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REVIEW ARTICLE

Education and training in intravenous cannulation and administration of contrast media in Radiography: A literature review

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ABSTRACT

The scope of professional practice for radiographers is changing and expanding globally. In the last three decades, radiographers have started taking up new roles due to changing healthcare needs, increasing demand for medical imaging services, and bridging the gap created by the shortage of radiologists. To meet the advancing needs of the radiography profession, professional bodies and higher education institutions (HEIs) should respond to this change and establish new postgraduate training programmes to equip radiographers with appropriate knowledge and skills. One of these postgraduate training programmes is an intravenous cannulation and contrast media (IVCM) injection course. The issue of extended roles is still contentious in most countries, and therefore, educational literature that supports such practices should be collated, and a concise reasoning towards the same should be presented. Therefore, this paper aims to review the literature on IVCM education and training in radiography. The literature review identified four components critical to developing the IVCM course for radiographers: quality assurance, theory, practical, and assessment. The potential barriers to successful implementation of IVCM training are also identified. These include restricted scope of practice, perceived lack of funding, inadequate number of radiologists to teach radiographers and lack of teaching and learning materials. There was no reported postgraduate training programme for radiographers in IVCM in Africa. The findings of this review can assist radiography stakeholders in African countries, including Zambia and beyond, in planning formal training and ongoing professional development, emphasising the need for continuous learning and improvement in radiography.

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INTRODUCTION

Role extension in radiography requires additional education and training by radiographers before taking up new roles[1, 2]. Role extension refers to the responsibilities and skills of practitioners that extend beyond the statutory responsibilities and competencies at the point of professional registration[3]. One of the roles radiographers have taken up in developed countries such as the United Kingdom (UK), the Republic of Ireland, the United States of America (USA), Malta and Australia are intravenous cannulation and contrast media (IVCM) injection[4, 5, 6].The reasons that led to the introduction of radiographer-led IV cannulation and contrast media administration were a shortage of radiologists, changing healthcare needs and increasing demand for medical imaging examinations requiring contrast media. This resulted in changes to the scope of practice for radiographers. Literature shows that this initiative and practice improves departmental workflow and reduces patient waiting times[7, 8, 9]. This results in the delivery of quality imaging services.

Given the above, radiography professional bodies and higher education institutions (HEIs) in developed countries have responded to this change. In 1996, the Society and College of Radiographers of the UK developed and published a course of study for the certificate of competence in IV cannulation and administering contrast media to guide HEIs[4]. Since then, several HEIs in developed countries have established postgraduate training programmes to equip radiographers with additional knowledge, skills, and competence in performing IV cannulation and administration of contrast media. In the UK and the Republic of Ireland, courses are offered at the postgraduate certificate level with a 6-month duration[10, 11]. The course aims to provide appropriate theoretical knowledge and develop the clinical competence of learners at undertaking IV cannulations and administration of contrast media[4,11].

Three studies conducted in Africa have identified the educational gap in the training of radiographers in this new role. Studies conducted in South Africa by Munro et.al and Koch and a recent Namibian study by Shakela et.al identified educational gaps in undergraduate radiography training programmes related to IVCM[1, 9, 12]. Although theory about the pharmacology and reaction of patients to contrast media and basic life support is included in the undergraduate curriculum, it does not cover all components of IVCM. In addition, radiography students do not apply theory to practice. Therefore, the knowledge acquired at the undergraduate level is insufficient for radiographers to undertake the role of IVCM to patients undergoing imaging. To sustain role development, postgraduate education and training are required[1, 4, 13]. Namibia is the first reported African country to have the scope of practice for radiographers extended to include IVCM[9]. However, no IVCM course has been established. In addition, no radiography training programme on this subject was found in other African countries, including Zambia.

This educational article aimed to review the literature on the education and training of IV cannulations and the administration of contrast media in radiography. The literature review identified four components essential in IVCM education and training: theory, practical, assessment, and quality assurance[1, 4, 12] (Figure 1). The findings of this review would help curriculum developers in African countries, including Zambia and beyond, plan to establish IVCM courses.

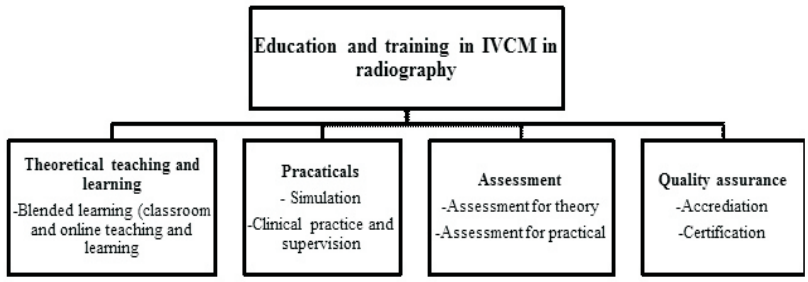

***Figure 1: Education* and training in IVCM in radiography**

THEORETICAL TEACHING AND LEARNING

The aim of the theoretical component of the IVCM course is to provide an appropriate theoretical background for practitioners to undertake IV cannulation and contrast media injection to patients undergoing medical imaging examinations[4]. The course content developed by the College of Radiographers includes the anatomy of the upper and lower limbs, physiology, emergencies, medical-legal issues, infection protocols, injection procedures and contrast agents. This is like courses developed by the University of Malta and University College Dublin[1, 11, 14]. The literature review found that a blended teaching and learning approach is used to deliver the theoretical component of the IVCM course[1, 11]. Blended teaching and learning are a flexible approach combining traditional face-to-face and online educational methods[15,16].

Classroom teaching and learning

The main approach used to deliver the theoretical component of the IVCM course is classroom teaching and learning[4, 11, 12, 15]. Classroom teaching and learning can be defined as physically instructing learners in an educational setting. Depending on the learning outcome, this approach teaches learners in large and small groups**.**

The literature review revealed that radiographers undertaking an IVCM course are taught theory in large groups using face-to-face lectures[11]. In radiography, a lecture is the most common teaching method used in conveying information to large groups of learners[17]. Generally, a lecturer delivers a lecture in person to learners using PowerPoint presentations and visual aids. A lecture is an economical and efficient method of delivering information to large groups of learners[16, 18]. In addition, a lecture can provide the learners with guidelines about further study of the topic and can be used to introduce the resources and other learning opportunities available[16]. However, the lecture is a passive learning experience that fails to engage learners in their learning[16, 19]. To overcome this weakness, learners are also taught in small groups.

Small-group teaching has been a feature of healthcare education programmes for many years[16, 20, 21]. The suggested ideal group size in the literature for small-group teaching is between five and eight learners[22]. However, the number of learners does not define small-group teaching but by achieving three key elements: active participation, face-to-face interactions of learners, and purposeful activities[16, 22]. To accomplish this, learners work together, interacting to achieve common learning goals, with the lecturer facilitating the group[16]. Koch points out that, learning in small groups enables radiographers to develop communication, critical thinking, and problem-solving skills[1]. These skills are essential in patient interactions, obtaining informed consent and problem-solving related to the reaction of contrast media. When compared to a lecture, small-group teaching provides deep learning with a more complete understanding of the subject rather than superficial learning, where there is an emphasis on memorisation[16, 22]. However, lecturers who are accustomed to lecturing may be less experienced in the role of facilitators in small group settings[16]. This may result in mini lectures. Therefore, training lecturers to facilitate small groups is key to achieving the benefits of this teaching approach.

Online teaching and learning

The literature review found that classroom teaching in IVCM is supplemented with online teaching and learning[11, 15, 23]. Online teaching and learning refer to instructions delivered through a wide range of electronic means using the internet[16]. Theory lectures are delivered live or recorded online through videoconference platforms such as Zoom, Teams and Blackboard. Using high-quality internet tools such as video demos, podcasts, and webcasts permits the lecturers to extend the lesson plan beyond the traditional textbooks and become more efficient educators[17]. On the other hand, **t**he study materials uploaded and provided in PowerPoint or multimedia formats offer positive experiences to learners[17]. Another advantage of online learning is that it allows learners to attend classes anywhere[16]. However, without a consistent internet connection, there can be

a lack of continuity in the teaching and learning process[16, 17].

PRACTICAL COMPONENT OF THE IVCM COURSE

The practical component of IVCM training for radiographers includes simulation and clinical practice[11, 12, 15]. During this stage, learners apply the knowledge acquired in the theoretical component to practice. This allows learners to develop competence and prepare to assume the new role of performing IV cannulations and administration of contrast media to imaging patients.

Simulation of the clinical experiences

The first practical component of IVCM training involves Simulation Based Learning (SBL) at the training institution. Simulation refers to imitating real-life events in a safe and controlled environment to enable learners to practise skills without endangering patient safety[24, 25]. Learners practice low-fidelity simulators such as a mannequin arm to prepare them for clinical practice on real imaging patients[11, 15]. For example, the University College Dublin and Queen Margaret University courses have a one-day compulsory IV cannulation clinical training[11, 26]. The training arm is utilised during practical sessions to demonstrate venepuncture and cannulation techniques. Low-fidelity simulations such as arms, skin, and veins are relatively economical and effective for learning psychomotor skills, equipment manipulation, insertion angle, and procedure[15]**.** This is an advantage to developing countries with limited resources for high-fidelity simulators. To educators, SBL provides an opportunity to expose learners to situations that help bridge the theory-to-practice gap[27]. Simulation helps learners receive a guaranteed and standard clinical experience, learn a procedure in a risk-free environment and practice with the simulator until they have mastered the skill[16]. For these reasons, SBL is significantly used in IVCM training to allow radiographers to practice extensively and repeat procedures until competency is achieved[11, 26, 27].

Clinical practice and supervision

After completing the theoretical and simulation components, a learner completes clinical practice in their respective radiology departments under an experienced clinical supervisor[11]. The agreed-upon supervisor can be a radiologist, radiographer, or radiology nurse, depending on the stage of practice in the radiology department. In the initial stages, experienced radiographers in IVCM may not be available, and this is when a radiologist or radiology nurse can help supervise radiographers undergoing training. The role of a clinical supervisor includes organising and managing training resources, clinical teaching, and role modelling, giving feedback to learners, conducting assessments, and supporting learners with learning challenges[4, 11, 28].

During clinical practice, learners must log observed, assisted and unassisted IV cannulation attempts[4, 11]. The appointed clinical supervisor should sign this off. Concerning the skill component, the Society and College of Radiographers guidelines and the University College Dublin require that learners execute at least 10 assisted and 20 independent IV cannulations[4, 11]. This is similar to the training requirements at the University of Malta that require trainee radiographers to observe a minimum of five IVCM administrations and record a minimum of 50 unassisted and independent IVCM administrations[14]. At the end of 6 months of training, the learner must demonstrate competence. The clinical supervisor must be satisfied that the learner can administer IV injections in various clinical settings[4,6].

ASSESSMENT

To meet the aims of IVCM training, the learner should demonstrate appropriate theoretical knowledge and clinical competence in undertaking IV cannulations and administering contrast media[4, 11]. This is achieved through the administration of formative and summative assessments. Formative assessment is undertaken during training to gather information about a learner's progress[21, 29, 30]. During

IVCM training, formative assessment is facilitated by the clinical supervisor, providing constructive feedback to the learner. The feedback allows the learner to monitor their progress towards achieving the learning objective[21]. On the other hand, summative assessment is the assessment that takes place at the end of training[21, 24]. For the IVCM courses, summative assessment occurs at the end of the taught theory[11, 26]. Both theoretical and practical assessments are conducted to achieve the aim of the IVCM course[4].

Theoretical assessment

The common written assessment methods for the theoretical component of the radiography programmes are multiple-choice questions (MCQs), problem-based essay questions and assignments[31]. However, there is limited information on the assessment methods used to assess theory in IVCM courses. During the literature review, only the University College of Dublin and Robert Gordon University stated that they were using the MCQ written examinations[10, 11]. The written examination is based on the theory covered during training: anatomy of the upper and lower limbs, physiology, emergencies, medical-legal issues, infection protocols, injection procedures and contrast agents. The primary purpose is to determine whether a learner has acquired the expected knowledge and understanding[16, 19, 31].

Multiple-choice questions (MCQ) examination is a form of assessment in which learners are asked to select one or more choices from a list of answers[32]. There are two commonly used formats for MCQs: single best option and multiple true or false questions[16]. Table 2 shows the advantages and disadvantages of MCQs.

Table 1: Advantages and disadvantages of multiple-choice questions (MCQ)

Advantages	Disadvantages
• The content area sampled is large, covering a range of topics or areas	• Mainly test recall of knowledge rather than in-depth understanding
• Takes less time to complete and is easy to mark	• It is time-consuming to set the questions
• Online MCQs provide immediate answers and feedback	• There is a possibility of guessing the correct answer
• Have high reliability, validity, and manageability	• It cannot test oral or written skills

Practical assessment

Two types of assessment are used for practical in IVCM courses: clinical competence and performance-based assessments.

Assessment of clinical competence

The Oxford English Dictionary defines competence as the ability to do something successfully or efficiently. Tests of clinical competence demonstrate what a learner can do in a controlled situation[16, 30, 33]. Clinical competence is, therefore, best assessed in a controlled (simulated) learning environment using the objective structured clinical examination (OSCE) [16, 31, 34]. This allows learners to be assessed risk-free[16]. Learners can make mistakes and appreciate their consequences without the risk of causing harm to patients. For example, Queen Margaret University uses OSCE to assess the clinical competence of radiographers undertaking the IVCM course[26]. The OSCE consists of multiple stations where each learner is asked to perform a defined task, such as taking written informed consent from a patient or performing an IV cannulation. OSCE is part of the summative assessment. Table 2 shows the advantages and disadvantages of OSCE[16, 19, 35].

Table 2: Advantages and disadvantages of OSCE in assessing clinical competence

Advantages	Disadvantages
• It provides a uniform scheme for clinical assessors and consistent examination scenarios for students	• It requires an extensive amount of organisation
• It reduces subjective bias attributed to an assessor as the learner encounters different assessors during the examination	• It is costly in terms of manpower, resources, and time
• It is an objective method of assessing other aspects of clinical expertise, such as procedural skills, interpersonal skills, technical skills, problem-solving, and decision-making	• Lack of trained assessors in conducting objective structured clinical examination (OSCE)

Table 3: Advantages and disadvantages of a logbook in assessing clinical performance

Advantages	Disadvantages
• It serves as a permanent record of the progress made by the learner	• It is time-consuming as learners must attend to the patients as well as complete the logbook
• It is a self -assessment tool where learners are actively involved in their learning process	• It is time-consuming for clinical supervisors because of the constant validations of the records
• It is economical in terms of resources since the learners only use hard copy or electronic logbook	• Learners may be unfamiliar with logbook as an assessment method
• Allows the standardisation of assessment to all learners undertaking the same training	• Learners may be recording false records, resulting in an invalid assessment

Assessment of clinical performance

According to the Oxford English Dictionary "performance" means the action or process of completing a task[33]. This means that clinical performance assessment tests what a leaner does in practice[16, 30]. Following the taught and simulation clinical experiences components of the IVCM course, learners undertake practice-based learning and record their performance in a logbook[4]. A logbook is a record that includes the minimum required for planned education and recorded practical learning[36]. In the IVCM course, learners record observed, assisted and unassisted IV cannulation attempts[4]. A logbook is very useful in focusing learners on important objectives that must be fulfilled within a specific period[36]. Therefore, logbooks are part of the formative assessment. The clinical supervisor monitors the recording of the learner's procedures, provides feedback, and assesses the learner's clinical competency and signs off the logbook[4,10,11,26] .Table 3 shows the advantages and disadvantages of a logbook in assessing clinical performance[36-39].

QUALITY ASSURANCE IN IVCM EDUCATION AND TRAINING

Quality assurance is critical in IVCM education and training to ensure that radiography programmes adhere to stringent standards, maintain educational excellence, and produce competent individuals capable of providing safe and effective patient care. During the literature review, two critical factors that contributed to quality assurance in IVCM education and training in radiography were identified: accreditation and certifications.

Accreditation of IVCM courses

Globally, accreditation is essential for an effective training programme system[40]. The World Federation for Medical Education (WFME) defines accreditation as the certification of the suitability of the training programme and the competence of HEIs in delivering it[41]. In radiography, respective professional bodies undertake the accreditation of IVCM courses. For example, in the UK and the Republic of Ireland, the Society and College of Radiographers (SCoR) and the Irish Institute of Radiography and Radiation Therapy, respectively, are responsible for the accreditation of IVCM courses[4, 6]. HEIs wishing to develop IVCM courses apply to respective professional bodies and supply documentation related to the name of the ward, the rationale for the development of the course, aim and objectives, entry requirements, teaching and learning resources, partnership arrangements with

the clinical departments, quality assurance processes, and teaching staff [4, 6]. The application is only granted to HEI to offer a training programme if the professional body is satisfied. This ensures that education standards are maintained. At the time of writing, four and eight education centres have accredited IVCM courses in the Republic of Ireland and the UK, respectively, in radiography[4,6].

Certification

Upon completion of training, successful candidates receive a certificate of competence in IV cannulation and administration of contrast media[10, 11, 14, 26]. The certification body varies from country to country. For example, in the UK, the College of Radiographers issues certificates to successful candidates while in the Republic of Ireland, it is respective HEIs offering IVCM courses[6,42].

PRACTICAL IMPLICATIONS FOR IMPLEMENTING IVCM TRAINING

Implementing IVCM education and training in radiography in Africa and other countries that are planning to establish this new role has significant practical implications. Role extension in radiography requires changes in the legal and policy frameworks[2, 9]. In Namibia, the Allied Health Professions Council of Namibia (AHPCN) changed the scope of professional practice for radiographers in 2020 to incorporate IVCM. In addition, role extension requires further education and training to impart radiographers with the necessary knowledge and skills[4,6].

The literature review identified four potential barriers to successfully implementing IVCM education and training (Table 4).

Table 4: Barriers to successfully implementing IVCM education and training

	Barrier
1	Restricted scope of professional practice for radiographers
2	Perceived lack of funding to develop IVCM courses
3	Inadequate number of radiologists to teach radiographers
4	Lack of teaching and learning materials, such as textbooks and simulators

Restricted scope of professional practice for radiographers: In most African countries, radiographers' scope of practice is limited to imaging patients. This means that IVCM courses cannot be developed by HEIs offering radiography training programmes without changes to the scope of professional practice. Professional bodies like the Radiological Society of Zambia (RSZ) should advocate for this new role. The advocacy aims to educate policymakers on the benefits of extending the role of radiographers to perform IVCM and bring change in delivering quality medical imaging services[43].

Perceived lack of funding to develop IVCM courses: IVCM is a medical imaging speciality. It is mainly performed by radiographers working in areas where intravenous urogram (IVU), computed tomography (CT), magnetic resource imaging (MRI) and nuclear medicine examinations are undertaken. Literature reports a perceived lack of funding to develop postgraduate training programmes in medical imaging in many African countries[44]. For example, most of the government budget of the Republic of Zambia is spent on salaries for public workers[30]. One possible solution to this can be engaging cooperating partners to assist in establishing the IVCM course. In addition, the tuition fees can be used to sustain the education and training programme.

Inadequate number of radiologists to teach radiographers: In the initial stages of the training programme, when experienced radiographers are unavailable, radiologists play a teaching and supervisory role. However, there is a global shortage of radiologists, and Africa is worst affected. There are 13 radiologists per 100,000 people in Europe compared to Africa, where an average of 3.6 radiologists per one million people[44, 45]. A survey conducted by Kawooya et.al found the following number of radiologists in selected African countries: Egypt (N=1250), South Africa (N=1200), Nigeria (688), Kenya (N=250), Tunisia (N=450), Ghana (N=60), Zimbabwe (N=25), Malawi (N=3) and Swaziland (N=1). In Zambia, 22 radiologists are serving a population of 19.6 million[46]. This is a

barrier to the training of radiographers due to their increased workload of clinical, managerial, and teaching roles[47]. To overcome this barrier, Zambian diaspora radiographers trained in IVCM, and local radiology nurses can assist in teaching trainee radiographers in the initial stages of the training programme.

Lack of teaching and learning materials, such as textbooks and simulators: Modern equipment and infrastructure are crucial to training competent healthcare professionals[44]. This also applies to IVCM education and training in radiography. High-fidelity simulators for simulation learning experiences are expensive for developing countries such as Zambia[15, 48]. There is also a lack of radiography textbooks on this topic. To overcome this barrier, low-fidelity simulations such as arms, skin, and veins, which are economical, can be used[15]. The nursing profession also has low-fidelity simulators and textbooks on IV cannulation, which can be used during training.

CONCLUSION

The review identified four critical components that constitute an effective IVCM education and training in radiography: quality assurance, theory, practical, and assessment. The advantages of such training are clear for all, especially in a resource-constrained environment such as African countries. In designing and implementing IVCM roles, we must prioritise education and training to ensure appropriate competence. The said training programmes must include the four elements identified in this review. Emphasis must be placed on appropriate stakeholder engagement, with the professional bodies playing a critical role in the advocacy process. Safeguards must be emphasised in the form of a quality assurance process to ensure patient safety and acceptability of the new extended role in radiography practice. This review also emphasises the significant role of radiography professional bodies in setting educational standards via the accreditation of training programmes. Therefore, it is recommended that professional bodies and HEIs collaborate in advocating for role extension in radiography and developing training programmes such as IVCM in Africa, Zambia included.

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COMPETING INTEREST

None

AUTHORS' CONTRIBUTIONS

Brian Mubanga conceptualised this literature review. It is part of an ongoing research project for his Master of Science in Diagnostic Radiography, titled "Knowledge and Perceptions of Radiographers Regarding Performing Intravenous Cannulation and Administration of Contrast Media in Lusaka Province," at the University of Zambia. Dr Osward Bwanga, Dr James Sichone and Stefan Kafwimbi are the supervisors for this research project. Mrs Phanny Nakonde Sichone assisted in literature research. They reviewed and corrected the manuscript before submitting it for publication.

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