Investigating the perception of perfusion educators on the training programmes in cardiovascular perfusion in South Africa

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ABSTRACT

Background: Perfusion education and training varies considerably throughout the world. In South Africa, only 3 universities offer the Bachelor of Technology degree in clinical perfusion. But, unlike most developed nations, where a common curriculum for perfusion education has been established, perfusion education in South Africa is plagued by the lack of standardised training curriculum, study and exit-level outcomes and competencies required of a cardiovascular perfusionist. Hence, this study aims to investigate the perception of perfusion educators on the adequacy and validity of current training programmes in cardiovascular perfusion in South Africa with a view to develop a standardised curriculum for perfusion education.
Methods: A descriptive, exploratory study design which employed a quantitative methodology using a questionnaire survey was used to obtain both qualitative and quantitative data on the perception of perfusion educators on the adequacy and validity of current training programmes in cardiovascular perfusion in South Africa.
Results: This study recorded a response rate of 71.4%. Perfusion educators in South Africa are in agreement that there is a need for a standardised curriculum and that a single exit examination, in both oral and written formats, conducted by a regulatory body, should be a requirement for certification and registration.
Conclusion: This study highlights the need for a revised, standardised curriculum for perfusion education in South Africa in order to improve competency amongst perfusion graduates and to produce perfusionists who are able to successfully apply their knowledge and skills to improve patients' outcome. SAHeart 2018;15:26-35

INTRODUCTION

Prior to the era of modern medicine, attempting any form of surgical intervention on the human heart was regarded as taboo as the heart was considered the "soul of life".[1] However, the development of therapeutic procedures such as the use of cardiopulmonary bypass (CPB) through extracorporeal circulation has made cardiac surgery a reality.[2] In the 1950s and early 1960s, operators of the heart-lung machine (Perfusionists),[3] were often laboratory technicians or surgeons (often residents), and skills were acquired on the job from observing successive cases in the operating theatre.[4,5] With the advancement in extracorporeal circulation technology and techniques in cardiac surgery, clinical perfusion was quickly recognised as an allied health profession that require formal education and training.[5]

Perfusion education was formalised in South Africa in 1981.[6] After completing theoretical and practical training, successful clinical perfusionists were awarded a diploma certificate and were registered by the South African Medical and Dental Council (now Health Professions Council of South Africa [HPCSA]) as clinical technologists (perfusion). Subsequently, the Bachelor of Technology Clinical Technologists (B. Tech) (perfusion) degree was introduced in 1990 and has remained the major requirement for registration in the category of independent practice as a clinical perfusionist.[7] Today, the B. Tech clinical technologists (perfusion) degree is offered by 3 universities in South Africa (SA), with different programme content and training philosophies, thus suggesting that the exit-level outcomes and/or competencies of graduating clinical perfusionists vary from one institution to the other.

Hence, the objective of this study was to investigate the perception of perfusion educators on the adequacy and validity of current study outcomes and essential content of the cardiovascular perfusion training programmes in South Africa,

with a view to develop a standardised, uniform and relevant curriculum for perfusion education.

METHODS

A descriptive, exploratory study design that employed a quantitative methodology using a questionnaire survey was used in this study to obtain both qualitative and quantitative data.

The survey population consisted of HPCSA registered cardiovascular perfusionists involved in training cardiovascular perfusion students in South Africa. Contact details of participants were obtained telephonically from the respective heads of the perfusion unit at each institution, or by consulting the official websites of the relevant universities where prospective participants were employed.

Determination of current outcomes and essential programme content of the cardiovascular perfusion programmes was obtained from the curriculum of the respective universities as well as the South African Qualifications Authority (SAQA) document on registered qualifications (clinical technology).

Quantitative and qualitative data was collected by means of a self-administered, semi-structured questionnaire, using the online survey-management system, EvaSys. The questionnaire contained both open- and closed-ended questions.

Data was collated and analysed using the EvaSys software and quantitative results presented in percentages. Participant responses to the open-ended questions are presented as quotes and no changes to the spelling or grammar were made throughout the document.

Ethics approval for this study was obtained from the Ethics Committee of the Faculty of Health Sciences, University of the Free State (ECUFS 07/2014).

RESULTS

Despite several reminders and the researcher resending the questionnaires to the participants numerous times, only 10 of the initial 14 questionnaires distributed were returned, thus giving a response rate of 71.4%. Results are presented as percentages in the form of tables.

DEMOGRAPHIC INFORMATION OF RESPONDENTS

Age

Participant ages ranged from 25 - 47 years, with a median of 29 years and an average age of 31.7 years. The majority, 60% were in the age group 21- 30 years, while 31 - 40 years made up 30% and only 10% was older than 40 years.

Gender

The majority of the participants were male (60%), with 40% being female.

Institutions where B. Tech qualifications were obtained

All the participants reported to have obtained their qualification from South African Universities of Technology. Sixty percent of participants obtained their B. Tech degree from the Central University of Technology (CUT), while 40% qualified from the Durban University of Technology (DUT).

Postgraduate qualifications in cardiopulmonary perfusion

The majority, 70% of the participants, had no postgraduate qualifications, while 30% had a Master of Technology (M. Tech) degree in Clinical Technology (Perfusion) and 10% had a Doctor of Technology (D. Tech) degree in Clinical Technology (Perfusion).

Employment at academic hospital

All the participants in this study (100%) indicated that they were full-time employees of an academic institution or hospital.

PERCEPTIONS OF PERFUSION EDUCATORS ON CURRENT EXIT-LEVEL OUTCOMES OF THE B.TECH PROGRAMME IN CARDIOVASCULAR PERFUSION

In this section, educators' opinions on the validity and adequacy of the current exit-level outcomes of the B. Tech programme in cardiovascular perfusion was investigated. Participants were asked to choose between "yes", "no" or "unsure" to closed-ended questions while the open-ended questions requested that respondents supply a motivation for their response to the closed-ended question, or an opinion or facts regarding subject matter.

Description of the current exit-level outcomes

When asked to indicate the current exit-level outcomes described by their respective institutions, some participants described specific requirements for qualification rather than actual exit level outcomes for the B. Tech programme in cardiovascular perfusion (cf. Quotes #1, #2, #3 and #4).

#1 **"120 Cases of which 20 or more must be children. With 2 years full time practical training".**

#2 **"120 Adults and 20 kids. B. Tech research. CUT".**

#3 **"4 Years of 2 are practical training".**

#4 **"The outcomes is met by practicals throughout the year and the student need to do 100 Adult CPB and 20 children. Central University of Technology".**

Adequacy of current exit-level outcomes

In this section, participants were asked whether the current exit-level outcomes described by their respective institution adequately prepare graduate perfusionist for the expectations of modern practice. Forty per cent of the participants indicated that attaining the current exit-level outcomes described by their institution adequately prepare graduate perfusionist for the expectations of modern practice, while 30% stated that the outcomes described by their institution was inadequate and another 30% were unsure whether the exit-level outcomes were adequate or not.

Competency of newly qualified perfusionists

When asked if the newly qualified B. Tech perfusionists employed in their hospitals were competent to fulfil the tasks required of them, 70% of the participants indicated that the newly qualified perfusionists were competent whilst 10% indicated that they were not, and 20% of the participants were unsure about the competency of the newly qualified perfusionists.

Modification of the current exit-level outcomes

Participants were asked whether there was a need to modify the current exit-level outcomes of the perfusion programme to better prepare perfusion graduates to meet new expectations. An emphatic 90% of the participants indicated that there is a need to modify the current exit-level outcomes (cf. Quotes #5 - #10).

#5 "I think there should be a more streamlined approach with regard to theoretical and practical training amongst the various institutions, as this shall prepare better the newly qualified for work in any of the various institutions".

#6 "Paediatric requirements need to be looked at. There are few academic hospitals doing regular paediatric cases. With Adults ECMO needs to be looked at as well as other LVAD support devices not used frequently at accredited training institutions. A weekend congress/learning/wet lab session should be held for fourth years to give them some exposure Mini CPB and centrifugal pump bypass can also be included in such a week/weekend".

#7 "Students need better exposure to other perfusion practices".

#8 "There is no standard practice and training amongst universities and hospitals".

#9 "Yes definitely. To make sure that the standard among the graduates is at the same level. According to the uniform outcomes the preparation and evaluation of the students could be compared between different units".

#10 "I think SA should have programmes like abroad which are strictly perfusion from 1st year".

Change in exit-level outcomes to improve graduate competencies

Eighty per cent of the participants indicated that a change in the exit-level outcomes would improve graduate competencies, while 10% indicated that it would not improve graduate competencies and another 10% were unsure whether a change in exit-level outcomes would improve competencies or not.

Need for a standardised curriculum

Ninety per cent of participants indicated that a standardised curriculum should be used by all institutions, while 10% were not sure if a standardised curriculum is required.

Single-exit exam

All participants (100%) were unanimous that a single exit exam should be a requirement for assessing that all outcomes have been met. Of the participants, 80% indicated that this exit exam should be both in written and oral form, whilst 20% indicated that it should be only in written form.

Conducting the single-exit exam

Participants were asked to indicate who should conduct the single exit exam. Sixty percent indicated the single exit exam should be conducted by an accredidted "college of cardiovascular perfusion" (cf. Quote #11), 20% indicated that the training institution should conduct the single-exit exam (cf. Quote #12), while another 20% selected "other".

#11 "Exams should be conducted by a College of Cardiovascular Perfusion that is accredited by all Institutes to ensure that those qualifying meet all requirements and are legible for registration with HPCSA".

#12 "The training institution".

PERCEPTIONS OF PERFUSION EDUCATORS ON STUDY OUTCOMES AND CURRICULUM CONTENT OF PERFUSION PROGRAMME

In this section, the perception of perfusion educators on outcomes and essential curriculum content of the B. Tech degree in perfusion was investigated. Participants were asked to indicate whether the outcomes and content of current perfusion programmes are "essential", "useful" or "not needed". Participants were also allowed to propose their own outcomes and content under each section and were asked to indicate whether the proposed content, or outcome, is essential or useful.

Clinical practice module

Regarding the outcomes for clinical practice module, participants unanimously agreed that outcomes 1 and 2 were essential, while outcome 3 was deemed useful by 10% and essential by

90% of the respondents (Table I). In addition, one participant proposed an outcome (cf. Quote #13). The participant did not indicate whether the outcome stated was essential or useful.

#13 "Basic Mechanical trouble shooting. Pharmacological knowledge".

With the exception of embryology, which was deemed essential by 40% of the respondents, the majority of the participants indicated that all the topics listed in the curriculum content are essential to meet the stated study outcomes (Table I). In addition, one participant suggested that "hypothermia, coagulation cascade, cardiac electro-physiology" is an essential topic that should be added (cf. Quote #14).

#14 "Essential – hypothermia, coagulation cascade, cardiac electrophysiology".

TABLE I: Study outcomes and curriculum contents for clinical practice module for B. Tech in cardiovascular perfusion (n=10).

Study outcomes	Essential %	Useful %	Not needed %
1. Independently evaluate the organ and system pathology and provide organ and system support for therapeutic/corrective procedures on neonatal, paediatrics and adult patients.	100	0	0
2. Independently perfuse the heart and provide cardiac support as well as arrest the heart when necessary during cardiac bypass surgery.	100	0	0
3. Identify causes of adverse perioperative physiological conditions and apply appropriate methods and techniques to prevent or minimise such conditions.	90	10	0
Curriculum contents			
Topics	**Essential %**	**Useful %**	**Not needed %**
Embryology	40	60	0
Anatomy of the newborn	80	20	0
Anatomy of the abnormal heart	90	10	0
Congenital heart disease and treatment	100	0	0
Cardiac anatomy	100	0	0
Respiratory anatomy	80	20	0
Obstruction of blood flow	90	10	0
Acquired heart disease and treatment	70	30	0
Diseases of the respiratory system	70	30	0
Defects of the aorta	90	10	0
Pulmonary hypertension	90	10	0
The Heart (ultrastructure)	80	20	0
Coronary blood flow	90	10	0
Cardiac physiology	100	0	0
Respiratory physiology	80	20	0
Acid-base management	100	0	0
Pathological effects of CPB	90	10	0
The inflammatory response to CPB	80	20	0
Free radicals	80	20	0
Ischaemic reperfusion injury (IRI)	80	20	0
Ischaemic preconditioning	90	10	0
Neuro-endocrine responses	70	30	0
Metabolic electrolyte responses	90	10	0

TABLE II: Study outcomes and curriculum contents for pharmacology module for B. Tech in cardiovascular perfusion (n=10).

Study outcomes	Essential %	Useful %	Not needed %
1. Ability to evaluate the need of drug, fluid, and solution use and the application thereof perioperatively.	90	10	0
2. Calculate the correct dosage of drugs, fluids, and solution for the correct weight of patients.	100	0	0
3. Able to identify perioperative signs and symptoms of adverse drug reactions and apply therapeutic drug and technical procedures to reverse or decrease the adverse effects.	100	0	0
4. Independently conduct, analyse, evaluate blood gas and coagulation processes, and provide corrective measures to prevent adverse physiological events perioperatively.	100	0	0
5. Identify, calculate and prepare the correct dosage of priming solutions and correctly prime the CPB circuit.	100	0	0
Curriculum contents			
Study outcomes	**Essential %**	**Useful %**	**Not needed %**
Pharmacological concepts	80	20	0
Solutions: compositions and therapy	70	30	0
Fluid balance and assesment	90	10	0
Electrolyte balance and assessment	100	0	0
Clinical pharmacology	80	20	0
Priming composition and methods	90	10	0
Blood gas measurements and interpretations	100	0	0
Acid base strategies: Alpha/pH stat	100	0	0

Pharmacology module

Four (outcomes 2, 3, 4 and 5) of the 5 study outcomes listed for pharmacology are considered essential by all participants (Table II). In addition, one participant suggested a study outcome that should be included in the phamacology module (cf. Quote #15)

#15 "Essential – in-depth understanding of pharmacokinetics, distribution, half-lives, action of all drugs used on the pump".

Three of the topics listed under curriculum content for the pharmocology module are considered essential by all participants (Table II). Participants had no further input regarding topics in the pharmacology module.

Perfusion technology module

Regarding the study outcomes for perfusion technology module, 5 (outcomes 1, 2, 3, 5 and 7) of the 9 listed outcomes are considered essential by all participants (Table III). An additional essential outcome was suggested by a participant (cf. Quote #16).

#16 "Essential – ecmo".

Participants were unanimous on 11 of the 19 content topics listed for perfusion technology (Table III), indicating that these topics are essential. Theatre and ICU emergencies were considered essential by only 60% of the respondents (Table III). One participant suggested a topic deemed essential (cf. Quote #17).

#17 "Essential – total circulatory arrest".

Blood management module

Four of 6 listed study outcomes for blood management were deemed essential by all participants (Table IV). Seventy percent of the participants indicated that outcome 5 is essential, while 80% indicated that outcome 6 is essential (Table IV). Of the content topics listed for blood mamangement, 6 topics are cosidered essential by 90% of the participants (Table IV). Two of the content topics were considered essential by 60% of the participants, while one of the content topics (Applied Microbiology) was considered essential by only 40% (Table IV).

TABLE III: Study outomes and curriculum contents for perfusion technology module for B. Tech in cardiovascular perfusion (n=10).

Study outcomes	Essential %	Useful %	Not needed %
1. Identify parts, accessories and components of a heart-lung machine and be able to assemble them correctly.	100	0	0
2. Correctly assemble, and operate the bypass system appropriately based on effective selection of disposables and application of knowledge in a professional context.	100	0	0
3. Ability to induce, maintain and reverse hypothermia together with maintaining the organ and system within physiologically acceptable limits.	100	0	0
4. Operate cogulation management systems (e.g ACT, TEG and Heparin management systems), interpret results and apply proper corrective measures.	90	10	0
5. Identify and administer correct myocardial protection solutions and dossages applying the most appropriate strategies.	100	0	0
6. Assemble and monitor the cardioablation machine with effective selection of appropriate disposables.	80	20	0
7. Able to identify emergency situations and apply measures to prevent loss of human life as well as assets.	100	0	0
8. Able to idependently perform hyperthermic isolated limb perfusion (HILP).	70	30	0
9. Independently perform hyperthermic intra-peritoneal chemotherapy (HIPEC).	70	30	0
Curriculum contents			
Topics	**Essential %**	**Useful %**	**Not needed %**
The heart-lung machine	100	0	0
Pumps (Roller vs. centrifugal)	90	10	0
Flow meter	90	10	0
Vaporisers	80	20	0
Thermometers	80	20	0
Warm and cooling apparatus	90	10	0
Safety devices	100	0	0
Filters	100	0	0
Tubing	100	0	0
Pressure monitoring systems	100	0	0
Cannulae	100	0	0
Temperature management and hypothemia	100	0	0
Coagulation management	100	0	0
ECC techniques	100	0	0
Myocardial protection	100	0	0
Cardio-Ablation (Maze)	80	20	0
Emergencies during CPB	100	0	0
Organ perfusion (Lung, kidney, HILP, HIPEC, etc.)	80	20	0
Theatre and ICU emergencies (Fire, etc.)	60	40	0

Haemodynamic monitoring and related technologies module

Both study outcomes listed under haemodynamic monitoring and related technologies module are considered esssential by 70% and 40% of the participants, respectively (Table V). Of the content topics, electrocardiography was considered essential by 50% of the participants, while the other 50% deemed it useful (Table V). Thirty percent of the participants indicated

TABLE IV: Study outomes and curriculum contents for blood management module for B. Tech in cardiovascular perfusion (n=10).

Study outcomes	Essential %	Useful %	Not needed %
1. Identify haematological disorders and apply appropriate preventive and corrective measures perioperatively.	100	0	0
2. Calculate the appropriate amount of haemodilution required for a particular procedure and administer solution dose.	100	0	0
3. Calculate the correct amount of blood required for the type and size of patients and tranfuse using the safest methods.	100	0	0
4. Assemble and operate cell saving equipment effectively and appropriately.	100	0	0
5. Operate cell saver to prepare platelet gel, platelet rich plasma (PRP), platelet poor plasma (PPP).	70	30	0
6. Applying effective perioperative infection control in all aspects of perfusion.	80	20	0
Curriculum contents			
Topics	**Essential %**	**Useful %**	**Not needed %**
Haematological system disorders	80	20	0
Haemolysis	90	10	0
Haemodilution	90	10	0
Haematological effect of CPB	90	10	0
Management of coagulopathy	90	10	0
Cell saving	90	10	0
Blood conservation techniques	90	10	0
Platelet sequenstration	80	20	0
Plasma pheresis	60	40	0
Applied microbiology	40	60	0
Sterilisation and sterile techniques	60	40	0

that non-invasive radiological techniques is not needed (Table V). Similarly, 10%, 20% and 10% indicated that knowledge of nuclear cardiology, MRI and computer tomography is not needed (Table V).

Mechanical circulatory support module

Eighty percent of the participants indicated that outcome 1 listed under mechanical circulatory support module is essential (Table VI). In addition, one of the participant suggested an outcome for machanical circulatory support module (cf. Quote #18).

#18 "Appropriate timing & duration of support should form part of the outcomes for mechanical circulatory support".

Of the listed curriculum content topics, learning about pacemakers was considered essential by 50% of the participants, while 10% indicated that knowledge of implantable devices is not needed (Table VI).

COMMENTS BY PARTICIPANTS

In this section, participants were asked to give any additonal comments, and only one participant commented (cf. Quote #19).

#19 "I think it will be good as diff acad institutions to meet & try to come up with a uniform curric, so that any graduate perfusionist can fit anywhere & to improve the standard of clinical practice & academic mind".

DISCUSSION

Recent advances in perfusion practice, operating on more complex cardiac problems, and the continued need to reduce mortality and morbidity in high-risk patients necessitate that an individual entering the perfusion profession must study in an educational programme that is compatible with graduate-level education.[8]

Pefusion education, training and criteria for certification of clinical perfusionists varies across countries,[9] but the funda-

mental rule of graduating from an accredited cardiovascular perfusion programme remains the same.[10] Cardiovascular perfusion is a small profession with only 16 perfusion education programmes in the United States graduating approximately 130 students annually.[8] Similarly, in South Africa, only 3 universities offer programmes in cardiovascular perfusion. However, unlike the United States, where a standardised curriculum for perfusion education and guideline for perfusion practice has been established,[11] perfusion education in South Africa is plagued with a lack of standardised curriculum, study outcomes and competencies required of a cardiovascular perfusionist. Hence, this study was aimed at investigating the perception of perfusion educators on the current study outcomes and essential content of the Bachelor of Clinical Technology in cardiovascular perfusion.

The outcomes-based-education (OBE) approach, is a student-centred learning method that focuses on measuring student performance (the "outcome"). The programme is thus defined by the outcomes to be obtained by the learner. In OBE, programme design starts by focusing on the end-goal, enabling educators to focus on "what students will do, rather than what the staff will do" (i.e. focus on the role of the student towards achieving academic success).[12] Analyses of data obtained by this study revealed that most perfusion educators are not aware of the exit-level outcomes of the perfuson training programme in their institution. This suggests that the relevant institution may not have provided educators with the outcomes needed to be met by the learner. In addition, these findings further substantiate the lack of standardised outcomes for students in order to achieve competency. Although 70% of the educators reported that newly graduated perfusionist employed in their respective academic hospital are competent, 90% of the educators still indicated that a standardised curriculum and modification of the current exit-level outcomes is necessary to prepare perfusion graduates for future challenges and improve competency (cf. Quotes #5 - #10). To this end, perfusion educators supported the establishment of a professional body that will be tasked with conuducting a single-exit examination to assess if all outcomes have been attained prior to registration (cf. Quote #11). This is similar to the American model of perfusion education where all perfusion graduates have to write the American Board of Cardiovascular Perfusionist (ABCP) examinations to be eligible for certification.[4,13]

Diverse responses on outcomes and content was obtained when perfusion educators were asked to respond to questions regarding current curriculum contents and study outcomes. In

TABLE V: Study outcomes and curriculum contents for haemodynamic monitoring and related technologies module for B. Tech in cardiovascular perfusion (n=10).

Study outcomes	Essential %	Useful %	Not needed %
1. Independently perform and/or interpret advanced selected diagnostic procedures using specialised equipment/methods such as ECG, pressure waves and measurements, Trans Thoracic Echocardiography (TTE), Near Infrared Spectroscopy (NIRS) and O_2 saturation monitoring.	70	30	0
2. Interpret radiological examinations and prepare appropriate equipment and disposables for the relevant corrective procedures.	40	60	0
Curriculum contents			
Topics	**Essential %**	**Useful %**	**Not needed %**
Laws of gas and fluid flow	80	20	0
Bedside assessment	40	60	0
Electrophysiology	70	30	0
Cardiac factors and measurement	70	30	0
Shock	60	40	0
Electrocardiography	50	50	0
Non-invasive radiological techniques	30	40	30
Magnetic resonance imaging (MRI)	30	60	10
Nuclear cardiology	30	50	20
Computer tomography scan	30	60	10
Echocardiography	60	40	0

TABLE VI: Study outomes and curriculum contents for mechanical circulatory support module for B. Tech in cardiovascular perfusion (n=10).

Study outcomes	Essential %	Useful %	Not needed %
1. Evaluate the patient's condition and indicate the use of the appropriate circulatory support system.	80	20	0
2. Independently assemble, operate and maintain the circulatory support system based on effective selection of disposables and application of knowledge in a professional context.	100	0	0
Curriculum contents			
Topics	**Essential %**	**Useful %**	**Not needed %**
Indication for the use of circulatory support	100	0	0
Intra-aortic balloon pump counter pulsation	100	0	0
Pacemakers	50	50	0
Ventricular assist devices	100	0	0
Extracorporeal membrane oxygenation	100	0	0
Implantable device	50	40	10

clinical practice module, a good majority of perfusion educators indicated that all study outcomes were essential (Table I), while only 40% of eductors considered the knowledge of Embryology essential (Table I). In the pharmacology module, one of the educator suggested that "in-depth understanding of pharmacokinetics, distribution, half-lives, action of all drugs used on the pump" is an essential outcome that should be included in the curriculum (cf. Quote #15). Following an intravenous bolus of drug, the volume of distribution of the drug varies with time, hence understanding the important pharmacokinetic parameter that relates to drug plasma concentrations is important for drug loading dose and maintenance dose calculations.[14]

In the perfusion technology module, theatre and ICU emergencies were considered essential by only 60% of the respondents (Table III), while one educator suggested that knowledge of "total circulatory arrest" is an essential topic that should be listed under this module (cf. Quote #17). In the blood management module, applied microbiology was considered to be useful, but not essential, by the majority (60%) of the educators (Table IV). According to the AmSECT (American Society of Extracorporeal Technology), a core outcome for blood management in perfusion education is for the perfusionist to be conversant with methods of minimising haemodilution and avoid unnecessary blood transfusions (Blood Management Standard 9.1). This is absent in the South African curriculum. In the haemodynamic monitoring and related technologies module only 30% of the educators indicated that the knowledge of non-invasive radiological techniques, MRI and CT scan is essential, while 20% indicated that knowledge of nuclear cardiology was not useful (Table V). In the mechanical circulatory module, the knowledge of implantable device was favoured to be essential by only 50% of the educators, while one educator suggested that "appropriate timing and duration of support should form part of the outcomes for mechanical circulatory support" and thus listed as a study outcome (cf. Quote #18).

Finally, one of the educators proposed that a combined effort by all traning institution would be required to develop a uniform curriculum to improve the standard of clinical practice and academic mind (cf. Quote #19).

CONCLUSION

This study revealed that perfusion educators are in agreement that there is a need for a revised, standardised curriculum for perfusion education in South Africa. A single exit examination in both oral and written formats, conducted by a regulatory body, should be a requirement for certication and registration. This will contribute to producing perfusion graduates who are able to successfully apply their knowledge and skills to improve patient outcome.

STUDY LIMITATIONS

The following limitations were recognised by the researchers in the course of this study:

- Low response rates to questionnaire survey. Despite sending numerous notifications to remind participants to complete the questionnaire.

- The lack of recent available literature on the research topic, especially related to perfusion education and training in South Africa, or even the rest of Africa.

ACKNOWLEDGMENTS

The authors thank all respondents who participated in this study, secretarial and administrative staff at the Faculty of Health Sciences Education University of the Free State, Mrs E. Robberts and Mrs C. Bester for their technical support.

FINANCIAL SUPPORT AND SPONSORSHIP

Musa Z. was supported financially by the Health and Welfare Sector Education and Training Authority (HWSETA), South Africa.

Conflict of interest: none declared.

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