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Running head: Non-medical expert clinical practice scoping review

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Evidence of expert clinical practice among nuclear medicine non-medical staff: A scoping review

Objective: This scoping review concerns expert clinical practice (ECP) by nuclear medicine practitioners (NMP), encompassing radiographers, technologists, and nurses. ECP is typically demonstrated by clinical skills with higher levels of autonomy and responsibility traditionally fulfilled by physicians. The Advanced Clinical Practice (ACP) framework by Health Education England (2017) specifies ECP as one aspect of advanced role progression. This scoping review aims to identify and categorise the extent and type of the existing NMP ECP evidence to support the establishment of Nuclear Medicine ACP

Methods: PubMed, CINAHL and Ovid Medline were searched for peer-reviewed literature published between 2001-2021 using *extended* and *advanced practice* as key terms alongside *nuclear medicine* and each NMP profession. Due to the sparsity of results, conference abstracts from prominent international societies were also searched. Studies were independently reviewed and graded for inclusion by four NMP.

Results: Of the 36 studies that met the inclusion criteria, 80.6% were conference abstracts and 66.7% were single-centres studies. Commonly reported NM ECP activities included image interpretation, cardiac stressing, and therapies. Less reported activities include ordering of complementary diagnostic procedures, invasive procedures, and physical examination. The United Kingdom presented itself at the forefront of NMP ECP publications.

Conclusion: This study demonstrates evidence of NMP ECP across a variety of clinical roles. The dominance of conference abstracts highlights NMP ECP as an emerging area of role extension and a potential preference for information dissemination by NMP. Greater research into specific NMP ECP activities is required particularly studies of greater sample size and robusticity.

Keywords

Advanced Clinical Practice, Nuclear Medicine, radiographer, technologist, nurse, clinical expertise, extended practice

Introduction

The technological and scientific advancement of healthcare prompted the establishment of new professions, consequently leading to a rich, diverse and increasingly specialised workforce. The once rigid medical hierarchy has since progressively evolved into a more fluid, flexible structure which encourages role development of nursing, allied healthcare professionals, and scientific personnel to provide an optimal skill mix [1]. Roles previously exclusive to the medical profession are now within the remit of non-medical healthcare professionals. Radiology is no exception, with diagnostic radiographers in the United Kingdom (UK) providing clinical reporting within plain film radiography, computed tomography and magnetic resonance imaging [2]. Once perceived as either an encroachment or erosion of professional barriers, the development of advanced practice has been shown to improve patient care, reduce financial burdens and contributes to increased job satisfaction [3-5]. For clarity, role extension has been described as supplementary skills or responsibilities that expand beyond the statutory responsibilities and competencies at the point of registration [6]. Within the UK, Health Education England (HEE) provides a multidisciplinary framework for advance clinical practice (ACP) which encompasses four pillars: expert clinical practice (ECP), leadership and management, education and research [7]. Of these, ECP is typically demonstrated by clinical skills which require substantial experience and advanced training and therefore entail higher levels of autonomy, complex decision making and subsequent responsibility. This knowledge should be underpinned by relevant Master's (level 7) qualifications, as per the European Qualifications Framework.

This study concerns Nuclear Medicine (NM) and the evidence of ECP among non-medical staff, namely NM nurses, radiographers and technologists. For brevity, the term Nuclear Medicine Practitioner (NMP) may be used and encompasses international titles accordingly. Frequently seen as a sub-specialism of radiology, NM has steadily extended its intervention scope, from diagnostics to therapies, and its growing complexity validates the rationale for NMP ECP. However, there is an apparent dearth of structural harmonisation between the educational needs, recognised progression pathway, nomenclature, definition and governance across different settings around the world [8]. This scoping review aims to summarise current international research concerning NMP ECP by mapping literature, describing key findings and identifying research gaps. In doing so, this research hopes to ascertain the existence of ECP evidence as demonstrated by academic literature and facilitate future research concerning NMP advanced role extension.

Methods

A scoping review was selected for this study due to the heterogenous nature of available NMP research, reflecting a wide array of extended roles being undertaken. In keeping with previous descriptions of scoping reviews, the objective was not to evaluate the quality of research, but instead characterise and quantify its existence [9]. This review used the evidence-based methodology proposed by Khalil et al comprising of five stages: identifying the research question, identifying relevant studies, study selection, presenting the data, and collating the results [10]. A protocol was created prior to search efforts, with inclusion and exclusion criteria being set by group consensus.

Objective and research question

The objective of this study was to map evidence of NMP ECP across international academic literature written in the English language. The research question was: What evidence is there, within academic literature, of ECP occurring among international non-medical NMP?

Inclusion and exclusion criteria

Evidence for NMP ECP included clinical roles that were beyond core competencies at the point of registration or completion of basic-level training [11]. Whilst not seeking to evaluate the quality of articles, a threshold of peer-review was imposed during journal article selection to facilitate a robust selection. Due to sparsity of available literature, conference abstracts were included for analysis on the basis on a curated (if not fully peer-reviewed) selection process. Articles and conference abstracts were accepted without geographical restriction, however this review was limited to those written in the English language due to the linguistic abilities of the authors. To maintain relevance to current clinical practice a twenty-year time period was imposed (2001-2021). The authors accept the clinical importance of positron emission tomography (PET) and its hybrid combinations with computed tomography (CT) and magnetic resonance imaging (MRI) within molecular imaging. However, the focus of this scoping review was upon gamma camera imaging and non-imaging procedures as a distinct area of specialist practice. Both PET and hybrid combinations with CT and MRI

frequently require dedicated training pathways outside of the sphere of interest for this review [12]. An overview of inclusion and exclusion criteria used for this study is shown in Table 1.

Search strategy

Table 2 lists the terms used to search the title and abstract across the following databases: PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Ovid Medline. In addition to this, an extensive hand search was undertaken using reference lists of included studies. Grey literature, although not included, was searched for potentially relevant references. Conference abstracts were manually searched within the following publications: *Nuclear Medicine Communications* (associated with the *British Nuclear Medicine Society*), *European Journal of Nuclear Medicine and Molecular Imaging* (associated with the *European Association of Nuclear Medicine*), and the *Journal of Nuclear Medicine* (associated with the *Society of Nuclear Medicine and Molecular Imaging*, USA).

Study selection

Studies were collated by one individual (JE) and independently screened by all authors by reading the title and abstract. A grading system was used whereby articles were assigned scores; no relevance (1), partial relevance (2) and total relevance (3) to the research question (Table 3). Articles scoring a unanimous score of three were automatically progressed for full reading and eligibility assessment. Articles scoring a unanimous scoring of one were removed and any combination of scores (1-3) were discussed for progression or elimination from the review. Full articles were sought for those that lacked sufficient detail but indicated promising relevance to the review. An assessment of eligibility was performed by reading the full article with group consensus upon the type and value of evidence for ECP.

Data charting

The data charting process involved extracting key information to address the research question. Basic data regarding type of literature, scope of evidence and area of ECP were collated. In line with the search protocol, the type of literature was constrained to conference abstracts and peer-reviewed articles. No effort was made to delineate between types of peer-reviewed articles during the data charting, although this is discussed later.

The results of the literature search informed the data charting process, with an iterative approach used by the authors to refine categories based upon common themes. As a result, the scope of evidence was categorised into single-centre studies (presenting results from one hospital, locale or department), surveys of the workforce (locally, nationally or internationally) and educational studies which assess the efficacy or implementation of post-graduate training leading to ECP. The descriptions of NMP advanced practice by Waterstram-Rich et al [8], were used to guide categorisation of ECP activities, based upon self-reported descriptions within the studies. The main classifications included image interpretation, cardiac stressing procedures and radionuclide therapies. A group consensus approach was frequently necessary during categorisation due to ambiguous descriptions. For instance, 'reporting', 'clinical reporting' and 'image commentary' may be deemed different NMP activities and required closer scrutiny of article contents. The inclusive term of 'image interpretation' was adopted to simplify the process. Lastly, data concerning the professional group represented in the research (nurse, radiographer, technologist), year of publication and geographical location of study were collected for descriptive statistics.

Results

A total of 36 studies were identified for inclusion within this scoping review [13-48]. Figure 1 outlines the results of the literature search and selection process using the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 format [49]. Searches provided 604 unique studies with keywords related to non-medical ECP in NM. Scrutiny of titles and abstracts reduced this number to 164 articles, leading to full reading of texts and subsequent inclusion of 36 studies which aligned to the aim of the scoping review. Concordance in grading efforts were relatively high across all assessors, with 78% of included studies (n=28/36) being unanimously and independently assigned total relevance. The remaining eight studies required discussion between authors and were ultimately included. A graphical summary of included articles is shown in Figure 2, with a full data charting list within the supplementary file (Appendix).

Description of literature

The majority of studies were conference abstracts (80.6%, n=29), with the remainder being peer-reviewed articles. It was not possible to determine whether conference abstracts were exclusively podium talks or poster exhibitions due to an absence of associated files. Across all included abstracts, two had identical authors, title, and publication year but at different conferences [19,20], suggesting possible duplication of results. Indeed, the abstracts were remarkably similar between the two but due to the inability to access the posters and/or oral presentation content, they have been included within the results as separate studies. Of the seven peer-reviewed articles, six were self-identified as primary research (original/research article), with one classed as an invited perspective but included previously unreported data from a survey [47]. Articles were predominantly from *Radiography* (5 of 7), an international journal which caters for diagnostic and therapeutic radiographers [50]. Across all included literature, 67% presented ECP at single sites (i.e. one hospital or organisation), 22% were surveys of the workforce and 11% were education studies. Examples of single-centre studies included personal accounts of cardiac stressing procedures (nurse) [44], audit of image interpretation (radiographer) [17], and delegation of NM therapy procedures (technologist) [42]. There were eight surveys of the workforce, with seven reporting ECP from the UK [13,23,25,33,36,43,48] and one from the United States of America (USA) [47]. The article by Harris et al involved analysis of radiographer job descriptions involving advanced practice [48]. Although not strictly a survey of the workforce (with questionnaire or interview), the authors present a cross-section of potential ECP activities (including NM). Of the four educational studies, all included an academic diagnostic radiographer as the primary author investigating pedagogical techniques or outcomes for image interpretation by NMP staff [27,28,35,46]. In terms of geographical origin of publication, these included Denmark, France, UK and the USA.

Description of expert clinical activities

The areas of ECP presented within the literature covered a wide range of NM activities which have been grouped into seven main themes as shown in Figure 2. Across the 36 studies there were 44 self-reported accounts of ECP involving radiography, nursing or technologist staff (some studies listed multiple areas of NM ECP). Image interpretation was most prevalent (38.6%, n=17), with stressing for cardiac perfusion imaging also being highly represented (34.1%, n=15). Table 4 lists the anatomical areas covered during NMP image interpretation, with bone and lung scintigraphy being the most common. Of note, five studies present image interpretation as an area of NMP extended practice but did not specify the anatomical area [13,27,28,43,47].

Cardiac stressing procedures included both pharmacological and dynamic methods, however 50% of studies (n=8) did not specify between the two. Despite this issue, 43.8% of studies describe administration of pharmacological agents to perform cardiac stressing (n=7), with the remaining 6.2% being dynamic (n=1). NM therapies was used as a blanket term to encompass all activities involving the management of radionuclide therapies by NMP staff, such as Iodine-131 [40,42,44,47] or Radium–223 services [41]. One study did not specify the nature of therapy being used [48]. Areas of ECP that were represented to a lesser degree included protocolling or authorising of scans [36,47], physical examination of patients (thyroid) [30], and invasive procedures (vulva sentinel node administration of radiopharmaceutical) [39]. The ordering of complementary imaging, namely radiographs, was identified in two studies [36,37]. Across all publications identified during this scoping review, ECP activities have been associated with radiographers and technologist staff (n=28/36 each), but nursing staff were noticeably less (n=9/36).

Discussion

Evidence of expert clinical practice

This scoping review has identified evidence of NMP ECP from academic literature, although this is predominantly from the UK and demonstrated within conference abstracts. Peer-reviewed literature regarding extended roles in NM tended to be surveys of the workforce rather than detailed analysis of specific activities. The exception was Elliott [17], who presented a personal account of image interpretation development (bone, lung, renal) alongside quantitative efforts for accuracy when compared to a radiologist. Similar accounts of radiographer image interpretation were found among conference abstracts [26,45], along with a personal account of cardiac stressing by nursing staff [44]. Otherwise, literature explored groups of individuals, either at national or team level. It was not always possible to ascertain the level of autonomy by NMP staff, whether they were under direct supervision, protocol-driven or acting as independent practitioners. Three main areas of ECP activities were identified: image interpretation, cardiac stressing procedures and NM therapies. Despite the veracity of efforts to develop an NM advanced associate (NMAA) within the USA [8,51-53] only one article provided evidence of these activities occurring for NMAA staff [47]. Furthermore, although scoping reviews do not assess research quality *per se*, the same article presents anecdotal quotes from a small sample size (n=18)

with an absence of survey methodology [47]. Nevertheless, all three activities are mentioned. Outside of the UK and USA, international evidence appears sparse, with France and Denmark offering the only other indications of NMP ECP [30,40,42]. Language bias would offer an obvious explanation as the authors of this study were limited to the English language. An alternative explanation may be the increasing acceptance of NMP extended roles within the UK [54,55] and therefore the increased incidence of published evidence.

NMP ECP publication habits

The dominance of conference abstracts suggests two concepts, firstly that NMP ECP activities may be an emerging area of research and secondly the publication preferences of NMP staff towards scientific or medical gatherings. Typical topics at conference include novel clinical findings (such as those described in case reports) or practices which may not be commonplace but of potential value to the clinical or academic community. The proliferation of ECP accounts within conference abstracts attests to changes in practice, however they are typically isolated to single centres rather than widespread adoption. These studies are inherently limited to localised changes in practice, sometimes personal accounts, which lack substantive methodological detail expected for peer-review articles. Rather poignantly, none of the conference abstracts within this review appear to have progressed as fully-fledged journal articles. In comparison, the study by Scherer et al [56] indicates a publication progression of 37.3% for biomedical research initially presented at conference (of 307,028 abstracts). The paucity of NMP ECP articles and poor publication progression from conference abstracts may therefore indicate an emerging research theme, a lack of large-scale investigations, or at the very least a niche topic for NM practice.

A tenuous link may be made between NMP publication preferences and the results of this review, assuming that NMP staff appear in the author list. A frequent source of contention, the possible inclusion of non-contributing persons on author lists may affect the analysis of authoring professions [57]. Nevertheless, concerted efforts have been made to quantify the academic output of NMP staff, with a focus upon radiographers [58,59] and NM technologists alike [60]. These studies demonstrate consistent publication within peer-reviewed journals by international NMP staff, however no comparable studies exist for NMP conference abstract rates. In addition to this, academic staff are more prolific than their clinical counterparts (62% versus 35% of authors) [61] and may therefore create a bias towards educational topics. Barriers to

research within radiography and NM have been identified as a lack of time, research skills or an absence of a research culture [62,63]. In contrast, authors who present at meetings typically benefit from lower time investment and relatively quick dissemination to a target audience [64]. Consequently, the appeal of conferences as a viable alternative is apparent, especially when considering the social and networking benefits [65]. Regardless of these factors, conference abstracts lack the same rigorous peer-review and therefore may be considered as low-quality evidence.

Workforce considerations

The extension of allied healthcare profession roles has gained momentum, especially within the National Health Service (UK) with clear guidance for advanced practice recognition [66]. The extent to which this has transcended into the NMP workforce is, as yet, unquantified. Efforts to survey radiographer advanced practice have either omitted NM as a sub-specialism [54] or grouped results alongside other professions without clear discrimination between specialist roles [55,67]. A confounding factor may be the multidisciplinary nature of NM, with nurses, radiographers and technologists constituting the NMP workforce. Despite the growing published works of NMP research, the hybrid workforce may appear to lack a distinct identity amenable for direct comparison. This review confirms the involvement of all three disciplines and indicates that NMP staff are undertaking ECP roles but does not address whether advanced practice is being undertaken. Whether some or all of the evidence located in this review may be attributed to the other pillars of ACP is open to debate. Aspects of leadership or management, education or research may be assumed from the identified evidence, however it is not possible to ascribe advanced practice to individual roles. At the very least, the results of this review highlights research activities (of variable quality) specifically related to NMP ECP. Until a dedicated NMP ACP pathway is established which takes into account the diversity of ECP roles, the recognition of advanced roles in NM within the workforce may be stunted.

Gaps in the knowledge

In keeping with a comparable study by Evans et al [67], this review highlights a need for more robust research to evidence the development, delivery, and efficacy of NMP ECP activities. In contrast, there is greater quantity and quality of research within other radiology ECP roles, particularly clinical (radiographer) reporting [68] and mammography [69]. As a sub-specialism in radiology, NM non-medical staff may share similar research habits

with other lesser-prominent specialisms such as dual energy x-ray absorptiometry [70], but it is beyond the remit of this paper. Although conference abstracts play an important role in information dissemination, the undertaking of more complex, multiple-site studies within NM should be encouraged. Alternatively, dedicated investigations of NMP conference participation habits could explain their popularity and identify barriers or opportunities to further study or progression to peer-reviewed publication. Lesser-represented areas such as invasive procedures and physical examinations by NMP staff would benefit from root analysis to determine whether there are obstacles or if there are other underlying reasons for low uptake of practice (i.e. knowledge, skills, proficiency). For instance, the BNMS has published guidance on the minimum requirements for NMP to keep clinical competence in Myocardial Perfusion Scintigraphic Stress Testing, indicating the need for written evidence of completing a minimum of 50 tests per year as well as a practical assessment [71]. To progress the knowledge base of NMP ECP the authors propose a dedicated workforce survey for Nuclear Medicine clinical activities. After which, multi-site analysis of NMP ECP efficacy and patient experience could be compared to a gold standard.

Limitations

A limitation of this study was the exclusion of non-English language articles from the review. The linguistic constraints of the authors will have inevitably introduced language bias, through the active exclusion of research published in alternative languages. Further research to include these articles would inevitably provide greater contextualisation for an international perspective. A second limitation was the inability to effectively search and access some conference abstracts due to a myriad of paywalls, incomplete or absent cataloguing of presentations and/or posters across international organisations. Although time consuming, the systematic search of conference presentations within our results provided rich results that may be further expanded by analysis of similar conference meta-data. Lastly, the inclusion of PET as a potential area of NMP ECP should be considered for future research within molecular imaging, particularly as it also involves cardiac stressing procedures.

In conclusion, this study has quantified and characterised published evidence of NMP ECP and found a plethora of role extensions involving nursing, radiographer and nuclear medicine technologist staff. The

majority of evidence has been presented within conferences as abstracts, with proportionately few examples of peer-reviewed articles. Evidence regarding image interpretation, cardiac stressing and therapy management by NMP staff occurred most frequently. Of which, most were self-reported activities within single centres rather than larger studies. Whilst reports of ECP were found internationally, the UK dominates in regard to examples of primary research studies. Greater research of individual ECP activities would be beneficial to facilitate the acceptance, integration and consolidation of NMP ACP. Furthermore, although conference abstracts offer a relatively quick, targeted approach to sharing clinical experiences their value as evidence is limited. Research studies with robust methodological design and peer-review is required to investigate NMP ECP activities.

Compliance with Ethical Standards

This article does not contain any studies with human participants performed by any of the authors.

Statements and Declarations

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Table 1. Inclusion and exclusion criteria overview.

Criterion	Inclusion	Exclusion
1. Time period	2001 to 2021	Prior to 2001
2. Language	English	Non-English languages
3. Types of articles	Peer-reviewed articles of any type. Or curated conference abstracts (poster or presentation).	Articles lacking author names or abstract that did not clearly explain how they matched expert clinical practice and for which the corresponding poster/presentation were not available.
4. Study focus	Post-qualification clinical skills beyond core competencies considered as expert clinical practice.	Examples of leadership, education, research (defined by HEE as advanced practice).
5. Setting	Gamma camera nuclear medicine departments (public or private healthcare). Including single, dual or multi-head cameras and SPECT-CT. Imaging and non-imaging procedures.	PET, CT, MRI or combinations thereof.
6. Place of study	National and International	Nil
7. Population and sample	Qualified healthcare professionals in NM including radiographers, technologists, nurses or similar terminologies.	Undergraduate students of any profession.

Abbreviations: SPECT-CT = Single photon computed tomography – computed tomography, PET = Positron Emission Tomography, CT = Computed Tomography, MRI = Magnetic Resonance Imaging. HEE = Health Education England.

Table 2. Search terms of scoping review for title and abstract

Nuclear Medicine Practitioner
Nuclear Medicine + Radiographer
Nuclear Medicine + Technologist
Nuclear Medicine + Nurse
Nuclear Medicine + Extended
Nuclear Medicine + Advanced Practice
Radiographer + Advanced Practice
Technologist + Advanced Practice

Table 3: Study grading system for selection process

No relevance **(removed from review)**	Purely discursive studies such as literature reviews, opinion pieces and editorials. Or activities conducted by non-NMP staff.
Partial relevance **(discussed within group)**	Suggestive of NMP ECP but lacking key details or involving activities that may not align with ECP.
Total relevance **(included in review)**	Primary data collection of NMP ECP or specific mention of patient interaction by NMP staff involving extended roles.

Abbreviations: NMP = Nuclear Medicine Practitioner, ECP = Expert Clinical Practice

Table 4. NMP image interpretation by anatomical area.

Areas of image interpretation	Occurrence in literature
Bone	10
Lung	9
Renal	5
Thyroid	2
Sentinel node	1
Lymphatic	1
Type not specified	5

NB. Some studies listed multiple areas of image interpretation

Fig. 1 PRISMA 2020 flowchart of search results

Fig. 2 Graphical summary of scoping review results. Size is representative of prevalence in current academic literature (not to scale)