posts has facilitated the growth of the profession, although the evidence base is still evolving.

Through a number of research projects this thesis will explore the growth in the radiography evidence base with specific reference to the extending role of the radiographer in image interpretation. Parallel clinical and academic developments have provided evidence of a scholarly profession which is slowly establishing its place through publication and a growing research base.

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Appreciation also goes to Professor Neil Small, who acted as mentor for this process, for pushing me to wait until the latter publications were complete before submitting – it was the right thing to do.

Finally I must acknowledge the role of my employers and colleagues, for their unstinting support. Their receptiveness to the proposals for practice and role developments has enabled the rewards to be felt by the most important people ... patients.

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II	Hardy M, Snaith B, Smith T (2008) Radiographer reporting of trauma images: United Kingdom experience & implications for evolving international practice. *The Radiographer*. 55: 11-4.	R	***
III	Snaith B, Hardy M (2008) Radiographer abnormality detection schemes in the trauma environment – An assessment of current practice. *Radiography*; 14: 475-81.	R	***
IV	Hardy M, Spencer N, Snaith B (2008) Radiographer emergency department hot reporting: An assessment of service quality and feasibility. *Radiography*. 14: 301-5.	R	***
V	Hardy M, Snaith B (2009) Radiographer interpretation of trauma radiographs: issues for radiography education providers. *Radiography*. 15: 101-5.	R	***
VI	Hardy M, Snaith B (2011) The impact of radiographer immediate reporting on patient outcomes and service delivery within the emergency department: designing a randomised controlled trial. *Radiography*. 17: 275-9.	R	***
VII	Snaith B (2012) Collaboration in Radiography: A bibliometric analysis. *Radiography*. 18: 270-4.	R	*

VIII	Hardy M, Snaith B, Scally A (2013) The impact of immediate radiographic reporting on patient outcomes and service delivery within the emergency department: a randomized controlled trial. *British Journal of Radiology*. 86: 20120112.	R	***
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XI	Snaith B, Hardy M (2013) The perceived impact of an emergency department immediate reporting service: An exploratory survey. *Radiography*. 19: 92-6.	R	**

Key

R Refereed * Sole author ** Principal author *** Joint author

PROJECTS

Table 1: List of projects, chronology, publications and author contribution[1]

Project	Date	Article type[2]	Number	Contribution
Localised case studies	2005-12	Research	**I1**	BS developed, contributed to and evaluated the service redesign.
			IV	BS and MH designed the study, BS participated, MH and NS undertook data analysis, all contributed to the publication.
			XI	BS and MH designed the study, BS undertook data collection, BS and MH contributed to publication.
National role exploration	2007-8	Research	**II**	BS and MH designed the study, undertook data collection and analysis. BS, MH and TS contributed to publication.
			III **V**	BS and MH designed the study, undertook data collection, analysis and publication.
Role effectiveness	2008-12	Research	**VI** **VIII** **IX**	MH was chief investigator; BS was clinical lead and principal investigator for 2 hospital sites. Both contributed to data collection, analysis and publication. AS contributed statistical advice and analysis, JH contributed economic advice and analysis.
Radiography scholarship	2011-2	Research	**VII** **X**	BS conceived the idea, undertook data collection, analysis and publication.

[1] Contribution of individual authors is verified in Appendix 4
[2] As defined by CINAHL

CHAPTER 1

INTRODUCTION

1.1 Context

Radiography, the allied health profession (AHP), has developed its own identity over the latter part of the last century, having previously worked in the shadow of the related medical profession – radiology (Forsyth and Robertson 2007). Gaining graduate status in the 1990s (Slumming 1996; Pratt and Adams 2003) the move to higher education and resultant academic opportunities has supported the emergence of radiography, with its diagnostic and therapeutic disciplines, as a true profession.

1.2 Drivers for change

Over the last three decades radiographic roles have evolved, driven by technology, increasing workloads, growing financial pressures, workforce shortages and professional aspirations (Price, Miller and Mellor 2002; Royal College of Radiologists (RCR) and the Society and College of Radiographers (SCoR) 2007). With the need to improve patient access and reduce waiting times to diagnosis, imaging services at this time were seen as a critical service and ripe for change (Department of Health (DH) 2003; Woodford 2006). Unfortunately existing resources were unable to support service expansion and waiting list reduction and

the radiology profession was facing chronic staff shortages (RCR 2002). For radiographers this provided a key opportunity, as all healthcare professions were being challenged to develop new roles and break down professional barriers (DH 2000a; 2001).

The resultant imaging solution was a new career progression strategy for radiographers, colloquially termed the four-tier structure but more formally, entitled ‘radiography skill mix’ (DH 2003). This encouraged and enabled clinical staff to develop new skills and achieve advanced and consultant status, but also required the delegation of other tasks to a new tier of assistant practitioners.

1.3 Role developments

Changes in the diagnostic radiographer role were most pronounced in the 1990s with the breakdown of radiography-radiology boundaries (RCR and CoR 2007; 2012). This provided radiographers with opportunity to extend and advance their scope of practice including taking on procedural (undertaking barium, ultrasound and interventional examinations) and/or interpretational (independently reporting a range of examinations) tasks previously the domain of medical staff (Price and Le Masurier 2007). Initially roles were supported by in-house training and later underpinned by postgraduate and masters level education (Miller, Price and Vosper 2011).

However, radiographers were not alone in developing roles, other professions were also blurring traditional professional boundaries, supported by national workforce

strategies and pay structures for nursing (DH 1999a), AHPs (DH 2000b), diagnostic imaging (DH 2003) and the wider national health service (NHS) (DH 2000a). These expected patient-focussed roles, rather than the uni-professional or technological based careers of the past (Hardy and Snaith 2007) and career progression would in the future be related to increased responsibility (DH 1999b), rather than time served.

These developments established a non-medical career and skills escalator and introduced the concept of a four-tier structure, with assistant, practitioner, advanced and consultant levels, together with a more robust support workforce (DH 2001). As a result, senior clinical professionals have been able to achieve, in name, equal status with physicians as nurse or AHP consultants (DH 1999a; 1999c; 2000a). However, non-medical consultant roles are multidimensional, their core purpose being to promote and develop practice at clinical, strategic and policy levels (Higgins 2003). As leaders, consultants are expected to deliver clinical care at the boundaries of professional scope whilst developing staff and services in line with the evidence base (Price and Paterson 2002).

1.4 Research evidence

In parallel with the education and skill developments of the last 30 years, the need for a radiographic evidence base to support role development has been recognised (Nixon 2001; DH 2003; CoR 2005; 2010). Although numerous studies have demonstrated the ability of radiographers to undertake tasks previously performed

by medical practitioners, there remains a lack evidence of their clinical and cost effectiveness (Donovan and Manning 2006). Further, the broader radiography evidence base has been slow to evolve despite increased expectation of research and evaluation activities by clinical practitioners (advanced and consultant) and academics (Challen, Kaminski and Harris 1996; Nixon 2001; CoR 2005; Reeves 2008; Malamateniou 2009; CoR 2010; Harris 2011). These issues are not unique to radiography and other non-medical professions have reported similar concerns (Humphreys, et al. 2007; McKenna, Keeney and Hassan 2009).

This thesis explores radiography's growing evidence base through the publications of an individual and identifies their unique contribution to the subject knowledge and their resultant personal growth.

CHAPTER 2

SUBJECT KNOWLEDGE CONTRIBUTION

This chapter will place the publications submitted within this thesis (Appendix 1) in the context of the radiography knowledge base, whilst evidencing their contribution to the debate and evolution of the radiographic role. The place of these in radiography publications more broadly is discussed in chapter 3, whereas the impact and reach are examined more thoroughly in chapter 4.

2.1 Radiographer role evolution

Clinical radiographers have extended their scope of practice and in doing so have demonstrated a high level of procedural and interpretive accuracy, comparable to consultant radiologists (Brealey et al 2005), ensuring that standards of patient care and service quality are maintained. These developments have been widely adopted across the United Kingdom (UK) (Price and Le Masurier 2007; Price, et al. 2008; SCoR 2012), and increasingly internationally (Hardy, et al. 2008; Cowling 2008) and have created clinical capacity and/or reduced costs to meet NHS efficiency drives (Price et al. 2008).

2.2 Advancing practice

Radiographers embraced these new tasks as delegated by radiologists, in doing so they extended their professional scope rather than necessarily advancing their practice. The semantics associated with the terms 'role expansion and advancement' are important when understanding the skills required (Hardy and Snaith 2006). Although, there remains a lack of understanding of advanced practice, the confusion is even more apparent regarding consultancy (Price and Paterson 2002). Non-medical consultant roles were intended to seamlessly blend expert clinical practice and professional leadership, whilst embedding a workplace research and learning culture. To fulfil these multifaceted, and potentially, conflicting functions consultants have to master many different skills, often within complex relationships and organisations (Price and Edwards 2008).

Despite national role outlines and strategies, consultant posts have been slow to develop (SCoR 2009; 2012) – perhaps exacerbated by persisting reliance on procedural tasks rather than the wider responsibilities (Hardy and Snaith 2007; Price and Edwards 2008). It was expected that advanced and consultant roles would stimulate research engagement and activity, but this is also yet to be proven (Price et al. 2008). However, acknowledged gaps in research skills and confidence within the clinical workforce may be holding back appointments at consultant level (Price and Edwards 2008; Harris 2011).

2.3 Image interpretation

In diagnostic radiography the most prevalent role extension (and subsequent advanced practice) has been the interpretation of diagnostic images. Restricted from passing comment on image appearances in the 1920s (Price 2001), developments in radiography education enabled the recognition of abnormal injury and disease patterns. These skills were acknowledged by radiologists, radiographers and others, thus enabling radiographer image interpretation to commence afresh in the 1980s (Price 2001), although practice was initially significantly limited to preserve the time-honoured professional hierarchies. Donovan and Manning (2006) argue that radiographers remain limited in their ability to take on radiology roles because of a lack of medical training. However, the authors do acknowledge that in discrete areas such as the emergency department (ED) radiographers are developing clinical skills to support their practice. This is important because although the first radiographer reporting programmes were developed to prepare radiographers to only report on musculoskeletal trauma referrals (Loughran1994; Robinson 1996; Prime, Paterson and Henderson 1999), a wider clinical knowledge base is required to understand underlying disease processes (Paterson et al. 2004).

2.3.1 Radiographer Abnormality Detection Schemes (RADS)

In 1981 the first published trial of service innovation utilising radiographer image interpretation occurred in Ealing, UK (Berman, et al. 1985). This novel role

extension was in response to the recognised medico-legal issues of missed injuries in the ED and provided a risk management safety net. RADS allowed radiographers to highlight bony injuries on radiographs and communicate these findings on a paper pro-forma, but did not go as far as enabling radiographers to provide a definitive interpretation. This system evolved and radiographers started to flag abnormal radiographs with a red sticker, hence the recognised 'red dot' scheme. Over the next 20 years UK-wide surveys demonstrated its spread across the UK (Price, Miller and Mellor 2002; Price and Le Masurier 2007; **III**; SCoR 2012). However, the 'red dot' was not without issues (Thorne and Wainford 1999; Dimond 2000) and as radiography moved into higher education institutes (HEI), and the pathological knowledge base developed, there was increasing acceptance of the potential of radiographer image interpretation and frustration at the limited opportunities.

By 1993 the first UK reporting trials were being undertaken proving that radiographers could, with significant additional education, provide definitive reports in lieu of a radiologist (Loughran 1994). But mainstream practice for radiographers remained unchanged and the 'red dot' remained the standard for initial interpretation. No significant changes occurred until Snaith (1999) re-explored the use of a paper pro-forma RADS and the first radiographer commenting scheme was introduced. Over the next 5 years other such schemes evolved in the UK and Australia (Smith and Younger 2002; Keane 2010) and challenges to the historic red dot scheme were finally made. But comment schemes have been slow to be implemented in practice (Snaith 2003; **III**). Instead, RADS have remained

predominantly through the application of the ‘red dot’, despite **V** demonstrating that image interpretation is both taught and assessed within undergraduate education programmes which should have facilitated developments.

Over a decade after the development of the first commenting schemes it has now been accepted by the UK professional body that the ‘red dot’ is flawed (Kelly 2011). Further, the SCoR has recently confirmed it’s expectation that radiographers should contribute actively to the diagnostic process in the ED, with a preliminary clinical evaluation (PCE) being reaffirmed as a first post competency (SCoR 2013).

It was expected that by 2010 all radiographers would be providing a PCE (SCoR 2005), however an, as yet, unpublished 2011 survey suggests that the UK remains a long way from this aim (Snaith, Hardy and Lewis 2013). It will therefore be interesting to observe whether other countries such as Australia implement such strategies on a more systematic national basis, as they have recently adopted commenting as a national RADS standard, without first introducing the ‘red dot’ (D Collier – personal communication 2012).

2.3.2 Independent reporting

By the late 1990s reporting by radiographers was a mainstream, if geographically limited, task (Price, Miller and Mellor 2002). But radiographers continued to emulate historic reporting practices, despite their more direct contact with patients. The result was definitive reports, from both radiographers and radiologists, dictated

days or weeks after imaging (Audit Commission 2002), despite suggestions that radiographers could better influence decision-making by reporting images immediately (Robinson 1996; Brayley 2000). Immediate reporting was seen as an opportunity to supplement or replace RADS and negate the need for further radiology review of images. However, by 2007 immediate reporting was only achieved in a small number of hospitals (**II**).

Immediate reporting has been demonstrated to improve patient care with opportunity for service redesign (**I**; Henderson, et al. 2012). But if it is such a positive step, have the barriers to its introduction been the lack of evidence around its potential impact on report quality or service delivery?

Most evidence has been established around the work of Hardy and Snaith and was initially through a single site evaluation of the accuracy of immediate reports (**IV**). This demonstrated no significant difference in the quality of immediate reports in the ED compared to a later unpressurised environment with no time limitations (delayed reporting), a finding subsequently confirmed by Barker and Mackay (2007). If report quality is therefore perceived to be equivalent, the gap in the evidence base around immediate reporting appears to be around impact on service delivery and cost. As ED patient attendances cannot be manipulated around report sessions there is a requirement for a radiographer (or radiologist) to be available when workloads are unknown. In a randomised controlled trial (RCT) of immediate versus delayed reporting (**VI**) effectiveness was evaluated with respect to patient journey time (**VIII**), report discrepancies (**VIII**) and cost (**IX**). This

research provided the first definitive proof that immediate reporting can reduce ED and radiographer interpretive errors and the additional step does not delay patient care. Analysis also demonstrated that the eliminated recalls and smaller number of short term bed stays also reduced whole economy costs, even when the implementation costs to a radiology department are factored in. Although the impact of such a service on referring clinicians and radiographers has been shown to be very positive, it is perceived to reduce opportunities for other radiographers (**XI**).

2.4 Summary

Radiography has evolved over the last century from a technical role to that of a clinical expert. Advanced and consultant radiographers now provide leadership for services and, in collaboration with academic colleagues, contributing to the evidence base.

The unique contribution of the publications to the knowledge base has been to advance the understanding of radiographer role development, including identifying underpinning competencies, and evidence the spread and impact of skill mix.

CHAPTER 3

RADIOGRAPHY AND PUBLICATION

3.1 Evidence based practice

Despite the academic achievements and advances in clinical roles there remain questions regarding radiography as a research active profession, or whether this is left to a small number of interested individuals. The gap between radiography theory and practice has been highlighted by Baird (2008), who affirms the need for engagement in research or evidence-based activities.

Despite increased postgraduate education to support role developments, the number of radiographers completing a Masters degree appears limited (Marshall and Brennan 2010). It is also unclear whether developments have improved research and publication rates as a result of, or unrelated to, the promotion of advanced and consultant radiographer (together with senior academic and professorial) posts.

There is a clear understanding that the academic community is expected to undertake scholarly activity and increasingly progress their research skills to PhD level, but ongoing debate regarding senior clinicians, particularly whether doctoral education is justified for consultant radiographers (Manning and Bentley 2003; Lee, Gambling and Hogg 2004; Hardy and Snaith 2007; Forsyth and Maehle 2010; Harris 2011). With the move to increase the standing of radiography in the clinical

and HEI environments, it is perhaps disappointing that there remain very few doctorally qualified radiographers, with only 27 PhD theses completed or in progress (SoR 2013).

3.2 Evidence-base dissemination through publication

Although the number of radiography peer-review journals is relatively small, publication activity has increased, both at home and abroad (**VII**). Clinical radiography engagement in research, as measured through dissemination of articles, remains low, but appears to have been positively influenced by collaboration with peers and academic colleagues (**VII**, **X**). However, radiography authors remain predominantly academics or academic collaborators (n=519/835; 62.2%) (figure 1).

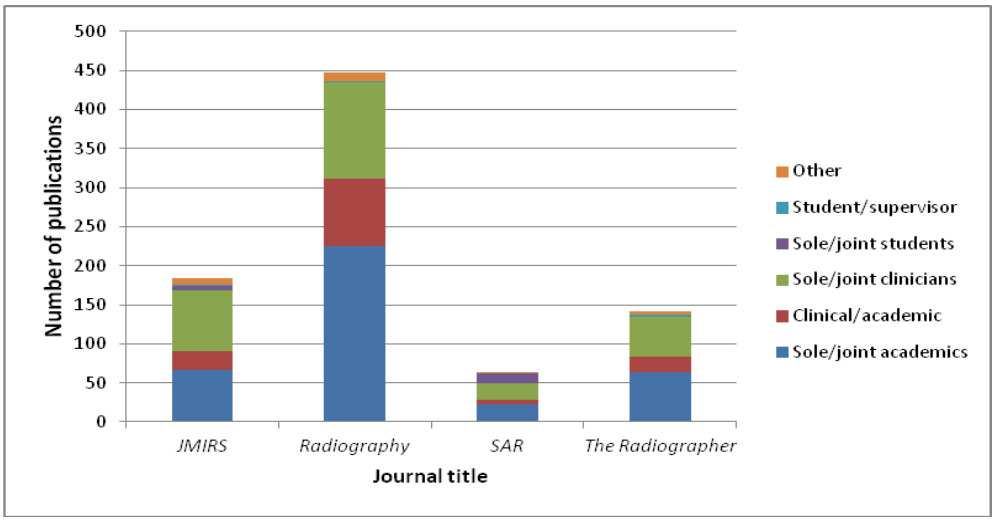

Figure 1: Author status across international radiography journals

3.3 Research and publication activity

Only limited investigation of AHP publication practices have been undertaken previously, including a United States mapping exercise and reviews of physical therapy and radiography journals (Schloman 1997; Wiles, et al. 2012). Radiography is a relatively young profession in terms of research (Harnett et al. 2008; Aaron, Baker and Gill 2010) which probably explains why the examination of authorship has been limited to date (Hogg, et al. 2011). Publications can be an indicator of research activity (Harnett, et al. 2008; Moed 2008) in terms of quantity and quality (Moed 2008; Hall 2011), but not impact (Nightingale and Marshall 2012). As radiographers publish in both disciplinary and wider journals assessment of total radiography research activity is difficult, however examination of radiography focussed publications can help understand the profession's scholarship and place the publications of an individual in context.

3.4 Author productivity

In relation to the research base of a profession or journal, examination of the author distribution has been used by others as a proxy of scholarly maturity (Tsay 2003; Askew 2008; Aaron, Baker and Gill 2010). Despite the large volume of papers reviewed for the bibliometric study of radiography journals (**VII**, **X**) the majority of authors contributed just one article (n=1012/1306; 77.5%), with only 9.4% of authors publishing more than twice over the 8 year period (n=123/1306). The most commonly cited metric of author productivity is the applicability to Lotka's law and

although this has been used within numerous studies (Pao 1985; Tsay 2003; Askew 2008; Tsai and Chi 2012), it has not previously been applied in radiography.

Alfred Lotka undertook his seminal research in 1926, examining physics and chemistry publications, suggesting that authorship within a mature profession followed an inverse square distribution with the number of authors writing *n* articles equating to $1/n^2$ of those publishing one (Tsay 2003; Askew 2008). In practical terms, Lotka's law implies that for every 100 authors writing 1 paper, only 25 will write 2, 11 write 3, etc. Although consistently reported in the literature as an inverse square distribution, Lotka actually found the value of the negative slope (exponent *n*) to be -2.02 in physics and -1.89 in chemistry. Later research suggests that it may lie between -1.2 and -3.8 but still allow correlation with Lotka's distribution, as an inverse power law (Askew 2008). This implies that productive authors will contribute disproportionately to the evidence base, as illustrated by Baker, Robertson-Wilson and Sedgewick (2003) in their review of sports psychology with 3% of the authors contributing 24% of the articles within their study.

Author productivity on a macro (professional) or micro (individual) level has not previously been examined in radiography. The better known bibliometric indices of impact factor (IF) and *h*-index, named after its creator Jorge Hirsch, are influenced by productivity but more by citation analysis (Baldock 2007; Kurmis and Kurmis 2010; Nightingale and Marshall 2012). The *h*-index has been shown to be inconsistent across disciplines due to differences in citation patterns (Kurmis and Kurmis 2010), but previous studies of academic authors' productivity in the

radiography related medical professions of radiology (Fuller, Choi and Thomas 2009) and oncology (Rad, et al. 2010) have demonstrated positive correlation with academic rank and faculty size.

3.5 Radiography and Lotka's law

Secondary analysis of the bibliometric data published as **VII** and **X** was undertaken to evaluate radiography productivity and place this thesis in context. The original data was compiled from 4 English-language journals covering diagnostic and therapeutic disciplines, the *Journal of Medical Imaging and Radiation Science* (Canada), *Radiography* (UK), *The Radiographer* (Australia – now the *Journal of Medical Radiation Sciences*) and *The South African Radiographer* (South Africa). Original and review articles, case reports and correspondence were included between 2004 and 2011.

Controversy exists in bibliometric research as to whether analysis of author productivity should include only the 'senior' author or all contributors (Pao 1985; Askew 2008) and whether authors should be whole or fractionally counted (Pao 1985; Ahmed and Rahman 2009). Convention within research is that the most senior author is listed last, although the radiography literature does not wholly support this premise, and therefore data for all authors was included. The least squares method was used to identify *n*, author frequency and goodness-of-fit were evaluated using the one-sample Kolmogorov-Smirnov (K-S) test for ranked data. The author data also allowed examination of the most productive in terms of

demographics (country, discipline, role and subject base) and collaboration. The total number of papers published, including those outside the studied journals, and author *h*-index for the same period were identified from Scopus (Elsevier 2013). Correlation between author productivity, collaboration and *h*-index was calculated using Spearman rank correlation coefficient (SPSS version 16.0; Chicago, USA).

3.5.1 Results and analysis

The results demonstrate that of the 1306 authors, 1012 (77.5%) published just a single paper and one individual was the first author on 19 articles (table 2).

Table 2: Distribution of radiography author productivity (all authors)

NP	Author(s)	TP	Accumulated publications (%)	Accumulated authors (%)
19	1	19	19 (0.95)	1 (0.08)
14	2	28	47 (2.35)	3 (0.23)
13	3	39	86 (4.30)	6 (0.46)
12	1	12	98 (4.90)	7 (0.54)
11	4	44	142 (7.10)	11 (0.84)
10	3	30	172 (8.60)	14 (1.07)
9	4	36	208 (10.41)	18 (1.38)
8	5	40	248 (12.41)	23 (1.76)
7	5	35	283 (14.16)	28 (2.14)
6	13	78	361 (18.06)	41 (3.14)
5	7	35	396 (19.81)	48 (3.68)
4	24	96	492 (24.61)	72 (5.51)
3	51	153	645 (32.27)	123 (9.42)
2	171	342	987 (49.37)	294 (22.51)
1	1012	1012	1999 (100)	1306 (100)

NP: Number publications; TP: Total publications

In order to determine the slope of the author distribution (the exponent *n*) the log of the publication and author frequencies were calculated (table 3).

Table 3: Calculation of the exponent *n*

NP (x)	**Author (y)**	**X (Log x)**	**Y (Log y)**	**XY**	**XX**
1	1012	0.00	3.01	0	0
2	171	0.30	2.23	0.67	0.09
3	51	0.48	1.71	0.81	0.23
4	24	0.60	1.38	0.83	0.36
5	7	0.70	0.85	0.59	0.49
6	13	0.78	1.11	0.87	0.61
7	5	0.85	0.70	0.59	0.71
8	5	0.90	0.70	0.63	0.82
9	4	0.95	0.60	0.57	0.91
10	3	1.00	0.48	0.48	1.00
11	4	1.04	0.60	0.63	1.08
12	1	1.08	0	0	1.16
13	3	1.11	1.48	0.53	1.24
14	2	1.15	0.30	0.35	1.31
19	1	1.28	0	0	1.64
Total	1306	12.22	14.14	7.55	11.65

The data in table 3 was used to calculate the constants n and c, where the number of data entries (N) is 15 and x represents the publications 1,2,3,...19.

$$n = \frac{N\sum XY - \sum X \sum Y}{N\sum X^2 - (\sum X)}$$ n = -2.334

Although the value of the exponent n is -2.3, higher than those derived by Lotka it lies within the limits previously described and implies that radiography authorship follows an inverse power distribution, with most authors publishing only one article and significantly smaller numbers contributing higher publication levels.

In order to compare this result with Lotka's law the fraction of authors expected to publish one paper within the sample (c) was calculated using Lotka's equation.

$$C = \frac{1}{\sum_{1}^{p-1} \frac{1}{x^n} + \frac{1}{(n-1)(p^{n-1})} + \frac{1}{2p^n} + \frac{n}{24(p-1)^{n+1}}} \qquad C = 0.712$$

Based upon Lotka's calculations and using the slope specific to radiography (-2.3) the data predicts that 71.2% of authors will publish 1 paper whereas the observed number was actually 77.5%. This figure can be applied to the distributed author data in a comparison of observed and predicted authorship values in the K-S goodness-of-fit test (table 4).

Table 4: The K-S test for radiography authorship

NP	Observed value	Accumulated observed value Sn(x)	Predicted value	Accumulated Predicted value Fo(x)	Absolute value Fo(x)-Sn(x)
1	0.7749	0.7749	0.7122	0.7122	0.0627[1]
2	0.1309	0.9058	0.1412	0.8534	0.0524
3	0.0391	0.9449	0.0548	0.9083	0.0366
4	0.0184	0.9632	0.0280	0.9363	0.0270
5	0.0054	0.9686	0.0166	0.9529	0.0157
6	0.0100	0.9786	0.0109	0.9638	0.0148
7	0.0038	0.9824	0.0076	0.9714	0.0110
8	0.0038	0.9862	0.0056	0.9769	0.0093
9	0.0031	0.9893	0.0042	0.9812	0.0071
10	0.0023	0.9916	0.0033	0.9845	0.0075
11	0.0031	0.9946	0.0026	0.9871	0.0062
12	0.0008	0.9954	0.0022	0.9892	0.0067
13	0.0023	0.9977	0.0018	0.9910	0.0067
14	0.0015	0.9992	0.0015	0.9925	0.0067
19	0.0008	1.0000	0.0007	0.9933	0.0067

NP: Number publications; [1]: maximum deviation (Dmax)

At the 0.10 level of significance (Black 2003) the critical threshold for Lotka's law is 0.0337. As the variation between expected and observed authorship, the Dmax (0.06), is larger than the critical threshold value (0.0337) it can be confirmed that radiography author distribution does not correlate with Lotka's law.

To identify the most prolific authors the 1306 were ordered by publication productivity (Harande 2001). Harande's original cut off (top 25) lay within a group of authors with 7 publications, therefore the 23 authors contributing more than 8 articles were selected for evaluation (n=23/1306; 1.8%). These 23 collectively authored 247 articles (range 8-19), 83.0% of which were collaborative (n=203/247) although the level of collaboration varied (table 5). As 38 of the collaborative articles represented articles co-authored with other prolific authors, there were 167 unique articles, 20% of the publications over the 8-year period (n=167/835).

The productivity of prolific authors was also ranked in relation to collaborative articles (table 5). To identify whether these authors were prolific only in radiography or had wider influence Scopus publication figures and *h*-indices for the same period were also identified.

Not all the journals are indexed on Scopus or any other single database and therefore some omissions of data are evident. One author (Middleton) has Scopus record of less than that identified within this study and therefore it is recognised that the data represents an underestimation of actual author activity.

Table 5: Details of prolific author publications

Author	Productivity		Collaboration		Total Articles[1]	*H*-index[2]
	NP	Rank	NP (%)	Rank		
Brennan, Patrick	19	1	19 (100)	1	75	8
Bolderston, Amanda	14	2	11 (78.6)	5	17	5
Hogg, Peter	14	2	14 (100)	2	17	4
Marshall, Gill	13	4	8 (61.5)	14	14	4
McEntee, Mark	13	4	11 (84.6)	5	38	5
Warren-Forward, Helen	13	4	13 (100)	3	20	5
Hardy, Maryann	12	7	12 (100)	4	13	5
Bentley, H Brian	11	8	1 (9.1)	23	9	0
French, John	11	8	5 (45.5)	21	11	5
Middleton, Mark	11	8	11 (100)	5	8	2
Poulos, Ann	11	8	9 (81.8)	8	16	6
Cox, Jennifer	10	12	9 (90.0)	8	21	5
Reeves, Pauline	10	12	6 (60.0)	19	13	3
Snaith, Beverly	10	12	9 (90.0)	8	11	5
Currie, Geoffrey	9	15	9 (100)	8	48	5
Davidson, Robert	9	15	9 (100)	8	11	4
Halkett, Georgia	9	15	9 (100)	8	34	8
Smith, Tony	9	15	4 (44.4)	22	18	5
Kurmis, Andrew	8	19	8 (100)	14	20	4
Nightingale, Julie	8	19	7 (87.5)	18	10	3
Palmer, Cathryne	8	19	8 (100)	14	10	4
Reed, Warren	8	19	6 (75.0)	19	9	3
Wheat, Janelle	8	19	8 (100)	14	45	5

NP: number publications; [1,2]: Scopus – limited to articles 2004-2011[accessed 27 February 2013]

These authors not only contributed the most articles to the journals examined, they also published widely, with a mean of 21 articles over the 8 years (range 8-75). Interestingly, Spearman rank coefficient of the ranked data demonstrated significant correlation between productivity and collaboration (rho=0.6; p=0.002).

Analysis of the author demographics (table 6) confirms the prolific authors to be radiographers, with the majority from the diagnostic discipline (16/23; 69.6%). Only 4 countries are represented, 3 of which publish the studied journals (UK, Australia

and Canada), the remaining two authors relocated from Eire within the study period. If recent location is used, then Australian authors predominate (13/23; 56.5%).

Although the UK journal *Radiography* published the majority of articles over the study period (n=447/835; 53.5%; **X**) the 23 most prolific authors only included 7 based in the UK (30.4%). In relation to article subject, the authors wrote on a range of topics, but the most frequently occurring diagnostic research interests/themes were role development and image perception (table 6).

Table 6: The characteristics of the most productive authors

Author	**Country**[1]	**Discipline**	**Affiliation**	**Recurring subject**
Bentley, H Brian	UK	Diagnostic	Academic	History
Bolderston, Amanda	Canada	Therapy	Academic	Radiotherapy
Brennan, Patrick	Eire/Australia	Diagnostic	Academic	Image perception
Cox, Jennifer	Australia	Therapy	Academic	Radiotherapy
Currie, Geoffrey	Australia	Diagnostic	Academic	Nuclear medicine
Davidson, Robert	Australia	Diagnostic	Academic	Computed radiography
French, John	Canada	Therapy	Manager	System improvement
Halkett, Georgia	Australia	Therapy	Academic	Patient education
Hardy, Maryann	UK	Diagnostic	Academic	Role development
Hogg, Peter	UK	Diagnostic	Academic	Nuclear medicine
Kurmis, Andrew	Australia	Diagnostic	Academic	Orthopaedics
Marshall, Gill	UK	Diagnostic	Academic	Research
McEntee, Mark	Eire/Australia	Diagnostic	Academic	Image perception
Middleton, Mark	Australia	Therapy	Manager	Radiotherapy
Nightingale, Julie	UK	Diagnostic	Academic	Role development
Palmer, Cathryne	Canada	Therapy	Academic	Education
Poulos, Ann	Australia	Diagnostic	Academic	Practice
Reed, Warren	Australia	Diagnostic	Academic	Image perception
Reeves, Pauline	UK	Diagnostic	Academic	Patient care
Smith, Anthony	Australia	Diagnostic	Academic	Rural health
Snaith, Beverly	UK	Diagnostic	Clinician	Role development
Warren-Forward, Helen	Australia	Diagnostic	Academic	Radiation protection
Wheat, Janelle	Australia	Therapy	Academic	Nuclear medicine

[1] in period 2004-11

3.5.2 Discussion

This study suggests that radiography, as represented by the 4 international journals, does not match the distribution of author productivity expected by Lotka's law when whole author count is used. It appears disappointing that only 22.5% of authors published more than 1 article, but the results are broadly in line with the expected level and consistent with other studies (Zainal and Zainab 2011; Serenko, et al 2011; Pulgarin 2012). It is perhaps more important to recognise that across 4 journals and 8 years, 20% of the publications (167 unique papers) were written by only 3% of the journal contributors. This skewed distribution is similar to the results of Baker, Robertson-Wilson and Sedgewick (2003) and demonstrates the potential level of influence that a relatively small number of individuals may have on a profession. This significant contribution of a small number to an individual evidence base is a common theme in the literature, and fuels the debate as to whether a discipline is influenced more by the limited volume of work produced by a broad body of scholars or the larger contribution of an 'eminent few' (Baker, Robertson-Wilson and Sedgewick 2003; Serenko, et al. 2011). Research has previously investigated the factors which influence this successful 'few' and cumulative advantage and superstar phenomenon have been proposed to explain their success including motivation, creativity, training and work habits (Serenko, et al. 2011).

Rather than the most prolific authors having only a positive contribution to the journals within this study, the data indicates their ongoing contribution to wider peer-review journals, with an average of 21 publications and *h*-index of 4.5. No

previous study of radiographer *h*-indices has been undertaken, but although lower than the average *h*-index identified amongst United States (US) academic oncologists (Rad, et al 2010), it is within the range for radiologists (Fuller, Choi and Thomas 2009). This suggests that the most successful radiographers (including *Snaith*) are working at a level equivalent to their medical peers. Citations are, however, dependent on subject and potential audience size, illustrated by the low *h*-index of Bentley, whose articles are predominantly historical commentaries. There is currently no specific benchmark for the *h*-index and a radiography level needs to be established as interdisciplinary comparison may be unfair (Baldock 2007; Watson 2009). Such benchmarking would need to be systematic in data extraction as the results of this study confirm the issues of indexing inconsistencies, although Scopus has previously been suggested as the most inclusive database (Meho and Rogers 2008; Nightingale and Marshall 2012).

It should be noted that a number of the most prolific authors are involved in the leadership of the journals studied, including current or previous editor-in-chiefs, including French (*JMIRS*), Bentley and Hogg (*Radiography*), and a further 12 (including *Snaith)* are members of one or more editorial boards. Editorial appointments are acknowledged to be the most productive or influential researchers in the field and as a consequence of such roles individuals may be more successful (Serenko, et al. 2011).

Academics, as solo or collaborative authors, are the most productive not only within the top 23, but also the whole author cohort, producing 62.2% of all articles, similar to previous studies (Hogg, et al. 2011; **VII**). Despite the drive for clinical

research, including a 10 year history of advanced and consultant radiographer roles in the UK, research activity is poorly evidenced. It is interesting however, that Canada has more clinical authors than academic (**X**), possibly as a result of their strategies to develop clinical research skills (Harnett, et al. 2008).

Inconsistency in recording author status between journals means that student work could not be accurately captured, but some clinical and/or academic authors may have published undergraduate or postgraduate work, either alone or with their supervisor. It is therefore not clear what proportion of co-authorship is academic supervision, but this provides an opportunity to develop writing skills and is encouraged (Marshall and Brennan 2008; Stockhausen and Turale 2011).

This evaluation of the literature has demonstrated correlation between co-authorship and productivity, confirming the findings of previous research (Harande 2001). The co-author may be a colleague, research collaborator or academic supervisor, but can positively influence productivity and increase citations and potentially the *h*-index (Figg, et al. 2006).

3.5.3 Conclusions

This publication analysis has provided an overview of research activity in radiography, and although it does not correlate with Lotka's law it demonstrates that the pattern of productivity matches other professions, with a significant number of one-time authors and small number of recurring author names. The international

profile of prolific authors evidences an evolving research base and confirms that research collaboration increases radiography productivity.

Bibliometrics is a relatively new field for radiography, however ongoing debate about productivity will require such methods to evidence the impact of current and future research strategies. Further debate about the anticipated level of scholarly activity, such as research and publication, by both academic and/or clinical radiographers is required to underpin future strategies.

CHAPTER 4

ASSESSING THE IMPACT

Whereas the previous chapters described the distinct contribution to the subject knowledge base, chapter 4 explores the impact on clinical practice and the radiography profession.

4.1 Impact

Traditionally the impact of an individual's work has been assessed by the volume of peer-reviewed publications and, potentially, quantitative analysis of citations with measures such as the *h*-index (Baldock 2005; Nightingale and Marshall 2012). Chapter 3 demonstrated that *Snaith* is a productive author in the radiography literature with a *h*-index of 5, 24 peer-review publications and a large number of peer-review presentations, unrefereed articles and books (appendix 2).

However, quantitative assessment can only indicate the potential impact of an individual whereas a qualitative review of citations can provide information regarding the true impact of published work (Davies, Nutley and Walter 2005; Nightingale and Marshall 2012). This has particular relevance currently, as the Higher Education Funding Council (HEFCE) requires universities to measure research impact at an individual and organisational level (HEFCE 2011). The forthcoming Research Excellence Framework defines *impact* as:

> "… an effect on, change or benefit to the economy, society, culture, public policy or services, health, the environment or quality of life, beyond academia"
>
> (HEFCE 2011, p4)

In a broader sense *impact* may be defined as influence or effect (Dictionary.com 2011). It may be measured by changes in radiography practice or policy including how widespread the changes have been felt. Therefore the publications submitted within this thesis will be considered in terms of *influence* and *reach.*

4.2 Influence

Citations to the articles included within this thesis were identified using the search engines Scopus, Proquest and Google Scholar. A broader review using the Google internet search engine identified 'grey literature' including books, government documents, online academic theses and magazines (Nightingale and Marshall 2012). In addition a search was performed of the SoR web pages for professional policy or guidance documents citing *Snaith*. A total of 40 unique citations were identified (appendix 2), 29 related to radiographer role development and 25 to image interpretation. The broader influence on practice and profession is more challenging, however key factors can be drawn from both citations and changes in professional policy.

The research projects included within this thesis provide current evidence of, and influence on, the evolution of the radiographer role in clinical practice. The

submitted work has been at the forefront of around changes in professional role, influencing scope, standards and monitoring implementation in practice.

Through publication *Snaith* and co-authors have demonstrated the accuracy of radiographer image interpretation (**I**; **IV**; **VIII**); demonstrated the clinical and cost effectiveness of immediate reporting (**VIII**; **IX**; **XI**); and provided evidence of spread (**II**; **III**; **V**).

The bibliometric evaluation of radiography publications (**VII**, **X**) provided the first evidence of radiographer scholarship at a national and international level and will provide a point of reference for future research. A single citation to the first paper has already been identified (in addition to self-citation in the later article), no other citations were identified to this work, although this is not unexpected given the contemporary nature of this research.

4.3 Reach

It is important in examining influence that it's spread is evaluated, in particular the geographical (local, regional, national and international) and professional (uni- or multi-disciplinary) reach of the published work.

4.3.1 Geographical reach

The UK has been at the forefront of radiographer role development and differences in education, healthcare systems and higher radiologist numbers in other countries may explain why progress has been slower elsewhere (Smith, et al. 2008; Freckleton 2012). Cowling (2008) suggests that countries where advanced roles are established could provide mentorship for the wider community, indicating the potential future requirements for, and continued impact of, the work presented within this thesis. Unsurprisingly, the majority of citations were within UK publications, including peer-review and unrefereed articles, professional documents and academic theses with common subjects being role development, image interpretation, advanced and consultant practice. Internationally, the citations have been identified within articles and policy documents in Europe (**III**; **V**; **IX**); United States (**VII**); Africa (**II**) and Australia (**I**; **II**). Many articles have been cited as exemplars of radiography roles in Australian policy review documents (**I**; **II**; **III**) including the establishment of commenting as a professional standard in Australia (D Collier, personal communication 2012).

4.3.2 Professional reach

It is not unexpected that little reference has been made to the work outside of radiography. The first of the bibliometric research articles (**XI**) has recently been cited within a study of author collaboration outside of radiography, recognising the common trends in publication.

4.4 Qualitative impact

Citations to published work may take a number of forms. Nightingale and Marshall (2012) describe a *seminal* citation as being influential to new understanding, whereas a *passing* citation may be within several grouped references in a literature review and a *comparative* citation provides a benchmark. They also conclude that a *positive* citation praises the quality of an article whereas a *negative* citation challenges research findings or methods. Using these headings table 7 (overleaf) identifies how the peer-review article citations listed in appendix 3 (excluding self-citations) have been used. Self-citations have been excluded to ensure the acknowledgements are representative of the wider body of knowledge within and out with radiography, rather than influenced by the individuals own work.

Table 7: An analysis of peer-review citations[1]

Citation[2]	Seminal	Passing	Comparative	Positive	Negative
Castillo, et al. (2011)	III				
Coelho, et al. (2011)				III	
Galevi (in press)		VII			
Henderson, et al. (2012)			I		
Howard (in press)		IV			
Kelly (2010)		I			
Kelly et al (2012)		III			
Knapp, et al. (2009)		IX			
Leishman (in press)		III, V			
Nunn, et al. (2011)		V			
Shi, et al. (2009)		I			
Smith S, et al. (2009)		III			
Stranden et al (2009)		V			

[1] Excluding author self-citations. [2] For full list of references refer to appendix 3

The majority of the citations indicate that the published work has predominantly been used as a *passing* citation.

4.4.1 Beyond citations

Citations play an important part in identifying the relevance of publications to other researchers. Nightingale and Marshall (2012) also identify the importance of understanding how articles are being read and they use article download data to model usage trends. Download activity for the *Radiography* journal on Science Direct identified 12 appearances of the articles included in this thesis in the top 25 quarterly download figures (**I**, **IV**, **V**, **VI**), demonstrating the regularity to which they are being read in practice.

4.5 Recognition

In relation to confirming the published work and author's role as a leader in the field, Adair (2003 p71) states that an individual cannot claim to be a leader until their knowledge and skills are recognised and accepted by others.

In the context of consultant leadership Hogg, Hogg and Henwood (2008, pe44) stated that:

> "Snaith has published several articles on how the future might look, some include fine details about practical implementation whilst others are broad and as such visionary. In one particular article Snaith envisions the future and demonstrates national political awareness."

Although only one specific article (Snaith and Hardy 2007) was cited, the additional articles in this thesis are likely to represent a number of the articles referred to.

In 2010, the award of an honorary Fellowship of the College of Radiographers evidences the authors' contribution to the profession. An excerpt from the citation reads:

> "Beverly Snaith is a consultant radiographer at the Mid Yorkshire NHS Trust. Her work in developing advanced radiographic practice in musculo skeletal imaging, particularly in trauma, has attracted international attention and has provided an inspirational lead for all members of the diagnostic imaging community in the UK … In her role, Bev has built a radiographic workforce using the four-tier model and demonstrated the benefits of multidisciplinary working in delivering the highest standards of service and efficiency. She has backed this work with extensive research and has been tireless in spreading good practice through publishing, training, and speaking throughout the UK and internationally."
>
> (Society of Radiographers 2010)

Describing meeting Hardy and *Snaith* during a UK visit, Eastgate (2011, p20) stated 'These names were well known to me from the literature relating to image interpretation' and further 'She (*Snaith*) brings real world experience to this team, and together they are formidable and unique.'

Recognising the global desire for image interpretation and role development, Johnson (2012, p20) describing Hardy and *Snaith's* presence at an international conference stated:

> "They both demonstrate such energy, passion and humility when sharing their skills and knowledge that I felt extremely proud and privileged to have been able to share their international sessions. There was a huge demand from other organisations to provide further information and support for their own radiographer role development."

The contribution to the development of knowledge and publication has also been acknowledged in the appointment as a joint guest editor of a special edition of *Radiography* on advanced and consultant practice. In demonstrating evidence of leadership of another of the editors (Kelly), Hogg, Hogg and Henwood (2008, pe41) describe the guest editor role as to 'define a vision, facilitate collaboration and influence/attempt to influence others.' .

CHAPTER 5

REFLECTIONS AND CONSIDERATION FOR THE FUTURE

5.1 Reflection on publishing

The published work within this thesis represents a proportion of the research and scholarly activity undertaken over a seven-year period and were chosen as they represent a specific theme. Further publications, both peer-review and unrefereed articles and books (appendix 2), provide additional support to the knowledge and ability of the author but are situated outside of this context.

5.1.1 Publication themes

The submitted works are framed around changes to the clinical radiographer role over the last decade, with emphasis on advancing practice and image interpretation. These publications have contributed to the developing evidence base which underpins skill mix changes within imaging. The bibliometric series of papers adds weight to these changes, demonstrating the growing evidence of clinical radiography scholarship alongside an established academic research base. However, this work also confirmed *Snaith* to be the only clinician amongst the most prolific authors (Chapter 3).

5.1.2 Research methodologies

Castle (2000) described radiography as an ‘academic tribe’ aligned with subjects where ‘primary outcomes are products and techniques (hard applied) with poorly defined boundaries influenced by neighboring subject areas (soft pure)’. This is mirrored in the personal choice of research methodologies with their positivist stance, using hard data collected through a range of methods.

The main research methods used within the submitted publications have been quantitative including action research; cross-sectional surveys and more recently bibiometrics and RCT. Such choice of research style is not unexpected in a science based profession such as radiography with it’s physics and numerical basis. Further, the literature provides evidence of variation between the diagnostic and therapeutic disciplines with diagnostic radiographers preferring quantitative research methods (**IX**). This may be influenced by their brief episodic contact with patients, with often only a single fleeting interaction, whereas those providing radiotherapy and oncological care may develop a relationship with individual patients over an extended period of time.

Radiography is, because of the potentially harmful effects of radiation, protocol driven and sits comfortably with the objective and outcome driven orientated characteristics of quantitative research. The reliance on fact and the determination of best practice drives the science of radiography, establishing rules and requirements – the empirical data, driven partly by radiation regulations and further by the need to standardise patient care.

A number of the publications have represented evaluations of practice changes from an insider perspective and presented unique challenges. Often using action research these have developed new knowledge whilst solving a service or clinical problem. The opportunistic nature of 'insider' research often means being an active participant, unable to achieve distance from the study and has benefitted from collaboration by providing external scrutiny and distance. This 'active intervenor' role making things happen in preparation for and during a research study is in contrast with traditional research approaches (Coghlan amd Brannick 2007 p33). This has been established through transformational change of services, studying the impact on patients and staff, thereby establishing the evidence base for new interventions or patient pathways.

5.1.3 Journal selection

It is with no regret that the majority of articles have been published in the journal *Radiography.* Key to journal choice are: audience; scope of journal and impact factor (Cargill and O'Connor 2011), but as no radiography journals have an impact factor the latter point is mute.

The invitation to join the editorial board of the *Radiography* journal in 2010 has influenced the continued support and this has increased significance as MEDLINE inclusion is sought in the next year. However, it is important that an article subject is relevant to its target journal and has the potential to influence the audience and articles have been published elsewhere. One example is **II**, which was submitted

to the Australian counterpart to the UK journal, *The Radiographer* and to ensure relevancy an Australian academic co-author was invited to contribute to the publication which was based on UK data.

The article **VII** presented the primary results from a recent RCT and was published in the *British Journal of Radiology,* as the subject and results are relevant to both radiography and radiology audiences.

The bibliometric series of articles originated from a single project and were accepted in 2 journals. *Radiography* presented an obvious choice for the longitudinal review of the same journal similar to Anyi, Zainab and Anuar (2009) with their single journal review. The international journal data was initially presented at the International Society of Radiographers and Radiologic Technologists conference in Toronto, Canada and therefore submitted to the Canadian *JMIRS*. The final article representing an analysis of author productivity, summarised in chapter 3, has been recently accepted for publication by the *Journal of Medical Radiation Sciences* (Snaith 2013).

In addition, publication has not been restricted to radiography and other journals have been selected for submission of articles over the last 2 decades based upon the relevance of the topic and/or audience.

5.2 Co-authorship

It was only when this thesis was embryonic that the question of co-authorship and individual contribution to publications arose. Without planning or forethought the majority of publications have been written with others.

5.2.1 Collaboration

An absence of robust evidence of collaboration prevalence in radiography and the wider community led to the bibliometric review, although this investigation was never envisaged as stand-alone research or expected to generate a number of articles. The project was, however, reassuring in its generation of data and tangible outcomes, but acted as a reminder of the lone research and publication process and frustration in the absence of a collaborator to develop, challenge and critique individual ideas.

Writing can be an isolating experience but developing effective partnerships with other authors is not straightforward. Individuals working together on a shared research and/or writing project (co-authors) are not necessarily collaborators. Katz and Martin (1997) define *research collaboration* as 'the working together of researchers to achieve the common goal of producing new scientific knowledge.' Although a number of projects submitted within this thesis and observed externally appear to broadly fit this definition, the key term appears to be 'together'. Many individuals will co-author an article, but does this represent collaboration or purely the sharing of tasks? Diamond and Mullen (1996) reflecting on their writing

relationship suggested that it had included many phases, including supervision, mentorship and co-authorship. The collaborative stages could therefore be described as hierarchical, both in terms of author support and inter-dependence (figure 2).

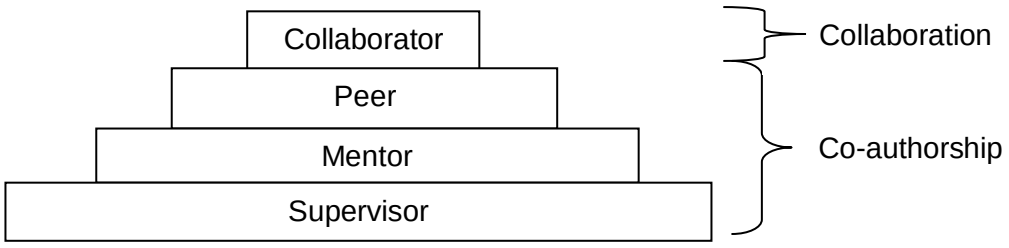

Figure 2: A proposed hierarchy of collaboration

Through supervision of a project or thesis, most commonly in the academic environment, the supervisor provides oversight, drawing out and challenging the beliefs of the student as they gain confidence, but importantly ensuring deadlines are met and the structure conforms to expected submission criteria. Beyond academic deadlines a mentor may act as a guide or advisor. Interestingly, Williams (2013) identifies the absence of such mentors as a key barrier in the development of an academic research culture in radiography. In the absence of a natural support structure individuals cannot gain the confidence to work within a peer relationship, taking on discrete elements within a project and sharing the results nor can they move towards true collaboration, working *together* to enhance ideas.

Within and out with the published works presented in this thesis different relationships with co-authors have existed, including as clinical supervisor on a

Masters project and contributing to subsequent publication, through supporting inexperienced colleagues, sharing elements of manuscript development towards the true collaborative relationship (table 8).

Table 8: Relationships within, and beyond, the submitted publications

Relationship	**Publication**
Collaboration	Snaith and Hardy 2006; **III**; **V**; **VI**
Peer	**VI**;**VIII**; **XI**; Hardy, Snaith and Littlefair (2008)
Mentorship	**V;** Field and Snaith (2013)
Supervision	McGuinness, et al. (2011)

The research presented in **VII** and **X** demonstrates that, in line with other disciplines, collaboration is common in radiography. Importantly, across many disciplines this collaborative approach has been linked with increasing publication productivity and quality (He, Geng and Campbell Hunt 2009).

5.2.2 Author credit

With respect to collaborative authorship, there may be hesitancy in accepting a predominance of co-authored work within a doctoral submission. Although authors may identify a specific weight to their publication contribution (allocated credit), Hagan (2010a) following his examination of a number of PhDs by publication in natural and biomedical sciences in Sweden argues that authorship credit is best

calculated harmonically. Harmonic counting accounts for position of an individual within the author team, unless the authors explicitly share first authorship, and allocates 1 to a single authored paper, 0.667 to the first of 2 authors, etc. ((1/position)/1+(1/number authors)). Within Hagan's study the median number of papers within the doctoral theses examined was 4, but harmonic counting calculated the actual median authorship credit to represent a maximum of 2.9 articles and only 1.6 undivided papers (as if sole authored).

To examine the contribution within this thesis, publications were reviewed by both allocated credit, based upon discussion with co-authors (appendix 4), and harmonic counting (Hagan 2010b) and subsequently analysed by total, mean and median contribution (table 9). The results demonstrate higher total and mean contributions based on allocated rather than harmonic count but both methods agree *Snaith's* contribution to be equivalent to approximately 6 single authored (undivided) papers and confirm the body of work to be in line with the 6 total articles and 2 undivided papers suggested as a benchmark by Hagan (2010a).

Table 9: Authorship credit based on allocated and harmonic count

Article	Allocated credit	Harmonic counting
I	1	1
II	0.45	0.2727
III	0.5	0.6667
IV	0.3	0.1818
V	0.5	0.3333
VI	0.4	0.3333
VII	1	1
VIII	0.45	0.2727
IX	0.2	0.1818
X	1	1
XI	0.6	0.6667
Total articles submitted	15	15
Total author article credit	6.4	5.909
Mean (per article)	0.582	0.537
Median (per article)	0.5	0.667

5.3 Doctoral outcomes

Alongside the volume of papers, this thesis must satisfy assessors of the outcomes of doctoral study, namely:

- Their competence in independent work or experimentation;
- Their understanding of appropriate techniques and ability to make critical use of published work or source materials much of which is at, or informed by, the forefront of their academic discipline, field of study or area of professional practice;
- That the publications contain original work of merit and form a distinct contribution to the knowledge of the subject;
- That the publications show evidence of the discovery of new facts and/or the exercise of independent judgement.

(University of Bradford 2010; 2012)

It is believed that the work (both individual and collaborative) within this thesis confirms achievement of these outcomes. All of the articles present the findings of, or process for undertaking, empirical research have demonstrated synthesis of

evidence and identified new and original information. These in turn have influenced developments in radiographic roles and professional activities.

5.4 Reflections on career

Research involvement was not an expectation for a radiographer or the radiography profession on qualification in the 1980s, although further education and development were a personal desire at this stage. The move to graduate status in the 1990s brought with it an academic community able to support and steer the development of the radiography evidence base. As radiographer roles evolved so did personal drive, allowing a career to remain at the forefront of clinical opportunities, supported in a large part by education. This academic achievement has underpinned both personal and professional development and could be perceived as solid preparation for consultant practice.

Ehrat (2001) states that 'potential for advancement assumes a skill set greater than required in a current role.' This has been borne out with academic achievements in advance of role requirements, although doctoral education via the professional doctorate route resulted in one of the few 'non-completions' as an academic student as a result of questions around it's feasibility and recognition.

The role of author has evolved alongside the clinical career with subsequent progression in clinical and leadership roles (figure 3). Each deliberate or speculative academic or career step has also brought new opportunities for research and development.

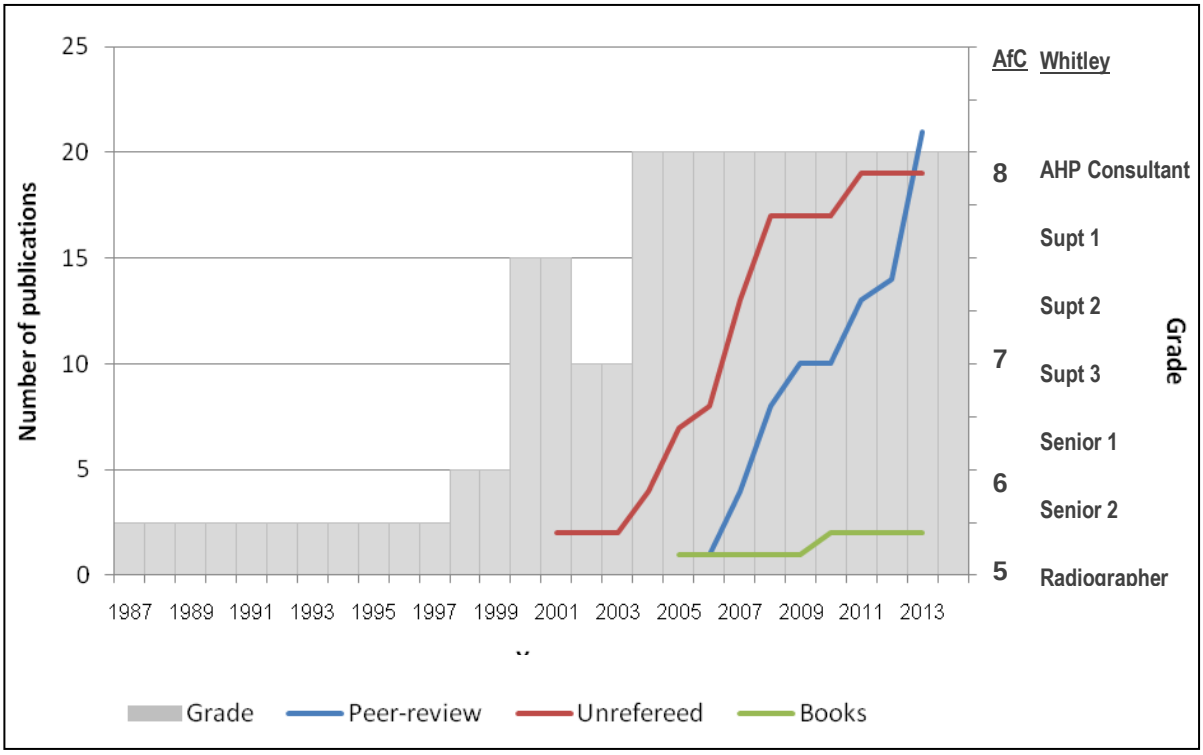

Figure 3: Cumulative publication record mapped to career progression

Rowley (1999) suggests that personal development forms part of the initial stage of research capacity building, where the second stage involves the integration of research strategy into the wider community. Further, Rowley describes 4 facets to research leadership, Ownership, Objectives, Outcomes and Organisation. These indicate the deliverables of a research leader in terms of establishing providing ownership for the planning process, defining research objectives, establishing expected outcomes and being responsible for the financial and human resources management of a research portfolio. Specific to research progression, Rowley (1999) describes development in terms of the different stages of a career through networking and quality. She expects researchers to 'enter the fray' by presenting at

their first conference, submitting their first article and undertaking a PhD, followed by penetration of, and integration into, national networks and the development of a wider reputation through participation in international collaboration (Table 10).

Table 10: Stages in Research networking (Reproduced from Rowley 1999)

Entering the fray	**Entering national networks**	**Integrating into national networks**	**Building national and international reputation**
First conference presentation	Several contributions to a focussed set of conferences and journals	Editorial board membership	Expenses paid invitations to conferences
First articles	Further research	Refereeing	Overseas conferences
PhD	Collaborative work	Large funded research projects	Meeting overseas academics
	Supervising PhD students	PhD external examination	Participation in multi-national research collaborations

Rowley's model for research networking seeks to establish the opportunities or pathways expected within a researchers development. Although these stages may fit the career expectations of a researcher, they provide a less natural fit with a heath academic or clinical researcher with a clinician and in particular a consultant taking a more circuitous path. On a personal basis, whereas early integration into national and international networks was facilitated by clinical role development, the evidence underpinning such activities has built and maintained this reputation.

There is limited published literature relating to the specific abilities and attributes of non-medical consultants, although a small number of studies have sought to link the effectiveness of posts (and post holders) to the characteristics of the individuals. Woodward et al. (2005) in their qualitative study of a small number of nurse consultants identified that the most successful were those with self-confidence, who showed determination but, collaborated with and empowered others. They demonstrated leadership qualities, and had led local and strategic initiatives, with some contributing to national agendas. Jones (2002) suggests that consultants should have substantial clinical skills, combined with a record of scholarship and publication, and experience of research and practice development. Using 360^0 feedback Turnpenny (2005) and Redwood (2007) have identified personal qualities such as motivation, enthusiasm, passion, resilience and opportunism, together with being an expert, a credible leader, a risk taker and a change agent who supports and involves staff. Although some have suggested that research is developed in collaboration with academic institutions (Chartered Society of Physiotherapists 2002; Paterson & Price 2002; Hardy & Snaith 2007), consultants should be able to lead research projects and secure funding. However to date the actual engagement of consultants in research varies significantly. Despite being one of the core functions of consultancy research and evaluation on accounted for 12% of a consultants time in a review of AHP consultants undertaken by Turnpenny in 2005. Guest et al. (2001) surveyed nurse consultants and found that 48% of respondents were heavily engaged in the research function. Due to the different methodologies used in collecting such data, direct comparisons between different professional groups cannot be drawn, however many have

recognised that research is the area in which consultants are least active (Woodward et al. 2005; Redwood 2007).

In developing and designing research, personal attributes have also been shown as influential in the method and type of research individuals pursue as different styles suit personal characteristics better. Boyce et al. (2003) suggest that researcher attributes play a significant role in research design based on their skills, interests and biases. These attributes may determine whether an individual can participate in and/or lead research. Indeed, they may be influential in whether researchers are seen as leaders or collaborators. Dei and Kempf (2006 p244) state that researchers have the authority to produce and define legitimate knowledge, and in doing so define the topic, initiate the study, choose methods, analyse, write and communicate the results. The literature demonstrates that researcher skills include inter-personal, analytical, problem solving and organisational skills, but these are supplemented by visionary (identifying and grasping the opportunity), decision making skills to not only initiate and undertake research but to ensure the outcomes are disseminated and applied to practice. It is clear that he responsibility of research leader appears to be one which could fit with the non-medical consultant role, and in turn provide, leadership to their own profession, service and team.

5.5 Future developments

More than ever, healthcare is reliant on innovation, productivity and evidence of clinical and cost-effectiveness of treatments (DH 2012). The debate about clinician-researchers has been waging in the AHPs for over 15 years (Moore 1997), but appears now to be at the forefront of national strategy.

Research has been identified as a core business of the NHS (DH 2012) and the research active clinician has evolved into a new clinical-academic role, defined as:

> 'A nurse, midwife or allied health professional who engages concurrently in clinical practice and research, providing clinical and research leadership in the pursuit of innovation, scholarship and provision of excellent evidence-based healthcare.'

Although the numbers of non-medical clinical academics remains low (Council of Deans 2012), such roles may naturally sits with the consultant practitioner who holds advanced theoretical and practical knowledge and should be working at the post-doctoral level (DH 2012). However, the clinical professions still need to agree, as PhD achievements have been slow, particularly in radiography.

So for the future, a potential clinical-academic career, grounded in clinical practice and responding to opportunities this brings, but within an academic collaborative framework.

GLOSSARY (INCLUDING ABBREVIATIONS)

Allied Health Profession (AHP) – The groups of professions regulated by the Health and Care Professions Council.

CINAHL – Cumulative Index to Nursing and Allied Health Literature is an index of English-language and selected other-language journals.

College Of Radiographers (CoR) – The UK professional body representing radiographers

Immediate report – A definitive radiology report issued at the time of patient attendance, often referred to as ‘hot’ reporting.

ISRRT – The international collective organisation representing radiography.

MEDLINE – The index of journals by the US National Library of Medicine

Radiographer – The health professional specialising in imaging (diagnostic radiographer) or oncology (therapy radiographer).

Radiologist – A medical practitioner specialising in imaging.

Report – The definitive diagnostic interpretation, provided by either a radiologist or reporting radiographer.

Royal College of Radiologists (RCR) – The radiology professional body.

Society of Radiographers (SCoR) – The combined trade union and professional body representing radiographers.

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APPENDIX 1

PUBLICATIONS

Full text removed:

Please Note: The full text of each of the published articles, which are listed on page vii, has been removed from the PhD online copy due to the publisher's copyright restrictions.

To see the final full text version of the articles listed on page vii, please visit the publisher's website. Available access to the published online version may require a subscription.

Journal of Medical Imaging and Radiation Science: *http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1754-9485*

Radiography*: http://www.sciencedirect.com/science/journal/10788174*

British Journal of Radiology: *http://www.birpublications.org/toc/bjr/current*

Appendix 1: Attitudinal statements used in the survey

		Strongly Agree	Agree	No Strong Opinion	Disagree	Strongly Disagree
1.	I believe 'hot' reporting improves the quality of the ED service	☐	☐	☐	☐	☐
2.	'Hot' reports improve my confidence in clinical decision making	☐	☐	☐	☐	☐
3.	'Hot' reports should only be available for musculoskeletal radiographic examinations	☐	☐	☐	☐	☐
4.	'Hot' reports reduce the risk of clinical error	☐	☐	☐	☐	☐
5.	I am able to seek a hot report/advice over the telephone when a reporting radiographer is not available locally	☐	☐	☐	☐	☐
6.	'Hot' reporting is most useful 'out of hours'	☐	☐	☐	☐	☐
7.	I don't look at the radiographic image when a hot report is available	☐	☐	☐	☐	☐
8.	Reporting radiographers are NOT available for advice	☐	☐	☐	☐	☐
9.	'Hot' reporting reduces my radiographic interpretation skills	☐	☐	☐	☐	☐
10.	'Hot' reporting is an essential service	☐	☐	☐	☐	☐
11.	I feel pressured to act on the findings in 'Hot' reports	☐	☐	☐	☐	☐
12.	'Hot' reports do NOT reduce the risk of clinical error	☐	☐	☐	☐	☐
13.	'Hot' reports should be available for all radiographic examinations	☐	☐	☐	☐	☐
14.	I feel that the 'hot' report takes away my autonomy to make clinical decisions	☐	☐	☐	☐	☐
15.	'Hot' reporting increases patient journey time	☐	☐	☐	☐	☐

Continued overleaf

		Strongly Agree	Agree	No Strong Opinion	Disagree	Strongly Disagree
16.	I am able to seek advice from reporting radiographers	☐	☐	☐	☐	☐
17.	I use the hot report to confirm my interpretation and clinical decision	☐	☐	☐	☐	☐
18.	'Hot' reporting should be available at all times	☐	☐	☐	☐	☐
19.	'Hot' reporting is NOT an essential service	☐	☐	☐	☐	☐
20.	I seek the advice of a radiologist when a reporting radiographer is not available	☐	☐	☐	☐	☐
21.	I feel I can question the accuracy of findings in a 'Hot' report	☐	☐	☐	☐	☐
22.	'Hot' reporting provides opportunities to develop my radiographic interpretation skills	☐	☐	☐	☐	☐

APPENDIX 2

CURRICULUM VITAE

Personal Details

Name	Beverly Ann Snaith
Date of Birth	16 November 1965
Address	53 Huddersfield Road, Barnsley, S75 1DR
Current Post	Lead Consultant Radiographer, Mid Yorkshire Hospitals NHST

Professional Membership

Health Professions Council (RA29344)
Society of Radiographers (39593)
European Society of Radiology (174521)

Current responsibilities

Perform and interpret a range radiography and ultrasound examinations;
Lead the radiographic workforce within a strategic radiology triumvirate;
Contribute to workforce planning, particularly in relation to skill mix;
Lead education, audit and research strategies;
Represent trust and profession on a number of external bodies.

Employment History

1987-1990	Radiographer, Rotherham District General Hospital
1990-2001	Radiographer & Senior Radiographer, Doncaster Royal Infirmary
2000-2002	Terminology Author & Project Manager, NHSIA
2002-2004	Clinical Specialist Radiographer, Mid Yorkshire Hospitals NHST
2004-2012	Consultant Radiographer, Mid Yorkshire Hospitals NHST

Professional Education

1987	DCR, Bristol & Weston School of Radiography
1996	PgC in Radiographic Reporting, University of Hertfordshire
1999	MSc Medical Imaging, Sheffield Hallam University
2006	PgC Interpretation of chest & abdomen, University of Bradford
2010	MSc Professional Practice (exit DProf), University of Salford
2010	PgD in Medical Ultrasound, University of Leeds
2013	PhD, University of Bradford

Personal Awards

2000 CoR - Alan Nichols award for the best presentation at IOS
2004 CoR - Beth Whittaker award for best poster at UKRC
2004 CoR Yorkshire and North Trent - Radiographer of the year
2005 West Yorkshire SHA - Improving patient experience modernisation award
2006 NHS Health and Social Care awards – Improving Access finalist
2010 Fellowship of College of Radiographers
2010 European Congress Radiology – Best paper presented by radiographer
2011 Mid Yorkshire Hospitals NHST Highly commended – Leadership Award
2011 CoR - Alan Nichols award for the best presentation at UKRC

Professional activities

1998-2001 Society & College of Radiographers Council
2000-2002 CiRiS Governing Board member
2002-2003 NHS MA Critical Care Programme AHP & HCS Advisory Group
2003-2004 Trauma Imaging Group chair
2005-2007 West Yorkshire Critical Care Network, AHP lead
2006-2007 RCR/CoR Skills mix review member
2006-2007 SoR Learning and Development Framework working party
2006-date *Radiography* Reviewer
2007-2008 UKRC service development programme organising committee
2008-2009 RCR/SCoR/DoH Radiology Accreditation Project steering group
2009 *Radiography* Advanced & Consultant special edition guest editor
2009-2012 Royal College of Radiologists Guidelines (*iRefer*) working party
2010-2011 UKRC service delivery programme organising committee
2010-date *Radiography* editorial board member
2011-2012 Skills for Health non-medical consultant expert panel
2011-2012 Yorkshire major trauma review group member
2011-date *Journal of Medical Imaging and Radiation Sciences* reviewer
2011-date CoR Approval and Accreditation board member
2012-date Mid Yorkshire Hospitals R&D committee member
2012-date DoH AHP Clinical expert database – major trauma
2013-date *Ultrasound* reviewer

Educational activities

2000-date Visiting lecturer, Sheffield Hallam University
2003-date Undergraduate and postgraduate assessor, CoR
2004-date Visiting lecturer, University of Bradford
2008-date Visiting lecturer, University of Leeds (including MSc supervisor)
2008-2012 External examiner, University of Hertfordshire (undergraduate)
2009-date Radiography education forum representative, Y & H SHA

2009-date Radiography advisory board member, University of Bradford
2009–date Honorary Visiting Research Fellow, University of Bradford
2011-date Visiting lecturer and MSc examiner, UNITEC (New Zealand)

Research Funding

1998-9 Snaith. A localised study to investigate the feasibility of introducing a radiographer comment scheme for accident and emergency referrals. *MSc dissertation: Trent WDC grant £1000*

2003 Snaith. Are Trusts replacing the red dot? *Trauma Imaging Group research grant £500*

2004 Spencer, Hardy, Snaith. A comparison of hot and cold reporting of A&E radiographs *Special Interest Group in Medical Image Interpretation research grant £500*

2006 Snaith. Hardy. Establishing a standard for radiographer commenting in the accident and emergency environment in the UK. *CoR research grant £5000*

2008-11 Hardy, Snaith, Jones, Barker, Walker. The impact of radiographer immediate reporting on patient outcomes and service delivery within the emergency department. *RFPB grant £260,254*

2009 Hardy, Snaith, Walker. Emergency ultrasound in the pre-hospital setting: the impact of environment on examination outcomes. *University of Bradford grant £14,925*

2009-11 Snaith West Yorkshire CLRN *Flexibility and Sustainability* funding *£63,267.60*

2010-12 Snaith West Yorkshire CLRN *0.1WTE research* funding *£23,582*

2013 Snaith, Hardy. Improving neonatal chest radiography: An evaluation of image acquisition techniques, dose and technical quality. *ISRRT grant £2500*

Books

Hardy M, Snaith B *Beyond red dot…..! A guide to musculoskeletal injuries.* Inprint and Design 2005.

Hardy M, Snaith B (Eds) *Musculoskeletal trauma: A guide to assessment and diagnosis.* Churchill Livingstone 2010.

Publications

Peer-reviewed

Hardy M, Snaith B. Role extension and role advancement: is there a difference – a discussion paper. *Radiography* 2006; 12: 327-31.

Snaith BA. Radiographer discharge in A&E: the results of a pilot project. *Radiography* 2007; 13: 13-7.

Snaith B, Hardy M How to achieve advanced practitioner status: a discussion paper *Radiography* 2007; 13: 142-6.

Hardy M, Snaith B How to achieve consultant practitioner status: a discussion paper *Radiography* 2007; 13: 265-70.

Snaith B, Lancaster A. Physical examination and history taking skills: a requirement for radiographers? *Radiography* 2008; 14: 51-3.

Hardy M, Snaith B, Smith T. Radiographer reporting of trauma images: United Kingdom experience & implications for evolving international practice. *The Radiographer* 2008; 55: 11-4.

Snaith B, Hardy M. Radiographer abnormality detection schemes in the trauma environment– an assessment of current practice. *Radiography* 2008; 14: 475-81.

Hardy M, Spencer N, Snaith B. Radiographer emergency department hot reporting: An assessment of service quality and feasibility. *Radiography* 2008; 14:301-5.

Snaith B, Kelly J, Cantin P. Consultant practice special edition editorial. *Radiography* 2008; 14: e4.

Hardy M, Snaith B. Radiographer interpretation of trauma radiographs: issues for radiography education providers. *Radiography* 2009; 15: 101-5.

Hardy M, Snaith B. The impact of radiographer immediate reporting on patient outcomes and service delivery within the emergency department: designing a randomised controlled trial. *Radiography* 2011; 4: 275-9.

McGuinness A, Snaith B, Wilson J, Wolstenhulme S. A cohort study to evaluate emergency medicine ultrasound by non-sonographers in clinical practice. *Ultrasound* 2011; 19: 214-20.

Snaith B, Hardy M, Walker A. Emergency ultrasound in the pre-hospital setting: the impact of environment on examination outcomes. *Emergency Medicine Journal* 2011; 28: 1063-5.

Snaith B. Radiography collaboration: A bibliometric analysis. *Radiography* 2012; 18: 270-274.

Hardy M, Snaith B, Scally A. The impact of immediate radiographic reporting on patient outcomes and service delivery within the emergency department: a randomized controlled trial. *British Journal of Radiology* 2013; 86: 20120112.

Hardy M, Hutton J, Snaith B. Is a radiographer led immediate reporting service for emergency department referrals cost effective? *Radiography* 2013; 19: 23-7.

Snaith B. Developing the radiography evidence base: a bibliometric study of international publication practice. *Journal of Medical Imaging and Radiation Science* 2013: 44: 37-43.

Field L, Snaith B. Developing radiographer roles in the context of advanced and consultant practice. *Journal of Medical Radiation Science* 2013: 60: 11-5.

Snaith B, Hardy M. The perceived impact of an emergency department immediate reporting service: An exploratory survey. *Radiography* 2013: 19: 92-6.

Lewis E, Hardy M, Snaith B. An analysis of survey reporting in the imaging professions: Is the issue of non-response bias being adequately addressed? *Radiography* 2013; 19: 240-5.

Lewis E, Hardy M, Snaith B Estimating the effect of nonresponse bias in a survey of hospital organizations. *Evaluation and the Health Professions.* 2013; 36: 330-51.

Snaith B. An evaluation of international author productivity in radiography journals 2004-11. *Journal of Medical Radiation Science* 2013; 60: 93-9.

Snaith B, Hardy M. Emergency department image interpretation accuracy: The influence of immediate reporting by radiology. *International Journal of Emergency Nursing* (in press).

Snaith B, Buckley K. Radiographic assessment of developmental dysplasia of the hip – A novel radiology reporting process and one year review of referrals. *Radiography* (in press)

Non-peer reviewed

Snaith B. A 40 year old female with a blow out fracture of the left orbit. *Synergy* 2001; 6: 4-5.

Snaith B, Davies C. Radiographers and the critical care agenda. *Synergy* 2001; 9: 8-9.

Snaith B, McGuinness A Yunis S. Introducing new roles: Does reality meet expectation? *Synergy* 2004; 3: 4-7.

Snaith B, McGuinness A, Arezina J, Yunis S. Introducing new roles: Bridging the gap. *Synergy* 2004; 4: 9-11.

Snaith B, General radiography – speciality status at last? *Imaging & Oncology* 2005; 1: 27-32.

Hardy M, Snaith B. Developing and implementing radiographer comments systems: Issues for consideration. *Synergy*. 2005; 11: 4-9.

Snaith B, Hardy M. Radiographer comments in practice: describing injuries *Synergy.* 2005; 12: 8-14.

Flintham K, Snaith B Horizontal beam lateral hip: a qualitative evaluation of two techniques *Synergy* 2006 ; 4:15-7.

Snaith B, Advanced assessment and diagnostic reasoning. *Synergy* 2007; 2: 20-22.

Snaith B, Skills mix is here to stay. *Imaging and Oncology* 2007; 1: 62-3.

Hardy M, Snaith B. Reviewing chest x-rays. *Synergy* 2007; 9: 14-7.

Snaith B, Hardy M. Describing and commenting on chest x-rays: an approach to detecting and describing pathology. *Synergy* 2007; 10: 14-9.

Snaith B, Hardy M. The chest radiograph – trauma and interventions. *Synergy* 2007; 12: 16-20.

Hardy M, Snaith B, Littlefair S.The acute chest radiograph. *Synergy* 2008; 1: 14-8.

Snaith B. Guest editorial: Advanced practice- the way forward. *Synergy* 2008; 6: 4-7.

Snaith B. Book review: Limited scope in the UK. *Synergy* 2008; 6: 16.

Flintham K, Stokes K, Snaith B. Advanced practice – implementing and sustaining change. *Synergy* 2008; 7

Snaith B. Developing radiography leadership: Trainee consultant roles. *Synergy* 2011; 1: 5-9

Snaith B, Hardy M. The chest radiograph – trauma and interventions. *Synergy* 2012; 3: 13-17.

Posters

Snaith B, Spencer N. Developing a radiographer hot reporting service for A&E. *UKRC* 2004.

Flintham K, Snaith B. Horizontal beam lateral view of the hip - qualitative evaluation of 2 techniques. *UKRC* 2005.

Spencer NJB, Snaith BA. The Emergency Care Consultant radiographer: A new role - emergency physician supporter and radiologist's friend. *RSNA*, 2005

Snaith B, Walker A, McGuinness A. Clinical governance of non-radiology ultrasound - A case study. *UKRC* 2007.

Tyldsley K, Hesling J, Snaith B. Developing a QA programme for CR/PACS: is it worth it? *UKRC* 2007.

Cooper J, Snaith B, Walker A. Reliance on the Ottawa ankle rules can result in missed avulsion fractures of the talus and calcaneum. *CEM* 2007.

Field L, Lancaster A, Flintham K, Snaith B. Advanced radiographer practitioner. *UKRC* 2009.

Snaith B, Field L, McGuinness A. Trainee Consultancy: The journey from advanced to consultant practice. *UKRC* 2010.

Hardy M, Snaith B, Wyton C, Jones H, Barker P. Is a 24/7 immediate reporting service feasible? *UKRC* 2010

McGuinness AJ, Field L, Snaith B. Ensuring diagnostic accuracy of advanced practitioner reporting – is peer review the answer? *BMUS* 2010.

Snaith B, Field L, McGuinness A. Peer review – a mechanism. *UKRC* 2011.

Buckley K, Lancaster A, Flintham K, Snaith B, Waring L. Radiographer reporting of paediatric hips. *UKRC* 2011.

Presentations

Invited

Snaith B, Hoban W. Consultant radiographer and trauma. *UKRC* 2001.

Snaith B. Consultant practice. *SMART conference* 2004.

Snaith B. Trauma radiography: an evolving role. *Integrated Musculoskeletal Trauma Conference* 2005.

Snaith B. Hidden trauma – the art of plain film radiography. *William Stripp Eponymous lecture UKRC* 2005.
Snaith B. Consultant radiographer and musculoskeletal reporting. *UKRC* 2005.
Snaith B. Radiographic career progression – the UK experience. *Fusion* 2005.
Snaith B. The role of the radiographer in trauma – a pathway to consultancy. *Fusion* 2005.
Snaith B. Role conflict. *Consultant radiographer day. CoR* 2006.
Snaith B, Hargraves K, Stokes K. An introduction to musculoskeletal clinical assessment for radiographers (workshop). *UKRC* 2006.
Snaith B. Features of good reports & good requests: consultants perspective. CoR: *Radiographer reporting at the leading edge: with the hard bits* 2007.
Snaith B. IR(ME)R referrers- role and responsibility. CoR: *IR(ME)R training for non-medical referrers* 2007.
Snaith B,Hardy M. Radiographer image interpretation in the trauma environment. *UKRC* 2007.
Hardy M, Snaith B. Radiographer consultant and advanced practitioner training. *UKRC 2007.*
Snaith B. Emergency radiographer: an evolving role. *ECR* 2008.
Snaith B, Jones H. So you think you do research. *UKRC* 2009.
Walker A, Snaith B, Hardy M. Point-Of-Care US: Let's get it out before we get to hospital! *NPOCUS* 2009.
Snaith B. Professionals, technicians and technical experts? The modern radiographers' role. *UKRC* 2011.
Snaith B. Clinical role development - Does 1 consultant radiographer = 1 skill set? *UKRC* 2011.
Snaith B. Developing the role of the Consultant Radiographer. *SCoR Radiology Manager Conference* 2013.
Snaith B. Radiography research. *STFC satellite session UKRC* 2013.
Snaith B. Radiographers and publication*. Cambridge Conference on Breast Cancer Imaging* 2013.

Proffered

Snaith B. Has radiography outgrown the red dot? *IOS* 2000.
Snaith B, Ferris C. Inter-professional education in medical image interpretation. *UKRC* 2002.
Snaith B. Are Trusts replacing the red dot? *UKRC* 2003.
Snaith B, McGuinness A, Yunis S. Specialist radiographers: Bridging the gap to consultant practice. *UKRC* 2003.
Snaith B, Hardy M. Achieving advanced practitioner or consultant radiographer status: thinking outside the box. *UKRC* 2006.
Hardy M, Spencer NJB, Snaith B. Accident and emergency musculoskeletal plain

film reporting: is there a difference in the diagnostic consistency between hot and cold reports? *UKRC* 2006.

Hardy M, Snaith B. Commenting on trauma radiographs: Developing and formalising the radiographers role. *ECR* 2008.

Hardy M, Snaith B. Radiographer reporting in the UK: Education to support changes in radiographer roles and responsibilities. *ECR* 2008.

Hardy M, Snaith B, Wyton C. The impact of radiographer immediate reporting on patient outcomes and service delivery within the emergency department: A randomised controlled trial. *ECR* 2010. Austria.

Hardy M, Snaith B, Wyton C. Radiographer immediate reporting on patient outcomes and service delivery within the emergency department: A randomised controlled trial. *UKRC* 2010.

Snaith B, Hardy M. Radiography skill mix- are we there yet? *ISRRT* 2010, Australia.

Hardy M, Snaith B. From red dot to immediate reporting- impact of radiographers on patient outcomes and service delivery within the emergency department. *ISRRT* 2010, Australia.

Hardy M, Snaith B. Is radiographer hot reporting cost effective? *UKRC* 2011.

Snaith B. Radiography publication: a bibliometric analysis. *ISRRT* 2012. Canada

Hardy M, Snaith B. Image interpretation: Essential knowledge and skills. *ISRRT* 2012. Canada

Hardy M, Snaith B. Is it normal? *ISRRT* 2012. Canada

Snaith B. Radiography authorship: a European and international review. *ECR* 2013. Austria.

Snaith B, Hardy M, Lewis E. Radiographer contribution to the interpretation of trauma radiographs: a survey of UK practice. ECR 2013. Austria.

Hardy M. Snaith B. Is a radiographer-led immediate reporting service for emergency department referrals a cost-effective initiative? ECR 2013. Austria.

APPENDIX 3

CITATIONS

In order to identify the influence and reach of individual publications the following tables list citations for each included publication, self-citations (including those by co-authors) have been identified specifically.

Citations have been classified as peer review journal article or other publication, these include:

A – Academic thesis

B – Book

E – Workforce evaluation – national/international level

G – Guidance document – national/international level

U – Unrefereed article

I - Snaith BA. Radiographer discharge in A&E: the results of a pilot project. Radiography 2007. 13:13-7.

Article citations
Snaith B, Lancaster A (2008) Physical examination and history taking skills: a requirement for radiographers? *Radiography*; 14: 51-3.
Hardy M, Spencer N, Snaith B (2008) Radiographer emergency department hot reporting: An assessment of service quality and feasibility. *Radiography*; 14: 301-5.
Shi J, Cox J, Atyeo J, Loh Y, Choung WL, Back M (2008) Clinician and therapist perceptions on radiation therapist-led treatment reviews in radiation oncology practice. *Radiotherapy & Oncology* 89: 361-7.
Paterson A (2009) Consultant radiographers - The point of no return? *Radiography* 15: 2-5.
Ford P (2010) Consultant radiographers - Does the profession want them? *Radiography* 16: 5-7.
Kelly JF (2010) Establishing consultant practice. *Radiography* 16: 93-4.
Hardy M, Snaith B (2011) The impact of radiographer immediate reporting on patient outcomes and service delivery within the emergency department: designing a randomised controlled trial. *Radiography*; 4:275-9.

Henderson D, Gray WK, Booth L (2013) Assessment of a reporting radiographer-led discharge system for minor injuries: a prospective audit over 2 years. *Emergency Medicine Journal*.30: 298-302.
Other citations
Hogg P, Hogg D, Francis G, et al. (2007) Medicines in radiography: Prescription, supply and administration. *Synergy* (U)
Kumar R (2007) *Evaluating Medical Radiation Technologists' image interpretation accuracy and clinical practice relative to their postgraduate educational experience in New Zealand*. MSc Thesis. Unitec, New Zealand. (A)
Snaith B (2008) Guest editorial: Advanced practice- the way forward. *Synergy*; 6: 4-7. (U)
McConnell J, Smith T (2008) *Submission to the National Health and Hospitals Reform Commission: redesigning the medical imaging workforce in Australia.* (E)
Oakley J (2010) *An exploration of factors potentially affecting the perception and interpretation of medical images used in higher education.* PhD thesis, University of Portsmouth. (A)
Total citations 13 (self citations 4)

II - Hardy M, Snaith B, Smith T. (2008) Radiographer reporting of trauma images: United Kingdom experience & implications for evolving international practice. *The Radiographer.* 55(1)11-14.

Article citations
Smith T, Praise P, Cook A (2009) The influence of a continuing education program on the image interpretation accuracy of rural radiographers. *Rural and Remote Health* 9: 1145-54.
Hardy M, Snaith B. (2011) The impact of radiographer immediate reporting on patient outcomes and service delivery within the emergency department: designing a randomised controlled trial. *Radiography*; 4:275-9.
Hardy M, Snaith B, Scally A. The impact of immediate radiographic reporting on patient outcomes and service delivery within the emergency department: a randomized controlled trial. *British Journal of Radiology*. (in press).
Munro L, Isaacs F, Friedrich-Nel H, Swindon L (2012) An analysis of the need for accredited training on the administration of intravenous contrast media by radiographers: results of an online survey. *South African Radiographer* 50: 27-34.
Hardy M, Hutton J, Snaith B. (2013) Is a radiographer led immediate reporting

service for emergency department referrals cost effective? *Radiography*. 19: 23-7.
Field L, Snaith B (2013) Developing radiographer roles in the context of advanced and consultant practice. *Journal of Medical Radiation Science*. 60: 11-5.
Snaith B, Hardy M (2013) The perceived impact of an emergency department immediate reporting service: An exploratory survey. Radiography. 19: 92-6
Other citations
McConnell J, Smith T (2008) *Submission to the National Health and Hospitals Reform Commission: redesigning the medical imaging workforce in Australia.* (E)
Hardy M, Snaith B (2010) *Musculoskeletal trauma: A guide to assessment and diagnosis.* Churchill Livingstone: Oxford (B)
Webb M (2011) *Best practice for minor injury units: a rapid review of the literature*. Betsi Cadwaladr University Health Board and Public Health Wales. (E)
Total citations 10 (self citations 6)

III - Snaith B, Hardy M. (2008) Radiographer abnormality detection schemes in the trauma environment – An assessment of current practice. ***Radiography.*** **14: 475-81.**

Article citations
Hardy M, Snaith B, Smith T. (2008) Radiographer reporting of trauma images: United Kingdom experience & implications for evolving international practice. *The Radiographer* 55(1)11-14.
Hardy M, Snaith B. (2009) Radiographer interpretation of trauma radiographs: issues for radiography education providers. *Radiography*; 15: 101-5.
Smith S, Reeves P (2009) The extension of the role of the diagnostic radiographer in the UK National Health Service over the period 1995-2009. *European Journal of Radiography* 1: 108-14.
Coelho JM, Rodrigues PP (2011) The red dot system: Emergency diagnosis impact and digital radiology implementation a review. ***HEALTHINF 2011*****.** 508-511
Kelly BS, et al. (2012) Collaboration between radiological technologists (radiographers) and junior doctors during image interpretation improves the accuracy of diagnostic decisions. *Radiography*. 18 :90-5.
Lancaster A, Hardy M (2012) An investigation into the opportunities and barriers to participation in a radiographer comment scheme in a multi-centre NHS trust. *Radiography*. 18: 105-8.

Leishman L (2013) Can skeletal image reporting be taught online: Perspectives of experienced reporting radiographers? *Radiography*. 19: 104-12.
Howard ML (2013) An exploratory study of radiographer's perceptions of radiographer commenting on musculo-skeletal trauma images in rural community based hospitals. *Radiography.* 19: 137-41.
Other citations
McConnell J, Smith T (2008) *Submission to the National Health and Hospitals Reform Commission: redesigning the medical imaging workforce in Australia.* (E)
Holmes K, Anderson C (2012) Reporting on … The mandible. *Synergy.* (U)
Hardy M and Snaith B (2010) *Radiographer abnormality detection systems: A guide to implementation*. Guidance for ISRRT 2010: University of Bradford. (G)
Anderson C, Holmes K (2012) Reporting on … Facial trauma. *Synergy.* (U)
Tityiwe JS, Crofts G (2012) A review of the impact of radiographers' role in radiographic interpretation. *ISRRT Newsletter.* November: 42-5. (U)
SCoR (2013) *Preliminary clinical evaluation and clinical reporting by radiographers: Policy and practice guidance*. London: SCoR. (G)
Total citations 14 (self citations 4)

IV - Hardy M, Spencer N, Snaith B. (2008) Radiographer emergency department hot reporting: An assessment of service quality and feasibility. *Radiography.* 14: 301-5.

Article citations
Knapp KM, Green S. (2009) Reporting of dual energy x-ray absorptiometry scans by radiographers. *Osteoporosis Review.* 17(1): 22-5.
Hardy M, Snaith B, Scally A. (2013) The impact of immediate radiographic reporting on patient outcomes and service delivery within the emergency department: a randomized controlled trial. *British Journal of Radiology*. 86: 20120112.
Other citations
Oakley J (2010) *An exploration of factors potentially affecting the perception and interpretation of medical images used in higher education*. PhD thesis, University of Portsmouth. (A)
Webb M (2011) *Best practice for minor injury units: a rapid review of the literature.* Betsi Cadwaladr University Health Board and Public Health Wales. (E)
Total citations 4 (self citations 1)

V - Hardy M, Snaith B. (2009) Radiographer interpretation of trauma radiographs: issues for radiography education providers. *Radiography* 15: 101-5.

Article citations
Stranden E, Rotstigen E, Norum IA, Thevatas U (2009) Quo Vadis, Radiographer? *Hold Pusten.* 36(8): 8-13
Nunn H, Nunn DL (in press) Determination of difficult concepts in the interpretation of musculoskeletal radiographs using a web-based learning/teaching tool. *Radiography* doi:10.1016/j.radi.2011.06.006
Lancaster A, Hardy M (2012) An investigation into the opportunities and barriers to participation in a radiographer comment scheme in a multi-centre NHS trust. *Radiography*.
Leishman L (2013) Can skeletal image reporting be taught online: Perspectives of experienced reporting radiographers? *Radiography*. 19:107-12
Total citations 4 (self citations 1)

VI - Hardy M, Snaith B (2011) The impact of radiographer immediate reporting on patient outcomes and service delivery within the emergency department: designing a randomised controlled trial. *Radiography.* 4:275-9.

Article citations
Hardy M, Snaith B, Scally A. (2013) The impact of immediate radiographic reporting on patient outcomes and service delivery within the emergency department: a randomized controlled trial. *British Journal of Radiology*. 86: 20120112.
Hardy M, Hutton J, Snaith B. (2013) Is a radiographer led immediate reporting service for emergency department referrals cost effective? *Radiography*. 19: 23-7.
Snaith B, Hardy M. Emergency department image interpretation accuracy: The influence of immediate reporting by radiology. *International Journal of Emergency Nursing* (in press).
Total citations 3 (self citations 3)

VII - Snaith B. (2012) Collaboration in Radiography: A bibliometric analysis. *Radiography*. 18: 270-274.

Article citations
Snaith B. (2013) Peer-review publication patterns: A comparison of international radiography journals. *Journal of Medical Imaging and Radiation Science*. 44: 37-43
Galevi G, Moed HF. (2012) International scientific migration and collaboration patterns following a bibliometrics line of investigation. Available from: http://arxiv.org/abs/1212.5194 [accessed 12.1.13].
Total citations 2 (self citations 1)

VIII - Hardy M, Snaith B, Scally A. (2013) The impact of immediate radiographic reporting on patient outcomes and service delivery within the emergency department: a randomized controlled trial. *British Journal of Radiology*. 86: 20120112.

Article citations
Hardy M, Hutton J, Snaith B. (2013) Is a radiographer led immediate reporting service for emergency department referrals cost effective? *Radiography*. 19: 23-7.
Snaith B, Hardy M. (2013) The perceived impact of an emergency department immediate reporting service: An exploratory survey. *Radiography*. 19: 92-6.
Total citations 2 (self citations 2)

IX - Hardy M, Hutton J, Snaith B (2013) Is a radiographer led immediate reporting service for emergency department referrals cost effective? *Radiography.* 19: 23-7.

Article citations
Snaith B, Hardy M. Emergency department image interpretation accuracy: The influence of immediate reporting by radiology. *International Journal of Emergency Nursing* (in press).
Other citations
SCoR (2013) *Preliminary clinical evaluation and clinical reporting by radiographers: Policy and practice guidance*. London: SCoR. (G)
Total citations 2 (self citations 1)

XI - Snaith B, Hardy M (2013) The perceived impact of an emergency department immediate reporting service: An exploratory survey *Radiography.* 19: 92-6.

Article citations
Snaith B, Hardy M. Emergency department image interpretation accuracy: The influence of immediate reporting by radiology. *International Journal of Emergency Nursing* (in press).
Total citations 1 (self citations 1)

APPENDIX 4

CO-AUTHOR CONTRIBUTION

Professor Maryann Hardy (MH)

	Publication	Contribution
II	Hardy M, Snaith B & Smith T. (2008) Radiographer reporting of trauma images: United Kingdom experience & implications for evolving international practice. *The Radiographer* . 55: 11-14.	MH 45% BS 45% TS 10%
III	Snaith B & Hardy M. (2008) Radiographer abnormality detection schemes in the trauma environment – An assessment of current practice. *Radiography*. 14: 475-81.	BS 50% MH 50%
IV	Hardy M, Spencer N & Snaith B. (2008) Radiographer emergency department hot reporting: An assessment of service quality and feasibility. *Radiography*. 14: 301-5.	MH 50% NS 20% BS 30%
V	Hardy M & Snaith B (2009) Radiographer interpretation of trauma radiographs: issues for radiography education providers. *Radiograph.*; 15: 101-5.	MH 50% BS 50%
VI	Hardy M, Snaith B (2011). The impact of radiographer immediate reporting on patient outcomes and service delivery within the emergency department: designing a randomised controlled trial. *Radiography*. 4: 275-9.	MH 60% BS 40%
VIII	Hardy M, Snaith B, Scally A. (2013) The impact of immediate radiographic reporting on patient outcomes and service delivery within the emergency department: a randomized controlled trial. *British Journal of Radiology*. 86: 20120112.	MH 50% BS 40% AS 10%
IX	Hardy M, Hutton J, Snaith B (2013) Is a radiographer led immediate reporting service for emergency department referrals cost effective? *Radiography.* 19: 23-7.	MH 60% JH 20% BS 20%

XI	Snaith B, Hardy M. (2013) The impact of an emergency department immediate reporting service: An exploratory survey. *Radiography*. 19: 92-6.	BS 60% MH 40%

I agree that the credit allocated to joint publications is correct

…… ……..

Signature Date