Validating international CanMEDS-based standards defining education and safe practice of nurse anesthetists

C. Herion[1] RN, NA, PhD, MME Unibe (iD), **L. Egger[2]** RN, NA, MME Unibe, **R. Greif[3]** MD, MME Unibe & **C. Violato[4,5]** PhD

1 Medical Educator, Department of Anesthesiology, Kantonsspital Aarau, Aarau, Switzerland 2 Scientific Assistant and Educator Medi, Centre for Medical Education, Bern, Switzerland 3 Professor, Department of Anesthesiology and Pain Therapy, Bern University Hospital, Bern, Switzerland, 4 Professor, Department of Medical Education, University Ambrosiana, Free University of Milan, Milan, Italy, 5 Professor, Department of Internal Medicine, University of Minnesota School of Medicine, Minneapolis, MN, USA

Aim: To investigate whether the CanMEDS-based International Federation of Nurse Anesthetists' Standards could adequately define the scope of practice and reliably be used to train and evaluate Swiss nurse anesthetists (NAs).

Background: Although nurse anesthetists represent a majority of the global workforce in anesthesia, policies that define the scope of practice are frequently non-existent. In low- and middle-income countries, the lack of anesthesia providers with adequate training is a major challenge.

Introduction: Despite stringent training requirements, the scope of practice of Swiss nurse anesthetists is actually not defined. Therefore, we surveyed and assessed whether nurse anesthetists felt that the professional competencies outlined in this framework were aligned with their clinical practice.

Methods: A cross-sectional survey investigated Swiss nurse anesthetists' relevance ratings of 76 competencies of the International Federation of Nurse Anesthetists according to their professional practice. Cronbach's alpha coefficients were used to determine the internal consistency of the competencies, as well as factor analyses to assess construct validity of these competencies integrated into the CanMEDS roles model.

Results: Participants rated the Standards overall as very relevant with high reliability. Factor analyses provided evidence of construct validity of these.

Discussion: The International Federation of Nurse Anesthetists' Standards of Practice provide a highly relevant framework and a valuable set of competencies for the scope of practice of Swiss nurse anesthetists, which enabled translation from global guides to local national standards.

Conclusion and implication for nursing and health policy: Adopted by low- and middle-income countries or countries where national standards are non-existent, this survey could introduce national and

Correspondence address: Dr Christian Herion, Department of Anesthesiology, Kantonsspital Aarau, Tellstr., Aarau, Switzerland; Tel: +41-62-838-6505; Fax: +41 (0)62 838 67 22; E-mail: christian.herion@ksa.ch.

local policies at minimally acceptable standards of care for nurse anesthetists worldwide. The above standards have the potential to align education, outcomes and assessment of nurse anesthetists with the needs of national healthcare systems.

Introduction

Non-physician anesthesia providers (NPAPs) represent the majority of the anesthesia workforce worldwide. NPAPs work independently, or under the supervision of anesthesiologists or other physicians. In low and middle-income countries (LMICs), where anesthesiologists are scarce, NPAPs provide medical, interventional, and surgical procedures under general anesthesia, as well as sedation and loco-regional anesthesia (Hodges et al. 2007). Worldwide, the educational systems, scope of practice and continuing professional development (CPD) activities of NPAPs is adapted to national and regional needs and legislations. We use the term NPAP to describe the entire non-physician anesthesia workforce; nurse anesthetists (NAs) are the predominant NPAPs worldwide.

Background

Nurse anesthetists provide induction, maintenance and emergence of anesthesia. In 40 LMICs, they work without physician supervision (Kempthorne et al. 2017). These differences influence the quality and safety of anesthesia care worldwide. NPAPs from 96 World Health Organization (WHO) member countries reported in a rare global survey no hospital policies in 26%, no governmental regulations in 41%, and no opportunities for continuing education were available in 50% of countries (Henry & McAuliffe 1999).

According to the WHO (World Health Organization 2016) and the Organisation for Economic Co-operation and Development (OECD 2016), the workforce crisis, including global migration of healthcare workers, further aggravates the problem. In 77 countries from WHO regions, the density of anesthesia providers is <5 per 100 000 habitants (Kempthorne et al. 2017). This results in a crisis of patient safety during anesthesia for the poorest of the poor.

Fundamental components to foster the quality of health systems are defined by the WHO (World Health Organization 2013, 2017, 2018) and the International Council of Nursing (ICN; Catton 2017). In order to address this safety issue, NA training and scope of practice should be regulated in LMICs where physician anesthesiologists are not sufficiently available (Lipnick et al. 2017). Identifying a set of international

standards that is relevant to the scope of practice for NAs and using those standards as a framework to train and evaluate NAs in LMICs can achieve this.

One possible set of standards that could be used come from the International Federation of Nurse Anesthetists (IFNA), a global organization representing over 40 member countries. The IFNA, an affiliate of ICN, provides international guidelines and recommendations addressing the quality of the care, education, safe practice and professional values of NAs (Meeusen et al. 2016). In 2016, the IFNA's Standards (Code of Ethics, Standards of Practice, Monitoring, and Education; IFNA 2016) were thoroughly revised on a competency-based approach by adopting the Canadian Medical Education Directions for Specialists (CanMEDS) Framework (Frank et al. 2015; Fig. 1). The CanMEDS consists of seven roles (Manager, Communicator, Professional, Scholar, Expert, Health Advocate, Collaborator) and have been widely used as a framework to describe physician competencies. The IFNA's Standards of Practice include 76 graduate competencies that
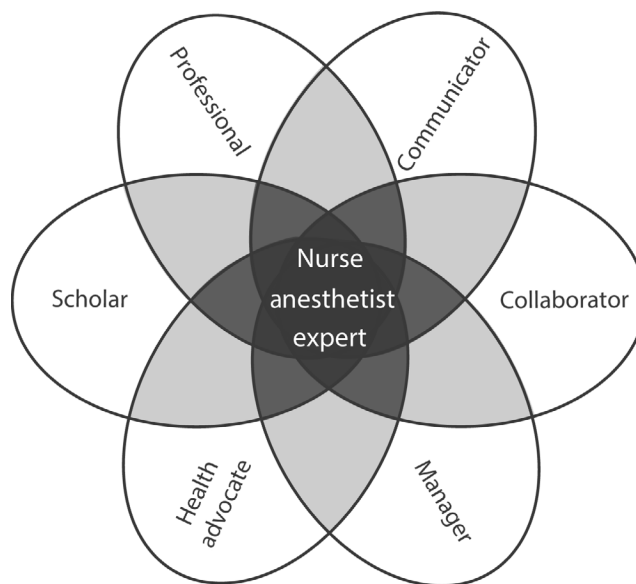

Fig. 1 Adapted by IFNA from the CanMEDS Physician Competency Diagram with permission of the Royal College of Physicians and Surgeons of Canada. Copyright © 2009.

are categorized within the seven CanMEDS functional roles and 23 anesthesia-related domains (Table 1).

In Switzerland, NAs are the sole recognized and regulated NPAPs, and there is a 50-year-long tradition of close collaboration between physicians and NAs. Currently, the Swiss NA workforce includes approximately 2000 registered certified professionals. A recognized nurse diploma is mandatory to apply to a 2-year nurse anesthesia program, which includes at least 900 h of additional didactic training (OdASanté 2012).

Despite these stringent training requirements, the scope of practice of Swiss NAs is actually not defined. In order to accomplish this, we surveyed NAs in Switzerland to assess whether they felt that the 76 professional competencies outlined in this framework were aligned with their clinical practice. We felt that an evaluation of the IFNA's Standards of Practice by Swiss NAs would provide a dependable analysis of that framework since the Swiss association of nurse anesthetists (SIGA/FSIA) planed to adopt the IFNA's Standards of Practice into the national NA curriculum revision in 2018.

If our study can demonstrate that the IFNA's Standards of Practice are representative of the scope of practice of NAs, then it stands to reason that LMICs or countries where national standards for NAs do not yet exist could adopt IFNA's Standards of Practice. This would introduce practice consistency at the minimally accepted standard of care for NAs worldwide.

Aims

The primary goal of our study was to investigate whether the CanMEDS Framework and the IFNA's Standards of Practice show coherence and consistency with the scope of practice of NAs. To establish and pilot a sound study design, the study focused on a well regulated, and for research purposes well controllable, professional community of NAs within one country (Switzerland). The findings can serve as a basis for further multinational research in high-, low- and middle-income countries.

Methods

Design and setting

In 2015, possible study participants for the cross-sectional online survey were contacted via the database of the Swiss association of nurse anesthetists (SIGA/FSIA; Appendix S1 English and Appendix S2 German survey).

Research population

Overall 734 NAs from all Swiss cantons were invited. Participants were excluded, if they had no basic medical education (e.g. nursing degree).

Data collection

Data were collected over a period of 32 weeks between 18 April and 27 November 2015.

Ethics

The *Ethics Committee Northwest/Central-Switzerland* (EKNZ UBE-15/19, 02/17/2015) declared the study as 'uncritical according to ethical aspects' and therefore granted a waiver of informed consent according to the Swiss Human Research Act.

Data analysis

Data were analyzed by SPSS 24.0 (IBM, Armonk, USA) and EQS 6.1 (Multivariate Software, Temple City, USA) and

Table 1 CanMEDS roles, domains and number of graduate competencies within IFNA's Standards of Practice

CanMEDS roles and domains	Number of graduate competencies
CanMEDS Role 'Nurse Anesthetist Expert'	
1. Preanesthetic patient assessment	5
2. Anesthetic management	5
3. Risk management	4
4. Monitoring	1
5. Advanced life support	4
6. Equipment	1
7. Termination of anesthesia	2
8. Postoperative care and pain management	4
9. Infection control	3
10. Documentation	2
CanMEDS Role 'Communicator'	
1. Communication and situation awareness	4
CanMEDS Role 'Collaborator'	
1. Collaboration and teamwork	7
CanMEDS Role 'Manager'	
1. Task management	5
2. Quality management	2
CanMEDS Role 'Health Advocate'	
1. Patient information	1
2. Patient education	3
3. Patient advocacy	1
CanMEDS Role 'Scholar'	
1. Continuous professional development	5
2. Research	4
3. Education	4
CanMEDS Role 'Professional'	
1. Professionalism	4
2. Advancement of anesthesia care	2
3. Accountability	3
Overall number of graduate competencies	76

presented as mean, SD or percentage. A *P*-value < 0.05 was considered statistically significant. Differences between the study participants' demographic variables (level of anesthesia education, age, gender, work experience in years and special job function) were analyzed using a multivariate analysis of variance (MANOVA). The demographic variables were set as the independent variables, with the ratings of the seven CanMEDS roles as the dependent variables. Cronbach's alpha coefficients were used to determine the internal consistency of graduate competencies within the seven CanMEDS roles. Construct validity of IFNA's graduate competencies for NAs integrated into the CanMEDS roles model was assessed by exploratory factor analyses and confirmatory factor analyses. Accordingly, we divided the data randomly into two cohorts. With cohort 1 (*n* = 225), we performed an exploratory factor analysis (EFA) employing varimax rotation with Kaiser normalization to investigate the factors structures underlying the instrument. This allowed us to identify and extract the significant factors from the 76 competencies, which influenced NAs' responses on the graduate competencies. Factor loadings >0.4 indicated acceptable strength and direction and the influence of a factor on the graduate competencies. EFA was performed with a resulting seven-factor solution. We hypothesized that these seven factors would correspond with the seven CanMEDS roles (Manager, Communicator, Professional, Scholar, Expert, Health Advocate and Collaborator). To determine the best-fitting model of graduate competencies within the CanMEDS roles that had been derived from cohort 1, we subsequently performed a confirmatory factor analysis (CFA) with cohort 2 (*n* = 224). A maximum likelihood estimation with a comparative fit index >0.9 was accepted as good fit. Construct validity of the optimized model would be underlined by investigating correlations between CanMEDS roles and graduate competencies. Factor correlation coefficients (*r*) were calculated and accepted to interpret loadings if >0.4. (For details on EFA and CFA see Appendices S3 and S4).

Results

Out of 734 NAs invited, 449 completed the online survey (response rate 61%, from 23 out of 26 Swiss cantons). Respondents ranged in age from 24 to 68 years [mean (*m*) = 44, standard deviation (SD) = 9]; 290 were female (65%). Of these, 430 (96%) had a nursing diploma from a Swiss-recognized institution as basic health education. A small number (*n* = 13, 3%) had a paramedic diploma and six (1%) had graduated from an accredited healthcare program in another European country (e.g. Germany, Austria). Overall, 381 respondents (85%) were Swiss NA diploma holders, 36 were

NA students (8%), 26 had a German diploma (6%), two from Austria (0.4%), one from the Netherlands (0.2%) and one from Sweden (0.2%). Two participants (0.4%) had no NA diploma.

Asked for their most accurate job function, the majority of respondents (*n* = 217, 48%) indicated they were predominantly in clinical practice. Nearly, a quarter (*n* = 104, 23%) worked primarily in education, 91 (20%) were primarily in management/leadership and 36 (8%) were primarily students in an anesthesia care training program.

Relevance ratings of NAs' competencies and CanMEDS roles

Overall, 62 of the 76 (82%) graduate competencies were rated relevant or very relevant (*m* = 4.45, SD = 0.71) in relation to the Swiss NAs' scope of practice. Fourteen graduate competencies were rated as moderately relevant or relevant (*m* = 3.2, SD = 1.05; Table 2).

In the aggregate, all seven of the CanMEDS roles (Table 2) were rated as relevant or very relevant (*m* = 4.22, SD = 0.42). On their own, five roles attained relevant or very relevant VAS-ratings: NA-Expert (*m* = 4.58, SD = 0.28), Communicator (*m* = 4.58, SD = 0.10), Collaborator (*m* = 4.35, SD = 0.16), Scholar (*m* = 4.07, SD = 0.39) and Professional (*m* = 4.25, SD = 0.32), while the remaining two roles, Manager (*m* = 3.81, SD = 0.29) and Health Advocate (*m* = 3.89, SD = 0.25), scored moderately relevant.

Reliability of CanMEDS roles

The overall internal consistency was very high for the overall CanMEDS roles (Cronbach's α = 0.97), as well as for NA-Expert (α = 0.91) and Scholar (α = 0.91). The internal consistency was high for Collaborator (α = 0.88), Manager (α = 0.88), Health Advocate (α = 0.86) and Professional (α = 0.86); for Communicator (α = 0.78) it was acceptable (Table 2).

Relevance ratings of CanMEDS roles and differences between survey respondents' characteristics

The analysis of study participants' differences revealed that the overall CanMEDS Framework was rated as more relevant by paramedics (*n* = 13, *m* = 4.35, SD = 0.52) than by nurses (*n* = 430, *m* = 4.21, SD = 0.52), followed by NAs with other basic education (*n* = 6, *m* = 4.18, SD = 0.51, *P* < 0.05). Participants with no NA education rated the CanMEDS Framework the most relevant (*n* = 2, *m* = 4.70, SD = 0.35, *P* < 0.01). Ratings of the CanMEDS Framework differed between women (*n* = 290, *m* = 4.22, SD = 0.49) and men (*n* = 159, *m* = 4.20, SD = 0.57, *P* < 0.01). These differences were due to higher scores by women for only two CanMEDS

Table 2 Descriptive statistics and reliability (Cronbach's α) of competencies and CanMEDS roles

CanMEDS Role 'Nurse Anesthetist Expert' (Cronbach's α = 0.91)	Mean	SD
Graduated Competencies of Nurse Anesthetist Expert	4.58	0.28
1. Preanesthetic patient assessment		
Nurse anesthetists		
A. Perform and/or participate in the performance of preanesthetic interviews by eliciting comprehensive histories and performing physical examinations based on patient's presenting symptoms	3.88	1.24
B. Assess and evaluate multiple variables (drugs taken, preexisting diseases, allergies, previous anesthetic experiences) that may affect the course of anesthesia. Identify potential risks to patient safety	4.45	0.85
C. Formulate an anesthetic care plan based on current knowledge, concepts, available evidence, and nursing principle	4.2	0.94
D. Provide accurate and understandable information to assist patients in giving informed consent	4.26	1.07
E. Integrate evidence to explain possible anesthetic and/or postanesthetic risks	4.18	0.92
2. Anesthetic management		
Nurse anesthetists		
A. Are continuously present during anesthetic management	4.54	0.73
B. Administer and/or participate in the administration of general and regional anesthesia to all patients for all surgical and medically related procedures	4.68	0.58
C. Prepare, administer, and adapt anesthetic medications, anesthetic procedures, and other interventions according to preexisting disease and surgical procedure, demonstrating advanced knowledge of human sciences, pharmacology, surgical and anesthesia procedures	4.57	0.67
D. Provide psychological support to help patients through the perioperative experience by using advanced communication skills to improve patient outcomes and design strategies to meet the patient's needs	4.53	0.79
E. Use a broad variety of techniques, anesthesia agents, adjunctive and accessory drugs, and equipment when providing anesthesia care and pain management. Exhibit a comprehensive knowledge of pharmacology and pharmacokinetics related to anesthesia practice. Select, administer, and prescribe appropriate medication based on accurate knowledge of patient characteristics, anesthesia technique, and surgical procedure	4.47	0.78
3. Risk management		
Nurse anesthetists		
A. Take appropriate safety precautions including documentation to ensure the safe administration of anesthesia care	4.85	0.31
B. Prepare anesthetic plans, equipment, and drugs according to standard operating procedures and globally recommended checklists	4.82	0.37
C. Recognize and take appropriate actions during anesthesia management by rapidly assessing a patient's situation through synthesis and prioritization of historical and available data. Advanced knowledge and experience are demonstrated at all times. Nurse anesthetists demonstrate confidence in their own abilities to identify normal and abnormal states in anesthesia	4.85	0.32
D. Engage in the development of guidelines, standard operating procedures, and checklists for equipment and drug use	4.36	0.8
4. Monitoring		
Nurse anesthetists		
A. Monitor, analyze and utilize data obtained from the use of current invasive and noninvasive monitoring modalities using critical thinking and clinical judgment. Identify priorities quickly using context-specific knowledge and accurately identify parameters for the safety of patients to ensure decisions are justified in the specific context. Respond constructively to unexpected or rapidly changing situations and develop flexible and creative approaches to manage challenging clinical situations	4.81	0.33
5. Advanced Life Support		
Nurse anesthetists		
A. Take corrective action to maintain or stabilize the patient's condition and provide advanced life support care	4.86	0.32
B. Assess and provide adequate advanced life support. Use advanced communication skills to inform the interdisciplinary team, organize and collaborate with appropriate experts, and use adequate medications and equipment	4.83	0.31
C. Provide regular education in basic life support and advanced resuscitation procedures to health professionals, as needed	4.22	1.03
D. Adhere to the latest international guidelines and accept responsibility for their own regular certified training in advanced life support	4.59	0.63
6. Equipment		
Nurse anesthetists		
A. Select, prepare, use and clean the appropriate equipment in routine and critical incident situations	4.62	0.65

Table 2 *Continued*

CanMEDS Role 'Nurse Anesthetist Expert' (Cronbach's α = 0.91)	Mean	SD
7. Termination of anesthesia		
Nurse anesthetists		
A. Assess, analyze and evaluate adequacy of the patient's condition before transferring care. Evaluate patient responses for readiness to move to next level of care by identifying patient situation, and take appropriate action in the immediate post-operative period	4.78	0.35
B. Report all essential data regarding the perioperative period comprehensively and completely to the personnel in charge of the next level of care	4.83	0.34
8. Postoperative care and pain management		
Nurse anesthetists		
A. Serve as a resource person in pain management and adequate postoperative care	4.2	0.94
B. Demonstrate advanced knowledge in pharmacology and pharmacokinetics of analgesic drugs in assessing and providing pain management	4.36	0.8
C. Assess and manage common postoperative complications such as respiratory, hemodynamic, neurological dysfunctions, and postoperative nausea and vomiting	4.21	1
D. Develop or participate in developing and revising standard operating procedures for all personnel covering postoperative care	3.91	1.1
9. Infection control		
Nurse anesthetists		
A. Apply practices such as proper hand hygiene and cleaning or sterilization of equipment	4.65	0.5
B. Maintain knowledge of and adhere to national and/or institutional standards of infection control to protect the patient and healthcare workers from infectious diseases	4.61	0.58
C. Adapt or participate in adaptation and revision of infection control standards for all anesthesia procedures, and adhere to national standards for storing, handling, prescribing and administering drugs	4.25	0.91
10. Documentation		
Nurse anesthetists		
A. Provide prompt, complete and accurate recording of pertinent information and action of care on the patient's record	4.8	0.4
B. Facilitate, through accurate recording, comprehensive patient care. Provide information for retrospective review and research data, and establish a medical-legal record	4.69	0.57

CanMEDS Role 'Communicator' (Cronbach's α = 0.78)	Mean	SD
Graduate Competencies of Communicator	4.58	0.10
1. Communication and situation awareness		
Nurse anesthetists		
A. Communicate in a calm, confident, and effective approach that brings comfort and emotional support to patients and their family, and create a climate that supports mutual engagement and establishes partnerships with patients	4.68	0.53
B. Engage in effective interpersonal and intraprofessional communication using advanced communication skills suitable for the interdisciplinary domain of the workplace	4.67	0.46
C. Create awareness of specific and overlapping functions and the potential for interdisciplinary tensions and demonstrate strategies of conflict management, if necessary	4.44	0.68
D. Display crisis intervention skills when required and assure patient understanding, respect, empathy and trust by maintaining confidentiality and discretion	4.54	0.65

CanMEDS Role 'Collaborator' (Cronbach's α = 0.88)	Mean	SD
Graduate Competencies of Collaborator	4.35	0.16
1. Collaboration and teamwork		
Nurse anesthetists		
A. Collaborate with others to identify innovative solutions to clinical and system problems. Advance patient care standards by partnering with interdisciplinary healthcare team members in research and educational activities	4.09	0.93
B. Implement new technologies that enhance patient care and promote patient safety goals	4.18	0.86

Table 2 *Continued*

CanMEDS Role 'Collaborator' (Cronbach's α = 0.88)	Mean	SD
C. Establish effective, collegial relationships with other health professionals that reflect confidence in the contribution that nurse anesthetists make to the system	4.3	0.75
D. Encourage cooperative relationships between nurse anesthetists, physician anesthetists, and other members of the medical profession, the nursing profession, hospitals and agencies representing a community of interest in nurse anesthesia	4.42	0.66
E. Respect roles and competencies of other team members and demonstrate joint decision-making skills to achieve the best possible patient outcome	4.6	0.58
F. Provide feedback and constructively discuss team strengths and weaknesses, listen to others, and ensure consistent information flow to patients and colleagues	4.41	0.78
G. Demonstrate effective solutions to problems concerning team issues	4.42	0.7

CanMEDS Role 'Manager' (Cronbach's α = 0.88)	Mean	SD
Graduate Competencies of Manager	3.81	0.29
1. Task management		
Nurse anesthetists		
A. Anticipate and make decisions in advance for challenges by allocating appropriate time frames, organizing appropriate staffing, and preparing equipment and materials	4.21	0.94
B. Use existing resources effectively and efficiently by designing or participating in designing evidence-based strategies to meet the multifaceted needs of patients	4.24	0.78
C. Consider fiscal and budgetary implications in decision-making regarding practice and system modifications	3.67	1.14
D. Organize and plan for the correct ecological handling of wastes such as gases, drugs, sharps, and infectious materials	4.12	0.98
E. Evaluate and optimize the use and impact of products, services, and technologies on high quality patient care	4.02	0.97
2. Quality management		
Nurse anesthetists		
A. Measure or participate in measuring patient satisfaction, cost, clinical outcomes, nurse satisfaction and retention by applying methods of quality assurance and improvement	3.45	1.28
B. Foster an interdisciplinary approach to quality improvement, evidence-based practice, research and transition of research into practice	3.67	1.17

CanMEDS Role 'Health Advocate' (Cronbach's α = 0.86)	Mean	SD
Graduate Competencies of Health Advocate	3.89	0.25
1. Patient information		
Nurse anesthetists		
A. Consider and evaluate various influences on patients' health status. Detect health related and anesthetic risk factors through anesthetic assessment, and promote individual health by addressing behavioral change	3.8	1.15
2. Patient education		
Nurse anesthetists		
A. Participate in the education of patients, other members of the health team and members of the community before, during, and after the operative period	3.34	1.26
B. Design or select health information and patient education appropriate to developmental level, health, literacy level, learning needs, readiness to learn, preferred learning style, and cultural values and beliefs	3.13	1.29
C. Facilitate patient and family understanding of the risks, benefits, and outcomes of proposed anesthesia regimen to promote informed decision-making	3.33	1.29
3. Patient advocacy		
Nurse anesthetists		
A. Support and preserve the rights of patients for privacy by protecting information of a confidential nature from those who do not need such information for patient care. Support the rights of patients for independence of expression, decision and action	4.59	0.69

Table 2 *Continued*

CanMEDS Role '**Health Advocate**' (Cronbach's α = 0.86)	Mean	SD
Graduate Competencies of Scholar	4.07	0.39
1. Continuous professional development		
Nurse anesthetists		
A. Commit to continuous professional development	4.6	0.6
B. Accept responsibility and accountability for practice and engage in lifelong professional educational activities	4.46	0.65
C. Engage in a formal self-evaluation process, seeking feedback regarding their own practice from patients, peers, professional colleagues, and others. Develop and implement strategies for lifelong learning	4.15	0.92
D. Are aware of and address individual needs for clinical inquiry through continuous professional development activities	4.04	0.93
E. Demonstrate knowledge of and adherence to the national legal regulations, accepting the respective responsibility and accountability of nurse anesthesia and others	4.36	0.74
2. Research		
Nurse anesthetists		
A. Incorporate evidence-based techniques and knowledge, as well as international guidelines and standards in clinical performance	4.14	0.91
B. Design or assist in designing and implementing studies, data collection, and analysis, as well as public dissemination and discussion of results. Use measurement instruments that are critiqued for validity, reliability and clinical applicability	3.32	1.22
C. Incorporate research into practice and assist the nursing staff and the institution in evaluating and rating evidence, applying evidence to practice, designing innovations, critiquing research studies and analyzing sources of evidence-based guidelines	3.46	1.21
D. Protect the rights of patients or animals involved in research projects and conduct the projects according to ethical research and reporting standards	3.55	1.32
3. Education		
Nurse anesthetists		
A. Facilitate and teach based on national and international standards of education and practice	4.42	0.81
B. Contribute to learning experiences for all professionals and students within their spheres of influence, and interact with colleagues at the local, national, governmental and regulatory levels to enhance professional practice	4.36	0.76
C. Assist healthcare professionals in identifying their educational needs related to anesthesia and acute care needs	4.01	1.04
D. Provide peers, colleagues, students and staff with constructive feedback regarding practice with the goal of facilitating improved outcomes and professional development	4.3	0.8

CanMEDS Role 'Professional' (Cronbach's α = 0.86)	Mean	SD
Graduate Competencies of Professional	4.25	0.32
1. Professionalism		
Nurse anesthetists		
A. Provide safe and patient-centred care based on available evidence. The nurse anesthetist recognizes the responsibility of professional practice and maintains a high level of quality in knowledge, judgment, technological skills, and professional values prerequisite to deliver patient-centred care	4.57	0.58
B. Accept responsibilities and correctly delegate responsibilities to other team members or healthcare professionals	4.56	0.6
C. Demonstrate self-appraisal activity	4.14	0.89
D. Identify opportunities for generating and using research and/or continuous professional development activities	3.8	1.07
2. Advancement of anesthesia care		
Nurse anesthetists		
A. Demonstrate leadership by disseminating outcomes of nurse anesthesia practice through presentations and publications and participation in local and national nurse anesthesia organizations. Promote and facilitate the awareness of public and professional policy issues that affect nurse anesthesia practice. Serve as a role model for nurse anesthesia practice and encourage and support staff in professional achievements	3.81	1.1
B. Use quality, satisfaction, and cost data to modify patient care, nurse anesthesia practice and systems. Accept accountability for own errors. Identify and handle critical incidents by entering them into critical incident reporting systems	4.1	1

Table 2 *Continued*

CanMEDS Role 'Professional' (Cronbach's α = 0.86)	Mean	SD
3. Accountability		
Nurse anesthetists		
A. Maintain credentials in nurse anesthesia, as mandated by national legislation or regulation	4.32	0.85
B. Respect the confidentiality of information about patients learned in clinical relationships, demonstrate overall respect, and maintain the basic rights of patients, showing concern for personal dignity and human relationships	4.69	0.52
C. Are aware of individual, ethnic, cultural, and religious differences, and provide appropriate care to deliver the best possible patient outcomes	4.58	0.62
Overall ratings of CanMEDS Roles (Cronbach's α = 0.97)	4.22	0.42

roles: Communicator ($P < 0.02$) and Professional ($P < 0.01$; MANOVA).

Subgroup analyses of job functions found that the CanMEDS Framework was most relevant for NAs who identified that their primary job function was in education ($n = 104$, $m = 4.34$, SD = 0.49), followed by students in NA educational programs ($n = 37$, $m = 4.22$, SD = 0.49), then by NAs primarily in management positions ($n = 91$, $m = 4.17$, SD = 0.54) or those predominantly in clinical practice ($n = 217$, $m = 4.17$, SD = 0.52; $P < 0.05$, overall). Differences in the relevance of the overall CanMEDS Framework and the roles of Collaborator ($P < 0.001$), Scholar ($P < 0.001$) and Professional ($P < 0.001$) were rated more relevant by NAs involved in education than by NAs operating in practice ($P < 0.001$).

Exploratory factor analysis

The EFA of cohort 1 revealed seven theoretically meaningful and cohesive factors. The seven factors accounted for 72% of the variance and reflected the seven existing CanMEDS roles of IFNA's Standards of Practice. Several factors correlated, ranging from 0.4 to 0.84 ($P < 0.01$; the optimum seven-factor solution is summarized in Appendix S3).

Confirmatory factor analysis

Based on the EFA of cohort 1 and the CanMEDS Framework, the seven-factor model was tested using a CFA on cohort 2. Twenty-six graduate competencies (loadings > 0.4) were selected to test the fit of the model with maximum likelihood estimation (Appendix S4).

As indicated by a large comparative fit index (CFI) of 0.952, small root mean square error approximation (RMSEA) of 0.037 and a 90% CI 0.024–0.046, the graduate competencies and the modified seven-factor model (namely the CanMEDS roles) of the EFA were well-fitting.

Overall, the CFA results showed that a strong relationship of the 26 graduate competencies as observed variables and the seven CanMEDS roles as underlying latent construct of IFNA's Standards of Practice exists. There were also strong relationships between several CanMEDS roles ($r = 0.41–0.75$). The CFA provided the construct validity of the seven CanMEDS roles by empirical investigation of relationships between the seven factors and graduate competencies of the IFNA's Standards of Practice.

Discussion

Limitations

One limitation of our study is that we focused on one single high developed country. Furthermore, the study was conducted with German and English only (not French and Italian) and might not capture all the language and cultural regions in Switzerland with the same rigidity due to language limitations.

To date, we are not aware of published studies investigating whether NAs or NPAPs consider the IFNA's Standards of Practice to accurately reflect their scope of practice. Our approach provided specific information and evidence about how the IFNA's Standards of Practice can be assessed following the CanMEDS Framework as a baseline.

This study demonstrates that the roles of Swiss NAs are identified by seven factors that correspond closely to the seven CanMEDS roles – Manager, Communicator, Professional, Scholar, Expert, Health Advocate and Collaborator. Furthermore, (a) all factors, except Communicator, show high internal consistency based on Cronbach's alpha; (b) the individual CanMEDS roles, except Manager and Health Advocate, were all rated relevant or very relevant; (c) the primary job function of respondents, especially educators, impacted on their rating of the relevance of the overall CanMEDS roles; (d) the EFA provides evidence of convergent and discriminant validity by identifying the seven factors corresponding to the CanMEDS roles; (e) the CFA demonstrates an optimal model for NAs' competency framework with evidence of

construct validity for CanMEDS roles and graduate competencies of the IFNA's Standards of Practice.

Content validity of the graduate competencies

Eighty-two per cent ($n = 62$) of the graduate competencies were rated as relevant or very relevant with respect to Swiss NAs' scope of practice, which confirms the CanMEDS roles of the IFNA's Standards of Practice provide evidence for content validity.

Only 14 of the 76 graduate competencies (18%), mainly from the Manager's and Health Advocate's roles, were rated moderately relevant. We submit the following four possible reasons why these 14 competencies are not in Swiss NAs' scope of practice and therefore received lower ratings: (a) 'anesthesiologists' area of accountability' may have been interpreted as the legal responsibility for obtaining informed consent by physician anesthesiologists; (b) 'accountability for management, leadership and education' may have been seen by general NAs as the responsibility of managers or leaders in the field; (c) 'health advocate' roles related to patient information and patient education might reflect the limited participation of NAs in pre-anesthetic patient management within Swiss NAs' scope of practice; and (d) 'scholarship' focusing on study design, implementation of research into daily practice, and protecting patient or animal rights appears secondary for clinically practicing NAs as does dissemination, presentations and publication of research.

Construct validity of CanMEDS roles and graduate competencies

The results of the EFA identified seven roles of NA competencies that corresponded to the seven CanMEDS roles. As we hypothesized, the EFA from cohort 1 identified seven factors (CanMEDS roles), which are meaningful. The factor loadings from the various items also supported the seven-factor solution. While factors were correlated, they proved to be independent and meaningful. Overall, this provides evidence of construct validity through both convergent and divergent validity.

The CFA results from cohort 2 provide evidence of construct validity because of good fit indices and small residual variance. The seven-factor model was confirmed, as was the pattern of loadings and the inter-correlations between the seven factors (the seven CanMEDS roles). Both CFA and EFA provided evidence for construct validity. The integration of the 76 graduate competencies together with the adopted CanMEDS role model provides a well-fitting conceptual framework for Swiss NA's scope of practice (represented in Appendix S4).

The relevance ratings of CanMEDS roles varied according to study participants' basic training. NAs engaged in education favoured the rating of the overall framework and the Collaborator, Scholar and Professional roles. We assume this is because many educators are already familiar with CanMEDS and the IFNA Standards of Practice, which have been promoted nationally. For the implementation of new policies, educators most likely cover an important role as change agents.

This study provides evidence that the IFNA's Standards of Practice are a valuable international framework to define national standards of practice for NAs. Our findings examine the validity of the IFNA's Standards of Practice by demonstrating its relevance to the scope of practice for Swiss NAs. As a result of this study the graduate competencies of IFNA's Standards of Practice were implemented into the national framework curriculum for Swiss nurse anesthetists during a revision in 2018.

A standardized competency framework for anesthesia providers might have the ability to increase patient safety and with the aim to improve quality of anesthesia care worldwide. This can be achieved by identifying a set of international standards that is relevant to NAs' scope of practice and using those standards as a framework to train and evaluate NAs in LMICs (Lipnick et al. 2017). Our survey therefore serves as an instrument to identify the local needs of NAs and helps to advance regulatory standards that aim to improve education and safe anesthesia practice, especially in LMICs.

Conclusion

To our knowledge, the present study is the first of its kind showing rigorous psychometric approaches applying factor analyses to provide evidence of construct validity of the CanMEDS roles and IFNA's Standards of Practice for NAs. The good fit of the CanMEDS model provides evidence of construct validity. The validation and successful implementation of the IFNA's Standards of Practice presented with this study can be applied worldwide to compare international standards to national and local standards. The study therefore is an example for and provides a sound approach to identify national demands of the healthcare systems and clinical needs for anesthesia care. The approach to the survey and the resulting study design could be expanded among other countries, and as a result it might expose differences in scopes of practice among NAs, which in turn could support the ultimate goal of improving anesthesia care quality, education and patient safety. For LMICs, where health policies or governmental regulations for NAs are missing, the IFNA's Standards of Practice could be a standardized and evidence-based starting point for defining a consistent scope of practice.

Implications for nursing and policy

By adopting the IFNA's international Standards of Practice into national and local policies and regulations, there is the potential to align initiatives of WHO (World Health Organization 2013, 2017, 2018) and ICN (Catton 2017) with education, outcomes and assessment of NAs and the needs of national healthcare systems. In addition, the use of the IFNA's Standards of Practice could make it feasible to compare differing healthcare systems worldwide. The regulations for continuing professional development (CPD) strategies, as well as the attempts for international recognition and certification of programs for NAs is recommended (Meeusen et al. 2016). As an approach, our validation has the potential that the IFNA's Standards of Practice might be suitable to support lifelong learning. Our national validation of the IFNA's Standards of Practice has underlined the role of NAs in daily anesthesia practice. This validation process of these graduate competencies can be used to develop competency-based teaching and assessment programs for NAs. In the event of workforce shortages and global migration of healthcare workers, WHO initiatives for international recruitment of health personnel and consistency of national policies (Campbell et al. 2016) might be supported by the application of the worldwide-approved IFNA's Standards of Practice to compare and equalize different NA-education programs.

Author contributions

Study design: CH, LE, RG, CV
Data collection: CH, LE, RG, CV
Data analysis: CH, LE, RG, CV
Study supervision: CH, LE, RG, CV
Manuscript writing: CH, LE, RG, CV
Critical revisions for important intellectual content: CH, LE, RG, CV

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Supporting information

Additional Supporting Information may be found in the online version of this article:

Appendix S1 Study Survey English

Appendix S2 Study Survey German

Appendix S3 Exploratory factor analysis: principal component extraction with varimax rotation to the Kaiser normalization criterion ($n = 225$) with factor loadings >0.4

Appendix S4 Confirmatory factor analysis with best-fitting model of seven factors and graduate competencies of IFNA's Standards of practice for nurse anesthetists