Radiography 18 (2012) 270–274

Contents lists available at SciVerse ScienceDirect

Radiography

journal homepage: www.elsevier.com/locate/radi

Collaboration in radiography: A bibliometric analysis

Beverly Snaith*

Radiology Department, Mid Yorkshire Hospitals NHS Trust, Pinderfields Hospital, Aberford Road, Wakefield WF1 4DG, United Kingdom

ARTICLE INFO

Article history:
Received 28 May 2012
Received in revised form
6 July 2012
Accepted 31 July 2012
Available online 13 August 2012

Keywords:
Publication
Radiography research
Collaboration
Bibliometrics

ABSTRACT

Introduction: Increasing research activity is an aim of the radiography profession, but there is a lack of knowledge of how this can be achieved. Collaboration between clinical and academic centres as well as between individuals has increased productivity in other professions and has been suggested as a strategy for radiography. This bibliometric study maps the current contribution to the radiography evidence base through a single journal.
Method: All articles published in *Radiography* from 1997 to 2011 were reviewed to identify collaboration trends together with article type and subject. Analysis also enabled comparison of research and publication patterns.
Results: 706 articles were published by 1205 individual authors. 63.0% were written by UK based authors, although this varied over time. Over 80% of authors published only single article. Two thirds of articles were collaborative with an increase in clinical-academic co-authorship over the 15 years of the study. Although the majority of articles were diagnostic imaging based, the pattern mirrors the UK workforce profile. Clinicians, including clinical-academic co-authors, tend to write about clinical practice and roles, whereas academics write about a broader range of topics.
Conclusions: There has been a growth in research and scholarship within the UK radiography journal and both clinical and academic radiographers are contributing to the evidence base through increased collaboration.

Introduction

Radiographers work in a multi-professional environment, learning and collaborating with others to deliver evidence-based patient care, whilst evaluating and improving services. This team based approach has been shown to yield benefits for patients, individuals and organisations[1] and has supported the developments in radiographer roles over the last two decades. The contemporary clinical department has advanced and consultant radiographers working with managerial and medical colleagues. But do clinical radiographer's activities actually extend beyond service delivery into research and evaluation, or are these perceived as academic activities grounded in universities? It has been suggested that academics contribute disproportionately to research,[2] but clinical radiographers are expected to use, and in the context of advanced and consultant practitioners contribute to, the evidence base.[3]

Radiography has been a graduate profession in the UK for almost two decades and as such radiographers carry the expectation to develop both the profession and its evidence base through research and scholarship.[4] Research may be seen by some as contrary to the team approach as it appears to be a solo pursuit working towards a thesis or publication. However, this role need not be undertaken on an individual basis and it has been shown that both research quality and output are increased through collaboration[5] and in order to gain funding (and hence time) for research, working with others as part of a team is essential.[6] It therefore would appear that collaboration, within and between clinical and academic organisations is crucial to develop radiography research activity and an underpinning culture.

The focus for clinical staff in practice is patient care, supported by education and research, whereas for academic radiographers scholarly activity and publication are core expectations of role, with the main business of universities being education and research.[6] For academics research productivity is also under increasing scrutiny with the next research assessment, the Research Excellence Framework (REF), on the horizon.[7] However, outputs alone are not enough and evidence of the impact of research through its use in practice and by other researchers through citation analysis is essential.[8] It is this impact where collaboration between clinical and academic centres can assist in translating research findings into clinical evidence and service change.[7]

* Tel.: +44 1924 542296.
E-mail address: bev.snaith@midyorks.nhs.uk.

1078-8174/$ – see front matter
http://dx.doi.org/10.1016/j.radi.2012.07.003

There is currently limited knowledge of how radiography research outputs are disseminated and more fundamentally a lack of understanding of the profession's research and publication profile. Hogg et al.[2] suggested that 60% of original research published in *Radiography* emanated from academic or academic collaborations, however this presents a limited portrait of research production and knowledge sharing within the profession.

Bibliometrics is the quantitative study of publication, whether journals, books or other communication media and has gained popularity as a research method over the last half century, particularly amongst information scientists.[9] The purpose of such studies is often to map the literature in a given field, identifying patterns of authorship and productivity as well as providing a direction for its future development. Many different approaches to the study of publication and information are available including indicators of quantity, quality and structure,[10] within these the most recognised bibliometric measures are journal impact factor and the related citation analysis.[8] A small number of bibliometric studies in the fields of imaging and/or oncology have been published, predominately related to citation analysis,[11,12] or increasing author productivity.[13–16] Bibliometric structural studies can provide an in-depth analysis of the connections between authors, publications and research topics[10] and analysis of co-authorship networks is an increasingly common, if not statistically complex, research field.[17]

This bibliometric study of a single peer review journal, *Radiography*, aims to identify patterns of authorship in an attempt to gain an understanding of radiography research collaboration. *Radiography* was the first peer-review journal within the field and is the official peer-review journal of the Society and College of Radiographers and the current scope includes diagnostic imaging, radiation therapy and oncology.[18] It was launched in its current form in 1995 with the aim of:

> '... promoting excellence in the profession of radiography by its commitment to the publication of research, by its support for education and by its encouragement and dissemination of best practice.'
>
> This aim remains unchanged today.[18]

Method

A convenience sample approach was taken and all articles published in *Radiography* over a fifteen year period (1997–2011) were scrutinised manually for author, nationality and subject. Type of collaboration was classified based on author affiliation to identify patterns both at an institutional (within the same organisation), intra-national (within the same country) and international level. Research, review, guest editorial and letters were included, however book reviews, editorials and professional columns were excluded as this study related to novel professional publications contributing to the evidence base rather than information sharing.

Data were collated and analysed using an Excel (Microsoft 2007) database. Statistical analysis was performed to identify patterns of authorship, including co-authorship and collaboration. Article type and subject analysis also enabled comparison of research and publication trends at an author, discipline and national level. Publications were categorised according to the Cumulated Index to Nursing and Allied Health Literature (CINAHL) criteria[19] as Research (original research or systematic review), Journal Article (non-systematic review or discussion), Clinical Literature (clinical innovation, case study, guidelines or interventions) or Opinion Piece (guest editorial, letter or short communication).

Bibliometric measures of collaboration were calculated, including collaboration index (CI), degree of collaboration (DC) and revised collaborative coefficient (RCC) as described by Liao and Yen.[20] The CI is an average of the number of authors per paper, the DC is the proportion of multi-authored papers and RCC is a calculation based on number of authors, where 0 represents all single authored papers and 1 an infinite number of authors.

Results

During the study period a total of 63 issues of *Radiography* were published, with 4 standard editions per year and supplementary special editions in 2007, 2008 and 2009. From these, 706 eligible articles were identified, a mean of 11 articles per issue (range 7–17) and 47 per year (range 31–72).

The 706 articles include 1766 contributing authors, accounting for 1205 unique individuals. The majority of authors only wrote one article ($n = 969/1205$; 80.4%) and in terms of productivity only 2% published more than five articles ($n = 24/1205$). These most productive authors comprise 14 males and 10 females and tend to be in academic roles, with 10 professors (or associate professors) and only three clinicians. Interestingly, two of these three clinicians are UK consultant radiographer practitioners.

63.0% of articles were submitted by a UK first author(s) ($n = 445/706$), although this has decreased from a high of 71.7% in 1997–9 to 57.3% in 2009–11. Almost one third of articles had a single author ($n = 222/706$; 31.4%) but this varied dependent on nationality, with 40.4% of UK authors writing alone ($n = 180/445$), compared to 16.1% of foreign authors ($n = 42/261$). In terms of collaboration, the author status and the basis of the author co-authorship were collated, however there was difficulty in ascertaining whether any of the academic or clinical/academic co-authorship represented student work at either an under- or post-graduate level. A small number of authors who did not fit the clinical or academic criteria and term 'other' refers to individuals in professional body, management consultancy or political roles. As with many publications the profession and qualifications are not universally

Table 1
Collaboration for all articles.

Collaboration	1997–99 No (%)	2000–02 No (%)	2003–05 No (%)	2006–08 No (%)	2009–11 No (%)	Total
Academic						
Sole	27 (25.5)	22 (19.0)	27 (21.4)	34 (19.7)	21 (11.4)	131 (18.6)
Joint	31 (29.2)	29 (25.0)	41 (32.5)	50 (28.9)	73 (39.5)	224 (31.7)
Clinician						
Sole	8 (7.5)	14 (12.5)	17 (13.5)	23 (13.3)	17 (9.2)	79 (11.2)
Joint	27 (25.5)	32 (27.6)	17 (13.5)	30 (17.3)	30 (16.2)	136 (19.3)
Clinician/academic	10 (9.4)	14 (12.1)	19 (15.1)	33 (19.1)	38 (20.5)	114 (16.1)
Student/academic	–	–	–	1 (0.6)	–	1 (0.1)
Other	3 (2.8)	5 (4.3)	5 (4.0)	2 (1.2)	6 (3.2)	21 (3.0)
Total	106	116	126	173	185	706

Table 2
Author status for UK first author papers.

Collaboration	1997–99 No (%)	2000–02 No (%)	2003–05 No (%)	2006–08 No (%)	2009–11 No (%)	Total No (%)
Academic						
Sole	24 (31.6)	20 (25.6)	17 (22.1)	19 (17.6)	19 (17.9)	99 (22.2)
Joint	19 (25.0)	19 (24.4)	16 (20.8)	28 (25.9)	27 (25.5)	109 (24.5)
Clinician						
Sole	7 (9.2)	12 (15.4)	15 (19.5)	19 (17.6)	15 (14.2)	68 (15.3)
Joint	16 (21.1)	13 (16.7)	12 (15.6)	14 (13.0)	16 (15.1)	71 (16.0)
Clinician/academic	7 (9.2)	9 (11.5)	12 (15.6)	26 (24.1)	23 (21.7)	77 (17.3)
Student/academic	–	–	–	–	–	–
Other	3 (3.9)	5 (6.4)	5 (6.5)	2 (1.9)	6 (5.7)	21 (4.7)
Total	76	78	77	108	106	445

documented and therefore comparison of interprofessional collaboration and publication practices is limited, however individual titles and affiliations included medical, physiotherapy and medical physics authors.

The results show an increase in collaboration over the study period with a greater number (and proportion) of articles published by clinical/academic partnerships (Table 1). The figures are relatively small but although the number of articles published by sole academics has increased, the overall proportion has demonstrated a decrease over time. This change in authorship patterns was more apparent when the UK-based first author publications were examined (Table 2).

Of the 706 articles, 484 were collaborative (range 2–13 authors), with co-authorship within the same organisation, university or hospital, the most common ($n = 252/484$; 52.1%), followed by intra-national authors ($n = 194/484$; 40.1%), however the number of inter-national collaborations were small (38/484; 7.9%). In comparison the UK sub-sample demonstrated greater intra-national collaboration (131/265; 49.4%) but even less international co-authorship ($n = 14/265$; 5.3%).

The variation in collaboration was further evaluated by calculation of the CI, DC and RCC. The CI, which represents the average number of authors, varies over time, however the more sensitive measures of collaboration, the DC and RCC, demonstrated growth in collaboration over the 15-year period, both within the whole sample and UK author sub-sample (Table 3).

In relation to the type of article published, over half of the articles presented the results of original research ($n = 365/706$; 51.7%), with journal articles comprising a further 22.2% ($n = 157/706$), clinical literature 17.4% ($n = 123/706$) with the remainder opinion pieces ($n = 61/706$; 8.6%) (Fig. 1). The latter were predominantly written by sole authors, whether academic or clinicians, whereas original research tended to be co-authored.

Table 3
Collaboration metrics for the *Radiography* journal 1997–2011.

	1997–99	2000–02	2003–05	2006–08	2009–11	Total
All authors						
Collaborative index (CI)	2.425	2.552	2.262	2.676	2.503	2.501
Degree of collaboration (DC)	0.642	0.655	0.635	0.665	0.784	0.686
Revised collaborative coefficient (RCC)	0.411	0.418	0.399	0.416	0.494	0.431
UK first author						
Collaborative index (CI)	2.053	1.962	2.078	2.028	2.132	2.054
Degree of collaboration (DC)	0.553	0.538	0.558	0.630	0.660	0.596
Revised collaborative coefficient (RCC)	0.346	0.327	0.349	0.365	0.392	0.355

In terms of radiographic discipline, 502 (71.1%) articles were on a diagnostic imaging subject, 72 (10.1%) about radiation therapy or oncology and the remaining 132 (18.7%) covered subjects common to both areas. Further examination of the article subject showed the majority related to clinical practice topics and the minority to historical perspectives (Table 4). Clinicians, including clinical-academic co-authors, tend to write about clinical practice and roles whereas academics write about a broader range of topics. The data from UK based authors varies from that of the whole sample, with a lower proportion of articles about clinical practice ($n = 186/445$; 41.8%) and a greater number on role development and skill mix ($n = 94/445$; 21.1%).

Discussion

The number of articles published over the 15 year time span of this review demonstrates the growth in radiography related research and scholarship, corroborating the findings of the radiology and oncology journals. Both article productivity and the number of co-authors increased over the study period. Suggested reasons for such findings in other journals include an acknowledgement of the range of skills (and hence individuals) required to undertake high quality research, repetitive publication and pressure to include faculty members to inflate biographies.[13,14] No evidence of these was found in this study, although this may relate to the high academic integrity or relative naïvity of radiography research and researchers.

Even when the increasing contribution of non-UK based authors is taken into consideration the activity of UK radiographers is encouraging. However, given the current number of academic awards in the field of radiography, particularly at Masters and Doctoral level, this figure should be higher but the opportunity is too often lost.[21] It should also be acknowledged that a number of the articles reviewed in this study were written by non-radiographers, but as the author role is often not included in the affiliation details the proportion cannot be verified. Where the author profession was identifiable the collaboration was predominantly disciplinary, although there was evidence of some multidisciplinary authorship, particularly between diagnostic and therapeutic radiographers and with radiologists or physiotherapists. In relation to gender and productivity, men were unduly represented within the most productive group, despite being in the minority within the profession.[22] Previous research has demonstrated that there are no gender differences between productivity[15] and preferences for research collaboration,[23] but it has suggested that women engage more in interdisciplinary research,[23] such analysis is beyond the scope of this paper but may be appropriate for further investigation in relation to radiography research and scholarship.

Like other professions radiographers also publish in other journals related to their area of practice or research therefore this study can only provide a limited account of radiography

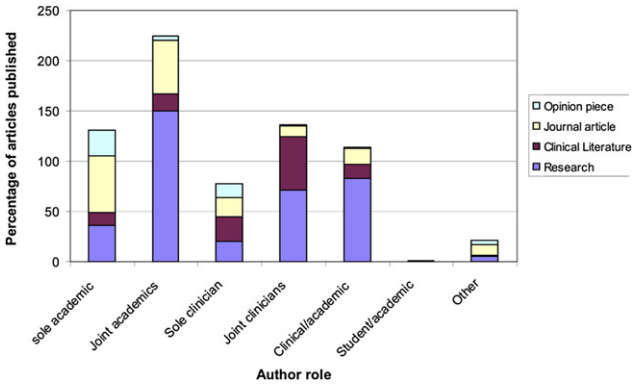

Figure 1. Article category compared to author role.

It is interesting to note that intra-national collaboration, which is authoring with an individual from another organisation, is slightly more common in the UK but overall collaboration between authors from the same organisation is most prevalent. Opportunities for collaboration between institutions, whether academic or clinical, need to exist and this has been identified in the Society and College of Radiographers' five year research strategy.[27] Clinical-academic roles, collaboration and formal research partnerships have been seen as key to developing and delivering evidence based practice.[7,28] The results of this study demonstrate that this is occurring, albeit in a measured way, and the increase in output particularly research or journal type articles supports the belief that collaboration facilitates increased research activity and productivity. The reason for, and influences on, collaboration are unclear but van Rijnsoever and Hessels[23] suggest that they may include: access to expertise, equipment or funds; social interaction and challenge or purely for pleasure. In the academic context, co-authorship may also include supervision of a thesis or project where collaboration on an article may follow completion of the award, however this proved difficult to map as author status was not clearly articulated within the articles. Further research to identify the opportunities and barriers to collaboration is suggested, indeed this study indicates that there are a number of successful research partnerships and further examination of their characteristics may provide an opportunity to explore the key success factors.

Table 4
Article subject by author type.

Collaboration	Clinical practice No (%)	Radiation dose/QA No (%)	Roles/skill mix No (%)	Education/ training No (%)	Research methods No (%)	Profession/ policy No (%)	History No (%)	Total
Academic								
Sole	37 (28.2)	5 (3.8)	13 (9.9)	23 (17.6)	16 (12.2)	23 (17.6)	14 (10.7)	131
Joint	84 (37.5)	19 (8.5)	28 (12.5)	31 (13.8)	16 (7.1)	43 (19.2)	3 (1.3)	224
Clinician								
Sole	46 (58.2)	3 (3.8)	20 (25.3)	3 (3.8)	3 (3.8)	3 (3.8)	1 (1.3)	79
Joint	115 (84.6)	8 (5.9)	9 (8.8)	2 (1.5)	1 (2.6)	1 (0.7)	–	136
Clinical/academic	66 (57.9)	6 (5.3)	27 (23.7)	5 (4.4)	–	9 (7.9)	1 (0.9)	114
Student/academic	–	1 (100.0)	–	–	–	–	–	1
Other	6 (28.6)	1 (4.8)	5 (23.8)	–	3 (14.3)	6 (28.6)	–	21
Total	354 (50.1)	43 (6.1)	102 (14.4)	64 (9.1)	39 (5.5)	85 (12.0)	19 (2.7)	706

publication. The pressure to publish in an impact factor journal[10] may push people away from *Radiography* or other radiographic related journals, however response to questions on the 2014 REF has indicated that impact factor will not be a measure of research quality in the next assessment.[7,24]

Although only 10% of articles have a radiation therapy focus, this is possibly to be expected with a diagnostic: therapy split of 10:1 in the UK radiographic workforce[25] and a separate UK radiotherapy journal. Over half of articles presented the results of research studies, with non-systematic review articles and those about clinical or academic practice, including case studies, comprising a further 40%. In a research active profession the majority of articles would be expected to be research-based and the proportion, which has increased over the last 15 years, is both reassuring and encouraging.

The subjects of the articles reviewed paint a picture of contemporary radiographic practice. It is also perhaps unsurprising that a greater proportion of UK authors wrote about role development and skill mix compared to the international authors, given the UK is widely acknowledged to be leading the development of radiographic advanced practice.[26] This area was also a key subject for sole clinician authors through the dissemination of local evaluations and innovative changes in roles.

The proportion of papers produced by academic collaborators has remained relatively unchanged over the last 15 years, whereas the overall increase in number of articles and in clinical-academic collaboration demonstrates that academia remains the area where the main research activity occurs. The results of this study concur with Hogg et al.[2] in relation to author productivity, with 66.6% of articles written by, or in collaboration with, an academic. A finding from previous research is the link between productivity through research collaboration and higher academic rank,[23] which appears to be borne out by this research and may provide a driver for career focussed academics.

Conclusion

This article has provided an insight into publication practice in *Radiography*, in particular the pattern of authors and collaboration. It is encouraging to see the growth in research and scholarship and that both clinical and academic radiographers are involved with the development of an evidence base, particularly in relation to clinical practice and role development. Further investigation of research productivity and analysis of successful research collaborations and networks may provide useful evidence to develop capacity and foci further.

To develop as a research active and research credible profession radiography still has further work to do and opportunities need not only to be identified, but also pursued, to continue to raise the profile of research in both clinical and academic settings.

References

1. Royal College of Radiologists and The Society and College of Radiographers. *Team working within clinical imaging: a contemporary view of skills mix*. London: Royal College of Radiologists and College of Radiographers; 2007.
2. Hogg P, Eaton C, Robinson L, et al. Factors affecting the selection of foci for radiography research. *Synergy Imaging and Therapy Practice* 2011;**6**:21–3.

3. College of Radiographers. *Learning and development framework for clinical imaging and oncology*. London: College of Radiographers; 2007.
4. Gambling T, Brown P, Hogg P. Research in our practice – a requirement not an option. *Radiography* 2003;**9**:71–6.
5. He Z-L, Geng X-S, Campbell-Hunt C. Research collaboration and research output: a longitudinal study of 65 biomedical scientists in a New Zealand University. *Research Policy* 2009;**38**:306–17.
6. Dilly SA. The multidisciplinary approach for health education, research and practice. *Radiography* 1999;**5**:191–2.
7. Price R. Research assessment. *Radiography* 2012;**18**:59.
8. Nightingale J, Marshall G. Citation analysis as a measure of article quality, journal influence and individual researcher performance. *Radiography* 2012;**18**:60–7.
9. Gauthier E. *Bibliometric analysis of scientific and technological research: a user's guide to the methodology*. Montreal: Observatoire des Sciences et des Technologies; Available from: http://www.statcan.gc.ca/pub/88f0006x/88f0006x1998008-eng.pdf [accessed 17.05.12].
10. Durieux V, Gevenois PA. Bibliometric indicators of scientific publication. *Radiology* 2010;**255**:342–51.
11. Chew FS, Relyea-Chew A. How research becomes knowledge in radiology: an analysis of citations to published papers. *American Journal of Roentgenology* 1988;**150**:31–7.
12. Burnham JF. Mapping the literature of radiologic technology. *Bulletin of the Medical Library Association* 1997;**85**:289–92.
13. Chew FS. Coauthorship in radiology journals. *American Journal of Roentgenology* 1988;**150**:23–6.
14. Halperin EC, Scott J, George SL. Multiple authorship in two English-language journals in radiation oncology. *Academic Medicine* 1992;**67**:850–6.
15. Mohanti BK, Bansal M, Sharma DN, et al. Publications by radiation oncologists from India: a brief survey. *National Medical Journal of India* 2004;**17**:195–7.
16. Fuller CD, Choi M, Thomas CR. Bibliometric analysis of radiation oncology departmental scholarly publication productivity at domestic residency training institutions. *Journal of the American College of Radiology* 2009;**6**:112–8.
17. Newman MEJ. Coauthorship networks and patterns of scientific collaboration. *Proceedings of the National Academy of Sciences* 2004;**101**:5200–5.
18. Editorial board. Aims and scope. *Radiography* 2012;**1**:I.
19. Fayland MJ. *Mapping the literature: a bibliometric analysis of evidence based practice literature in English language nursing journals*. Doctoral thesis. Louisiana State University. Available from: http://search.proquest.com/docview/304819060 [accessed 17.05.12].
20. Liao CH, Yen HR. Quantifying the degree of research collaboration: a comparative study of collaborative measures. *Journal of Infometrics* 2012;**6**:23–33.
21. Marshall G, Brennan P. From MSc dissertations to quantitative research papers in leading journals: a practical guide. *Radiography* 2008;**14**:73–7.
22. Bogg J, Hussain Z. Equality, diversity and career progression: perceptions of radiographers working in the National Health Service. *Radiography* 2010;**16**:262–7.
23. Van Rijnsoever FJ, Hessels LK. Factors associated with disciplinary and interdisciplinary research collaboration. *Research Policy* 2011;**40**:463–72.
24. REF 2014. *Research outputs FAQ 2012*. Available from: http://www.ref.ac.uk/faq/researchoutputsref2/ [accessed 6.07.12].
25. NHS Careers. *Radiographer*. Available from: http://www.nhscareers.nhs.uk/details/Default.aspx?Id=189 [accessed 17.05.12].
26. Freckleton I. *Advanced practice in radiography and radiation therapy: report from the inter-professional advisory team*. Available from: https://www.sor.org/news/document-sets-tone-advanced-practice-australia; 2012 [accessed 17.05.12].
27. Society and College of Radiographers. *Research and the radiography profession: a strategy for research 2010–2015*. London: SCoR; 2010.
28. Department of Health. *Developing the role of the clinical academic researcher in the nursing, midwifery and allied health professions*. London: DH; 2012.