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COMPETENCE ASSESSMENT IN ANAESTHESIA NURSING CARE

Yunsuk Jeon

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To my family

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ABSTRACT

In order to provide high-quality anaesthesia nursing care, competence assessment of nurses is essential. However, in anaesthesia nursing care there has been a lack of psychometrically tested competence assessment scales. Therefore, the purpose of this study was i) to develop an Anaesthesia Nursing Competence Scale (AnestComp) and ii) to assess the anaesthesia nursing competence of nurses using the scale, with the goal of promoting anaesthesia nursing competence of nurses and providing high-quality anaesthesia care.

The study was carried out in two phases: Phase I focused on describing the concept of anaesthesia nursing competence based on a literature review and experts' descriptions which then became the foundation for the AnestComp; this was followed by testing the psychometric properties of the scale. In Phase II, the anaesthesia nursing competence of anaesthesia nurses (n=222) was self-assessed by using the AnestComp. The psychometric properties of the AnestComp were tested: reliability (Cronbach's α), face validity, content validity, and construct validity. In this study, the data of nursing students (n=205) were also collected and analysed for the purpose of the construct validity testing of the AnestComp.

Anaesthesia nursing competence is a multi-dimensional conception comprising of seven competence areas: (1) ethics of anaesthesia care, (2) patient risk care, (3) patient engagement with technology, (4) collaboration within anaesthesia care, (5) anaesthesia patient care with medication, (6) anaesthesia nursing intervention, and (7) knowledge of anaesthesia care. The AnestComp developed based on these competence areas consists of 39 items and uses a Visual Analogue Scale (0-100mm). The AnestComp is considered a promising scale for assessing the anaesthesia nursing competence of nurses based on the testing of psychometric properties. Nurses' self-assessed competence (VAS 88) exceeded the expected level; in this study, the expected level was set as a mean of VAS 80. Collaboration within anaesthesia care was the highest competence area, whereas patient risk care and knowledge of anaesthesia care were the lowest, and thus identified as fields requiring educational needs. Work experience and specialised anaesthesia nursing education were significant factors related to the higher anaesthesia nursing competence of nurses.

The competence of nurses (particularly novices) in patient risk care and knowledge of anaesthesia care should be ensured through regular competence assessments. More opportunity for specialised anaesthesia nursing education might be one way to improve the anaesthesia nursing competence of nurses.

KEYWORDS: competence assessment, anaesthesia nursing care, nurse education, instrument development, self-assessment, psychometric testing

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TIIVISTELMÄ

Ammattipätevyyden arviointi on välttämätöntä korkealaatuisen anestesiahoitotyön toteuttamiseksi. Anestesiahoitotyössä ei ole aikaisemmin ollut validia psykometrisesti testattua ammattipätevyyden arviointimittaria. Tämän tutkimuksen tarkoituksena oli i) kehittää validi ammattipätevyyden arviointimittari anestesiahoitotyötä varten (AnestComp) ja ii) arvioida anestesiahoitajien anestesiahoitotyön ammattipätevyyttä hyödyntämällä kehitettyä arviointimittaria. Tavoitteena oli anestesiahoitotyön pätevyyden ja korkealaatuisen anestesiahoidon edistäminen.

Tutkimus toteutettiin kahdessa vaiheessa. Vaihe I painottui anestesiahoitotyön ammattipätevyyden käsitteen kuvaamiseen kirjallisuuskatsauksen ja asiantuntijoiden kuvausten perusteella. Sen jälkeen kehitettiin anestesiahoitotyön ammattipätevyysmittari (AnestComp) ja testattiin sen psykometriset ominaisuudet. Vaiheessa II anestesiahoitajat (n=222) itsearvioivat ammattipätevyyttään AnestComp mittarilla. Tilastollisten aineistojen analyysissä AnestComp-mittarin luotettavuus (Cronbachin α) ja rakennevaliditeetti testattiin sairaanhoitajien aineistolla. Tässä tutkimuksessa myös sairaanhoitajaopiskelijoiden (n = 205) aineistot kerättiin ja analysoitiin AnestComp-mittarin rakennevaliditeettitestausta varten.

Anestesiahoitotyön pätevyyttä kuvataan moniulotteisena käsitteenä, joka käsittää seitsemän pätevyysaluetta: (1) anestesiahoidon etiikka, (2) anestesiapotilaan riskien hoito, (3) teknologiavälitteinen potilashoito, (4) yhteistyö anestesiahoidossa, (5) anestesiapotilaan lääkehoito, (6) anestesiahoitotyön interventio sekä (7) tietämys anestesiahoidosta. Näiden ammattipätevyysalueiden pohjalta kehitettiin AnestComp-mittari (39 väittämää, VAS 0-100). Sitä pidettiin psykometristen ominaisuuksien testauksen perusteella lupaavana mittarina anestesiahoitotyön ammattipätevyyden arvioimiseksi. Sairaanhoitajien itsearvioitu pätevyys (VAS 88) ylitti odotetun tason, joka tässä tutkimuksessa oli asetettu VAS 80:ksi. Korkein pätevyysalue oli yhteistyö anestesiahoidossa, mutta anestesiapotilaan riskien hoito ja tietämys anestesiahoidosta tunnistettiin matalimmiksi ammattipätevyysalueiksi. Työkokemus ja erikoistunut anestesiahoitajakoulutus olivat merkittäviä tekijöitä, jotka liittyivät sairaanhoitajien ammattiosaamisen korkeampaan pätevyyteen.

Sairaanhoitajien osaaminen (erityisesti uusien hoitajien) kahdella heikoimmalla ammattipätevyyden osa-alueilla tulisi varmistaa säännöllisten ammattipätevyysarviointien avulla. Mahdollisuus erikoistua anestesiahoitotyöhön voisi olla keino edistää anestesiahoitotyön ammattipätevyyttä.

AVAINSANAT: ammattipätevyysarviointi, anestesiahoitotyö, sairaanhoitaja koulutus, mittarin kehittäminen, itsearviointi, psykometrinen testaus

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Abbreviations

AANA	American Association of Nurse Anesthetists
AnestComp	Anaesthesia Nursing Competence Scale
ANOVA	Analysis of Variance
APRN	Advanced Practice Registered Nurse
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
COVID-19	Coronavirus Disease 2019
CRNA	Certified Registered Nurse Anaesthetist
CVI	Content Validity Index
EC	European Commission
ECTS	European Credit Transfer and Accumulation System
EFA	Exploratory Factor Analysis
EQF	European Qualification Framework
GRS	Global Rating Scale
ICN	International Council of Nurses
IFNA	International Federation of Nurse Anaesthetists
OR	Operating Room
PACU	Post Anaesthesia Care Unit
PCA	Principal Component Analysis
RNA	Registered Nurse Anaesthetist
RR	Response Rate
SPSS	Statistical Package for the Social Sciences
SRMR	Standardised Root Mean Residual
UAS	University of Applied Sciences
VAS	Visual Analogue Scale
WHO	World Health Organisation

List of Original Publications

This dissertation is based on the following original publications, which are referred to in the text by their Roman numerals:

I Jeon, Y., Lakanmaa, R-L., Meretoja, R., Leino-Kilpi, H. Competence assessment instruments in perianesthesia nursing care: a scoping review of the literature. *Journal of Perianesthesia Nursing*, 2017; 32(6): 542-556.

II Jeon, Y., Meretoja, R., Vahlberg, T., Leino-Kilpi, H. Developing and psychometric testing of the anaesthesia nursing competence scale. *Journal of Evaluation in Clinical Practice*, 2020; 26(3): 866-878.

III Jeon, Y., Meretoja, R., Vahlberg, T., Leino-Kilpi, H. Self-assessed anaesthesia nursing competence and related factors. *Journal of Nursing Education and Practice*, 2020; 10(6): 9-18.

IV Jeon, Y., Ritmala-Castrén, M., Meretoja, R., Vahlberg, T., Leino-Kilpi, H. Anaesthesia nursing competence: self-assessment of nursing students. *Nurse Education Today*, 2020; 94: 104575.

1 Introduction

Anaesthesia nursing care is a nursing specialty focusing on the care of patients who are preparing for, undergoing, or recovering from anaesthesia (Mamaril, 2003; WHO, 2003; Ead, 2014). Anaesthesia in association with surgical or diagnostic procedures is an indispensable part of health care for the achievement of global and local health goals in various areas (Miller, et al., 2015; WHO, 2015; G4Alliance, 2018). The World Health Organization (WHO) has emphasised that surgical and anaesthesia care is a fundamental area of the global health sphere and should be stressed (WHO, 2015). It has been reported that about 60 % of cancer treatments need surgical and anaesthesia care and annually 250-300 million surgical procedures are undergone globally (Meara, et al., 2015; Shrime, et al., 2015; G4Alliance, 2018; Gabbard & Smith-Steinert, 2021). In Finland, over 350,000 cases of elective surgeries and anaesthesia care are undertaken annually (Rosenberg, et al., 2014; Koivusipilä, et al., 2015; Sjöholm, 2018; Liebenhagen, et al., 2019).

Patients in anaesthesia care usually undergo four phases of the anaesthesia care process (pre-anaesthesia, anaesthesia induction, during anaesthesia, and post-anaesthesia) in two main forms: general anaesthesia care and monitored anaesthesia care (MAC), which combines sedation and analgesia in local/regional anaesthesia (Freeman & Berger, 2014; Abelsson & Nygårdh, 2020). In general anaesthesia, the patient is placed in a totally unconsciousness state by the anaesthetic agents and intubated using an airway device to provide ventilation, thus, continual monitoring of the cardiorespiratory condition is needed (Shorthouse, 2017). In monitored anaesthesia care, a patient is not completely unconscious (different level of sedation) and intubation is not needed (Ghisi, et al., 2005). Nowadays, monitored anaesthesia care has become more important than previously. This is because monitored anaesthesia care requires a relatively small dosage of sedatives/analgesics and the patient usually remains for a shorter time in the post-anaesthesia care unit. Compared to general anaesthesia care monitored anaesthesia care is increasing, for example, in day surgery (Ghisi, et al., 2005; Das & Ghosh, 2015; Sohn & Ryu, 2016; ASA, 2018). In Finland, the proportion of day surgery has increased since 2000 (Rosenberg, et al., 2014) and approximately 51% of all the elective operations were carried out in day surgery in 2018 (Sjöholm, 2018). For the safe care of patients, no matter what

type of anaesthesia is used, nurses in anaesthesia care are required to ensure the patient's physical and emotional needs, prevent the patient from harm, and support the patient's advocacy (Nilsson & Jaensson, 2016).

Along with the advancement of medicine and technology, anaesthesia care has enabled more difficult operations and procedures that were not possible in the past and has also been expanding its application to other fields (Debas, et al., 2015; Miller, et al., 2015; G4Alliance, 2018; Liebenhagen, et al., 2019). For instance, the recent pandemic triggering severe acute respiratory syndrome caused by the Coronavirus disease (COVID-19) spread rapidly across the continents and a great number of people were infected globally in 2020 (Chen, et al., 2020a; Kharasch & Jiang, 2020; Sorbello, et al., 2020; Wax & Christian, 2020). The number of critically ill patients not only needed mechanical ventilation but also competent health professionals who could maintain ventilators and understand the patient's complicated hemodynamic condition. When the COVID-19 pandemic threatened the existing critical care settings in the United States, the American Association of Nurse Anaesthetists (AANA) announced that Certified Registered Nurse Anaesthetists (CRNA) were immediately available and could play a role in emergent airway management, ventilatory support, and hemodynamic monitoring for COVID-19 patients in critical care settings (AANA, 2020a). The reason that CRNAs were considered a first alternate source to complement the lack of critical care nurses was due to the fact that they were qualified to fill various roles across health care setting through their specialised anaesthesia nursing education and practice (AANA, 2020a; Martland, et al., 2020).

Globally, there are differences in the education of nurses that qualify them to practise anaesthesia nursing care. For instance, nurses must have post-registered anaesthesia nursing education to practise in Denmark, Iceland, Norway, Sweden, Switzerland, and the United States (Meeusen, et al., 2010; Jeon, et al., 2015; Flynn, et al., 2017; Hedenskog, et al., 2017; Jaensson, et al., 2017; Skogsaas & Valeberg, 2017; Dahlberg, et al., 2020). In several countries including Germany, the United Kingdom, and Finland, nurses who have completed a general nursing education and on-the-job training can practise anaesthesia care (Meeusen, et al., 2010; Jeon, et al., 2015; Nilsson & Jaensson, 2016; Aagaard, et al., 2017; Dahlberg, et al., 2020). A Finnish nurse is a regulated profession under the Directive 2005/36/EC (EC, 2005), the amended Directive 2013/55/EU (EC, 2013a) and the Finnish law on health professionals (Finlex, 2015). Finland as a part of the European Higher Education Area (EHEA) provides nurse education programmes for general care at universities of applied sciences (UASs, also called polytechnics) (EC, 2005; EC, 2013a; Finlex, 2014; Lahtinen, et al., 2014; Kajander-Unkuri, et al., 2020a). In line with the European Qualification Framework (EQF) (EC, 2017; Ensio, et al., 2019), the required competencies (bachelor's degree) provided by universities of applied

sciences are described as being at level 6 by the Finnish National Framework for Qualifications (FNQF) (Finlex, 2017; OPH, 2017; OPH & OKM, 2018).

The WHO (2003) suggested that nurses in anaesthesia care require specialised post-registration education such as a graduate diploma or degree in nurse anaesthesia (EQF level 7) after their nurse education in general care. In Finland, specialised post-registration nurse education is not a requirement as an official qualification to practise in anaesthesia care. Thus, each anaesthesia department in the hospitals trains registered nurses through their own work training schemes until the nurses obtain sufficient competence in anaesthesia nursing care (Vakkuri, et al., 2006; Mellin-Olsen, et al., 2007; Salmenperä, et al., 2019; Dahlberg, et al., 2020). This requires a considerable amount of time and resources and is a demanding situation for the nurses themselves and the operation units (Vakkuri, et al., 2006).

Nursing education aims to prepare competent nurses by providing appropriate theoretical knowledge and clinical experience for meeting the challenges of clinical practice (WHO, 2013; Rafiee, et al, 2014; Dalton, et al., 2015; EC, 2017; Helminen, 2017; Helminen, et al., 2017; Kaihlanen, 2020; Kajander-Unkuri, et al., 2020a). Competence has been a key issue in nursing education due to the inconsistency between competence required in health care practice and preparedness through nursing education (Fotheringham, et al., 2015; Henderson, et al., 2015; Salah, et al., 2018; Greenway, et al., 2019; Lee & Sim, 2019). In order to provide high quality nursing, it is natural to ensure the competence of nurses (Axley, 2008; Valloze, 2009; Smith, 2012; Riddle, et al., 2016; Liu et al., 2019; Elisha, et al., 2020). Assessing the competence of nurses enables the identification of the fields necessary for professional development and educational needs (Meretoja, et al., 2004; Dellai, et al., 2009; Church, 2016; Elisha, et al., 2020).

Competence assessment research on anaesthesia nursing care is scarce in Finland. Previous research has been done in terms of a description of the content of the professional competence of anaesthesia nurses (Tengvall, 2010) and task transfers from physicians to anaesthesia nurses (Vakkuri, et al., 2006). In addition, anaesthesia nurses' perceptions of professional nurse competence have been compared with other fields of nurses in different hospital work environments (Meretoja, et al., 2004; Meretoja & Koponen, 2012). However, no research could be found that focused on competence assessment of nurses in anaesthesia nursing care.

The purpose of this study was twofold: i) to develop the Anaesthesia Nursing Competence Scale (AnestComp) for competence assessment in anaesthesia nursing care and ii) to assess anaesthesia nursing competence of nurses using the AnestComp. The study was carried out in two phases (Figure 1). Phase I focused on the development of the AnestComp and Phase II assessed the level of anaesthesia nursing competence of nurses.

In this study, data from nursing students were also collected in order to test the construct validity of the AnestComp (Known-group technique); the levels of anaesthesia nursing competence of nurses were compared with a graduating nursing student group to ascertain how the anaesthesia nursing competence of students differs from nurses at the end of their nursing studies. In addition to the competence assessment of nurses, an assessment of the competence of nursing students is also important as a fundamental element in assisting educators to develop educational programmes and to prepare the student to practise as competent nurses (Cowan, et al., 2005; Yanhua & Watson, 2011; Rafiee, et al., 2014; Wu, et al., 2015; Helminen, 2017; Helminen, et al., 2017; Kaihlanen, 2020; Kajander-Unkuri, et al., 2020b). This summary includes the results of the competence assessment of graduating nursing students.

Initially, the study plan was to assess the anaesthesia nursing competence of nurses in Finland and compare it with one of the other Nordic countries; preliminarily, Sweden was considered. Based on the results of the scoping literature review (Paper I), it was decided to develop a new instrument for the competence assessment of nurses in anaesthesia nursing care and to focus on a competence assessment of Finnish nurses instead of a Nordic-country comparison; therefore, data collection in Sweden did not continue after the pilot test. Paper II describes the developing and psychometric testing of the new instrument (AnestComp). Paper III reports the results of the self-assessed anaesthesia nursing competence of nurses. Additionally, the results of the self-assessed anaesthesia nursing competence of nursing students are reported in Paper IV.

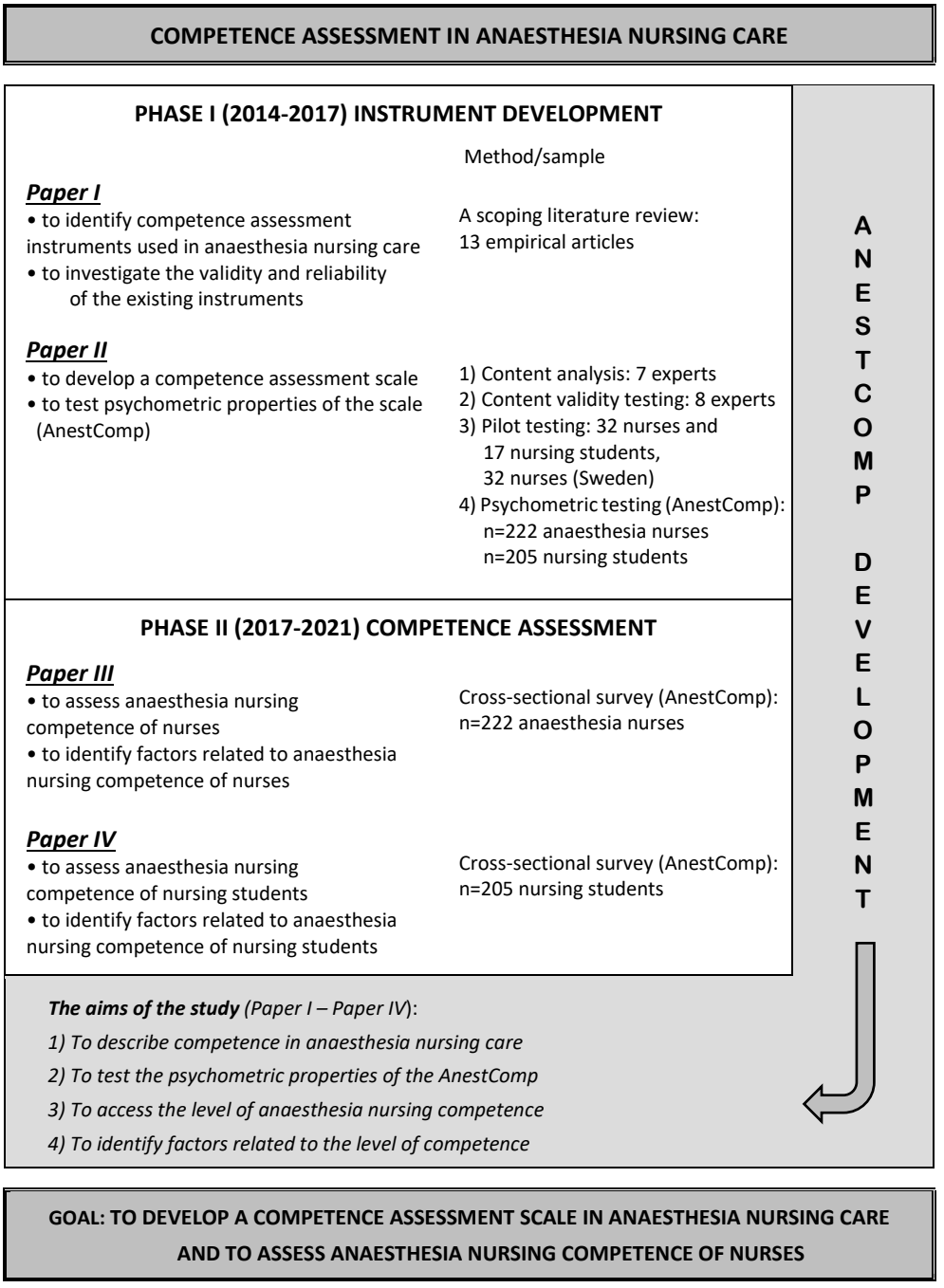

Figure 1. Design of the study.

2 Review of the Literature

In this literature review, the concept of competence in the specialty of anaesthesia nursing care was first described. Second, competence assessment instruments used in anaesthesia nursing care were reviewed (Paper I). Third, empirical studies conducted to assess competence in anaesthesia nursing care were reviewed.

2.1 The concept of competence in anaesthesia nursing care

Competence has been considered a comprehensive concept in nursing (Watson, et al., 2002; Sturmberg & Hinchy, 2010; Kajander-Unkuri, et al., 2013; Tavares & Boet, 2016; Liu et al., 2019). Many researchers and organisations have defined nursing competence (Table 1). Although there has been ambiguity and confusion in defining nursing competence during the last three decades, the concept of competence has predominantly been approached through three main streams: a behavioural (performance) approach, a general attribute approach, and a holistic approach (McMullan, et al., 2003; Cowan, et al., 2005; Smith, 2012; Garside & Nhemachena, 2013; Kajander-Unkuri, 2015; Church, 2016; Fukada, 2018).

The behavioural approach refers to "*a description of an action, behaviour or outcome in a form that is capable of demonstration, observation and assessment*" (McMullan, et al., 2003, p. 285) and focuses on a description of performance in defined observable tasks or jobs (Watson, et al., 2002; McMullan, et al., 2003; Garside & Nhemachena, 2013). There has been criticism that its focus on performance is fragmented and non-transferable and it might disable to capture basic skills related to cognition and emotion (McMullan, et al., 2003; Cowan, et al., 2005; Garside & Nhemachena, 2013).

The general attribute approach is defined as "*underlying attributes of practitioner associated with expert performance and broad clusters of abilities*" (McMullan, et al., 2003, p. 286). This approach assumes that the general underlying attributes such as knowledge, understanding, and affective skills are transferable to many situations (Gonczi, 1994; Garside & Nhemachena, 2013). However, this approach has been criticised as defying the situations where the attributes might be used (Gonczi, 1994). Since expertise (high level of competence) is domain specific,

it is difficult to transfer expertise from one part of an activity to another (Gonczi, 1994; McMullan, et al., 2003; Cowan, et al., 2005; Garside & Nhemachena, 2013).

The third concept, the holistic approach, tries to unify the underlying attributes with the situations where the attributes might be used. The holistic approach is defined as "*the complex combinations of attributes (knowledge, attitudes, values and skills) which are used to understand and function within the particular situation in which professionals find themselves*" (Gonczi, 1994, p. 29). This approach enables the incorporation of ethics and values as an area of competence and considers the importance of context (McMullan, et al., 2003; Cowan, et al., 2005; Garside & Nhemachena, 2013). In order to assess nurse competence, Meretoja, et al. (2004, p. 330-331) defined competence as "*functional adequacy and capacity to integrate knowledge and skills to attitudes and values in specific contextual situations of practice*".

Table 1. Definitions of nursing competence (1982-2020).

Author	Concept definition
Benner (1982a, p. 304)	The ability to perform the task with desirable outcomes under the varied circumstances of the real world
Gonczi, et al. (1990, p. 62)	Possessing the attributes (the knowledge, abilities, skills, and attitudes) enabling performance of a range of professional tasks to the appropriate standards
Kane (1992, p. 166)	The degree to which the individual can use the knowledge, skills, and judgement associated with the profession to perform effectively in the domain of possible encounters defining the scope of professional practice
Girot (1993, p. 84)	The ability to integrate cognitive, affective, and psychomotor skills when delivering nursing care
Gonczi (1994, p.29)	The complex combinations of attributes (knowledge, attitudes, values, and skills) which are used to understand and function within the particular situation in which professionals find themselves
Dunn, et al. (2000, p. 340)	The overlap of knowledge with the performance components of psychomotor skills and clinical problem solving within the realm of affective responses
Meretoja, et al. (2004, pp. 330-331)	Functional adequacy and capacity to integrate knowledge and skills to attitudes and values into specific contextual situations of practice
Cowan, et al. (2005, p. 361)	The application of complex combinations of knowledge, performance, skills, values and attitudes
Rutkowski (2007, p.35)	The skills and abilities to practice safely and effectively without the need for direct supervision
Takase & Teraoka (2011, p. 398)	The ability of a nurse to effectively demonstrate a set of attributes, such as personal characteristics, professional attitude, values, knowledge, and skills, and to fulfil his/her professional responsibility through their practice
Smith (2012, p.182)	Integrating knowledge into practice, experience, critical thinking, proficient skills, caring, communication, environment, motivation, and professionalism

Organisation	Concept definition
International Council of Nurses (ICN, 2009, p. 6)	The effective application of a combination of knowledge, skill and judgement demonstrated by an individual in daily practice or job performance
Australian Nursing and Midwifery Accreditation Council (ANMAC, 2010, p.10)	The combination of skills, knowledge, attitudes, values and abilities that underpin effective and/ or superior performance in a profession/occupational area
Nursing and Midwifery Council, UK (NMC, 2010, p.11)	The combination of skills, knowledge and attitudes, values and technical abilities that underpin safe and effective nursing practice and interventions
Nursing Council of New Zealand (NCNZ, 2012, p. 43)	The combination of skills, knowledge, attitudes, values and abilities that underpin effective performance as a nurse
American Nurses Association (ANA, 2017a, p. 20)	An expected level of performance that integrates knowledge, skills, abilities, and judgment

During the last decade, the holistic approach was the concept that has been adopted when defining competence by many organisations. The International Council of Nurses have used the definition of competence as "*the effective application of a combination of knowledge, skills, and judgement demonstrated by an individual in daily practice or job performance*" (ICN, 2009, p. 6). From the perspective of the European Qualification Framework for lifelong learning, competence was defined as: *the proven ability to use knowledge, skills and personal, social and/or methodological abilities in work or study situations and in professional and personal development*" (EC, 2017, p. c189/20). Based on the holistic approach (Gonczi, 1994; Cowan, et al., 2005; Smith, 2012; Garside & Nhemachena, 2013), the concept of competence can be summarised as a comprehensive ability to use knowledge, attitudes, values, and skills in the scope of professional practice. The scope of professional practice might differ across fields of nursing (Nagelsmith, 1995; Watson, et al., 2002; Gillespie, et al., 2012; Simth, 2012; Lakanmaa, et al., 2014a; Kajander-Unkuri, et al., 2020a).

Anaesthesia nursing care is a field of nursing associated with care for patients planning to have anaesthesia, undergoing anaesthesia, and recovering from anaesthesia (Mamaril, 2003; WHO, 2003; Ead, 2014; Abelsson & Nygårdh, 2020). Anaesthesia refers to the absence of feeling or sensation in the body by using sedation, analgesia, and anaesthesia for surgery or other therapeutic procedures (Martin & McFerran, 2008; Colman, 2014). Anaesthesia nursing care was described as "*by keeping in touch, watching over, and being one step ahead, the nurse anaesthetist can ensure a safe passage of the patient through the anaesthesia, support the patient's vital functions and emotional and physical needs, protect the patient and prevent harm and suffering, and respect the patient's integrity and*

dignity (Nilsson & Jaensson, 2016, p. 551). To provide anaesthesia nursing care, nurses are expected to be competent as regards meeting the complicated needs of anaesthesia patients (Mamaril, 2003; Plaus, et al., 2011; Ead, 2014; Hedenskog, et al., 2017; Sundqvist, et al., 2018).

The International Federation of Nurse Anaesthetists (IFNA, 2016), to which all the Nordic countries, the USA, and Switzerland are member countries, addressed the issue of nurses in anaesthesia care as requiring nursing and medical knowledge as well as clinical, technical, and non-technical skills. The IFNA has described nurses as needing to play the roles of experts, professionals, communicators, collaborators, managers, health advocates, and scholars in anaesthesia nursing care (Table 2). Globally, the anaesthesia nursing educational programmes, the scope of anaesthesia practice and continuing professional development programmes are closely related to national and regional needs (Jeon, et al., 2015; Herion, et al., 2019).

Internationally, there are two types of nurses practising in anaesthesia nursing care: nurse anaesthetists and anaesthesia nurses. A nurse anaesthetist has a specialised post-registration nursing education such as a graduate diploma or a master's degree in anaesthesia care after general nursing education and can initiate, maintain, and terminate general anaesthesia independently in four phases of anaesthesia care with some guidance from the anaesthesiologist. This type of nurse anaesthetist can practise in the Nordic countries and the United States (ANIVA & SSF, 2008; Meeusen, et al., 2010; Sundqvist & Carlsson, 2014; Jeon, et al., 2015; Jaensson, et al., 2017; Herion, et al., 2019). In the Nordic countries, nurses practising in anaesthesia nursing care must have completed a specialised post-registration education (12-24 months duration, 60-120ECTS) to a graduate diploma level or master's degree level. The content areas of competence provided in anaesthesia nursing education in the Nordic countries are medical/natural sciences, peri-anaesthesia nursing skills which are based on the anaesthesia process (pre-, induction, during, and post-anaesthesia phase), anaesthesia technology, crisis management, ethical and legal aspects, collaboration/teamwork, professional development, and resource management, and research methodology (Jeon, et al., 2015).

Table 2. Competence described by professional nurse associations.

Competence areas	Association
Nurse anaesthesia expert role: Pre-anaesthetic patient assessment, Anaesthesia management, Risk management, Monitoring, Advanced life support, Equipment, Termination of anaesthesia, Postoperative care and pain management, Infection control, Documentation **Professional role**: Professionalism, Advanced of anaesthesia care, Accountability **Communicator role**: Communication and situation awareness **Collaborator role**: Collaboration and teamwork **Manager role**: Task management, Quality management **Health Advocate role**: Patient information, Patient education, Patient advocacy **Scholar role**: Continuous professional development, Research, Education	The International Federation of Nurse Anaesthetists (IFNA, 2016)
Patient's right, Pre-anaesthesia patient assessment and evaluation, Plan for anaesthesia care, Informed consent for anaesthesia care and related services, Documentation, Equipment, Anaesthesia plan implementation and management, Patient positioning, Monitoring and alarms, Infection Control and prevention, Transfer of care, Quality improvement process, Wellness, A culture of safety	The American Association of Nurse Anaesthetists (AANA, 2019)
Anaesthesiologic nursing, Ethics, Research and Development, Leadership, Peri-operative care, Pedagogics of care, Profession under development	The Swedish Association of Nurse Anaesthetists and Intensive Care Nurses (ANIVA & SSF, 2008)
Ethics and legislation, Patient safety, Economy, efficiency and ecology, Information system and documentation, Aseptic, Emergency management, Pain management, Pre-operative care, Intra-operative care, Post-operative care	The Finnish Association of Nurse Anaesthetists (FANA, 2015)

Nurses practising in Sweden, for instance, complete one year of post-registration nurse anaesthesia education programmes: 60 ECTS, Graduate diploma in specialist nursing-anaesthesia care (Jeon, et al., 2015). The Swedish Association of Nurse Anaesthetists and Intensive Care Nurses (ANIVA & SSF, 2008) published seven competence areas for registered nurse practising in anaesthesia care; it corresponds to the roles defines by the IFNA of anaesthesia nurse being experts, professionals, managers, health advocates, and scholars. In the USA, certified registered nurse anaesthetists (CRNAs) are advanced practice registered nurses (APRNs) who have completed specialised post-registration nurse anaesthesia education programmes (28-36 months duration) to the level of a master's or doctorate degree; core competence areas that graduates have acquired from these education programmes

have been defined as an anaesthesia clinical core competence and include knowledge and skills in patient safety, individualised peri-anaesthesia management, critical thinking, communication skills, and professional responsibility (Sipe, et al., 2009; Gombkoto, et al., 2014; James, 2014; ANA, 2017b; COACRNA, 2019; AANA, 2020b; Starnes-Ott, et al., 2020).

The other type of nurses practising in anaesthesia nursing care are called anaesthesia nurses. The anaesthesia nurse is a registered nurse in general care and trained additionally for anaesthesia care (e.g., preparing, monitoring, maintaining, and recovering from the anaesthetised patient). The anaesthesia nurse assists the anaesthesiologist as a team in the anaesthesia patient care. These anaesthesia nurses practise in several countries including Finland (Jeon, et al., 2015). The Finnish Association of Nurse Anaesthetists (FANA, 2015) described the competence areas of anaesthesia nurses required in Finland to support the anaesthesia nurses' professionalism and career development. The Finnish competence requirements include the IFNA's nurse anaesthesia expert role and health advocate role and also mentions an ecologically sustainable concern in patient care.

In Finland, nurse education (Bachelor's degree) is provided by the UASs which have the responsibility to develop the curriculum contents for general nurse education based on EU directives (Salminen, et al, 2010; OPH, 2017; OPH & OKM, 2018; Ensio, et al., 2019; Kaihlanen, 2020; Kajander-Unkuri, et al., 2020a; Kajander-Unkuri et al., 2020b). Theoretical studies related to anaesthesia nursing care (e.g., anaesthesiology or perioperative nursing) differ among the UAS's curricula (2-5 ECTS of theoretical studies reported by the three UASs in this study). Finland does not have anaesthesia nursing education leading to a master's or doctorate degree (Jeon, et al., 2015). However, some of the UASs have arranged special continuing education in anaesthesia nursing care. For instance, Savonia UAS (30 ECTS, 2018-2019) and Lapland UAS (30 ECTS, 2020) provided a perioperative nursing programme including anaesthesia nursing care as continuing education (Savonia AMK, 2018; Lapland AMK, 2020). For specialisation in anaesthesia nursing care, Lahti UAS (2019-2020) and LAB UAS (2021-2022) provide a specialised continuing programme in anaesthesia nursing (30 ECTS) focusing on competence development in anaesthesia clinical competence, teamwork, risk management, development and consultation, and clinical practice (Lahti AMK, 2019; LAB AMK, 2020).

2.2 Competence instruments in anaesthesia nursing care

To investigate competence assessment instruments used in anaesthesia nursing care, a scoping review was undertaken (Paper I). A scoping review is considered an effective review methodology for mapping or overviewing the range of the field of

interest (Levac, et al., 2010; Armstrong, et al., 2011). The scoping review aimed to describe instruments used for competence assessment in anaesthesia nursing care and the psychometric properties of the instruments.

In the international databases, CINAHL (EBASCO), MEDLINE (Ovid), and ERIC, combined search terms were used in 2015: competen*, assess*, scale*, tool*, evaluat*, measure*, nurs*, perian(a)esth*, prean(a)esth*, intraan(a)esth*, postan(a)esth*, an(a)esthe*, PACU, perioperati*, preoperati*, intraoperati*, postoperati*, recovery. The search covered all countries, written in the English language, and from 1994 to 2015 (Paper I). In this summary, the search was updated to find additional articles published from 2015 to 2021 in CINAHL (EBSCO), MEDLINE (Ovid) and Eric (EBSCO); the final update was carried out in January 2021.

The participants were nurses in anaesthesia care such as anaesthesia nurse/nurse anaesthetist, recovery room nurses, OR nurses, perioperative nurses, and student nurses. The inclusion criteria were original empirical studies, mixed-method and instrument validation studies. The exclusion criteria were OR nurses or perioperative nurses without anaesthesia nurses (e.g., the focus was only on scrub nurses or circulation nurses), assessment instruments for other purposes (e.g., preceptors' competence assessment), literature reviews, editorials, and discussion articles.

Based on the literature search (13 articles, see Table 2 in Paper I) and an updated search for this summary (8 articles, Appendix 1), 21 articles were included in the analysis and 11 competence assessment instruments were summarised (Table 3): 1) Mini-CEX (Gabriel, 2013), 2) PPCS-R, Perceived Perioperative Competence Scale-Revised (Gillespie, et al., 2012; Gillespie & Pearson, 2013; Jaensson, et al., 2017; Gillespie, et al., 2018; Falk-Brynhildsen, et al., 2019), 3) NCS, Nurse Competence Scale (Meretoja, et al., 2004; Meretoja & Koponen, 2012; Greenfield, et al., 2014), 4) Professional Competence (Cook, et al., 2013), 5) Clinical Evaluation Instrument (Collins & Callahan, 2014), 6) Crisis Management Behaviour Tool (Gaba, et al., 1998), 7) NOTECHS II (Robertson, et al., 2014), 8) Technical Action Checklist (Gaba, et al., 1998; Murray, et al., 2005; Henrichs, et al., 2009; Gabriel, 2013; Kibwana, et al., 2016; Wunder, 2016), 9) Knowledge Examination (Gabriel, 2013), 10) ANTS, Anaesthetists' Non-Technical Skills (Wunder, 2016; Lyk-Jensen, et al., 2016; Flynn, et al., 2017) and 11) CCAT, Common Clinical Assessment Tool (Elisha, et al., 2020). The update search found two instruments (ANTS and CCAT) in addition to nine instruments identified in Paper I (See Table 3 in Paper I).

The scoping literature review of the competence assessment instruments used in anaesthesia nursing care provides an overview of which competence areas/domains were measured, which data collection methods were used, and which psychometric properties were reported. Among the instruments, eight competence areas were categorised: 1) ethical values, 2) risk management/situation awareness, 3) medical

technological skill/equipment, 4) collaboration, 5) leadership, 6) anaesthesia nursing skill/therapeutic intervention, 7) professional development, and 8) knowledge (Table 3). Frequently measured competence areas among the instrument were collaboration, anaesthesia nursing skill/therapeutic intervention, risk management/situation awareness, professional development, and knowledge (Table 3).

Table 3. Competence assessment instruments used in anaesthesia nursing care (1994-2021).

	Instrument (n=11)	1) Mini-CEX	2) PPCS-R	3) NCS	4) Professional competence	5) Clinical evaluation instrument	6) Crisis management behaviour tool	7) NOTECHS II	8) Technical actions checklist	9) Knowledge examination	10) ANTS*	11) CCAT*
Competence areas/domains	Ethical values	+	+	+								+
	Risk management /situation awareness	+		+	+		+	+	+		+	+
	Medical technological skill/equipment		+			+						+
	Collaboration	+	+	+	+	+	+	+			+	+
	Leadership		+				+	+				
	Anaesthesia nursing skill /therapeutic intervention	+		+	+	+	+	+	+			+
	Professional development	+	+	+	+	+						+
	Knowledge		+		+	+				+		+
Data	Direct observation						+	+	+		+	
	Self-assessment	+	+	+	+							
	Employer/Educator's assessment				+	+						+
	Written exam									+		
Relia	Cronbach's alpha	+	+	+						+	+	
	Inter-rater's correlation						+	+	+		+	
Validity	Delphi technique		+	+				+				+
	Principal Component Analysis		+									
	Exploratory Factor Analysis		+									
	Confirmatory Factor Analysis		+	+		+						
	Predictive validity					+						
	Concurrent validity			+				+			+	

* Instruments found by the updated search (2015-2021).

The eleven instruments can be categorised by four types of data collection methods: direct observation, self-assessment, employer/educator's assessment and a written

examination. The frequently used assessment methods in anaesthesia nursing care were direct observation in a simulation environment and self-assessment. In a simulated approach, raters are able to observe and evaluate a demonstration as an outcome of the nurse's competence (Watson, et al., 2002; Fotheringham, 2010; Paper I). For instance, it is possible to evaluate directly how a nurse behaves, makes decisions, and communicates with others in simulated situations (Bokken, et al., 2008; Henrichs, et al., 2009; Gabriel, 2013).

Self-assessment has been described as a time and cost-effective approach and a useful tool in outcome-based education (Kajander-Unkuri, et al., 2014a; Lakanmaa, et al., 2014a; Jaensson, et al., 2017; Kajander-Unkuri, et al., 2020b). The self-assessment method leads nurses to use a systematic way of evaluating their abilities, skills, and knowledge by referencing professional guidelines or standards. In the process of evaluation, nurses/students can assess their own performance and identify strengths and weakness (Eva & Regehr, 2005; Ross, 2006; Takase & Teraoka, 2011; Kajander-Unkuri, et al., 2014a; Kajander-Unkuri, et al., 2020b).

In competence assessment, a multi-method approach has the benefits of reducing the uncertainty of the results when using a single tool and supporting the validity of the measurement (Fotheringham, 2010; Gabriel, 2013). The instrument, Professional Competence (Cook, et al., 2013) was used by nurses for self-assessment and also an assessment by their employers. In addition, a written examination and a Technical Action Checklist were also used together (Gabriel, 2013). However, the multi-method approach requires a deliberate study design and should pay more attention to reducing the possibility of compound-errors in the results (Fotheringham, 2010).

The appropriate instruments for competence assessment can be determined based on the psychometric properties provided by those studies with a high methodological quality (Mokkink, et al., 2010; Flinkman, et al., 2017). Therefore, the detail of the validity and reliability of the instrument should be reported sufficiently. Validity can be expressed as the appropriateness or meaningfulness of an instrument (DeVon, et al., 2007). Reliability can be express as the consistency and stability of an instrument in measuring an attribute (DeVon, et al., 2007). Among the eleven instruments reviewed, four instruments (PPCS-R, NCS, ANTS, and NOTECHS II) reported both reliability and validity (Table 3). However, psychometric testing of the instrument was not clarified sufficiently in many studies (Paper I).

According to the results of the analysis, there was a need to develop psychometrically sound competence assessment instruments in anaesthesia nursing care; 1) the NCS and the PPCS-R are generic competence instruments, so there might be limitations in measuring specialised anaesthesia nursing competence, 2) the Mini-CEX, the Professional competence, Clinical evaluation instrument, and the CCAT are at the beginning of the instrument development, and 3) most of the instruments measured only some part of nursing competence such as technical skills (Technical

actions check-list), non-technical skills (Crisis management behaviour tool, NOTECHS II, and ANTS) or knowledge examination.

2.3 Competence studies in anaesthesia nursing care

In the section reviewing the empirical studies for competence assessment, the levels of competence of nurses in anaesthesia nursing care and factors related to their competence are described. For the description of the competence, this section presents which levels of competence were considered satisfactory or acceptable in the empirical studies. Since this study used nursing student's data, competence assessment studies conducted among nursing students are also reviewed.

For this summary, competence assessment studies in anaesthesia nursing care were searched using databases: CINAHL(EBSCO), MEDLINE(Ovid), and ERIC(EBSCO). The search aimed to review empirical studies describing the levels of competence among nurses in anaesthesia nursing care and factors associated with their competence. The search was conducted using the following keywords: competen*, assess*, evaluat*, measure*, nurs*, student*, perian(a)esth*, prean(a)esth*, intraan(a)esth*, postan(a)esth*, an(a)esthe*, PACU, perioperati*, preoperati*, intraoperati*, postoperati*, recovery. The search was limited to studies written in English and Finnish and from 1994 to 2021. The inclusion criteria were as follows: 1) the participants were anaesthesia nurses, nurse anaesthetists, OR nurses, perioperative nurses, nurse anaesthetist students, or nursing students, 2) the interest was focused on competence assessment and factors associated with competence, and 3) the study design was an empirical study. As a result, 19 empirical studies of competence assessment were identified. The majority of the studies (15 studies) were conducted among nurses and there were four studies where the participants were nursing students.

The level of competence of nurses and related factors in anaesthesia nursing care

Fifteen studies assessed nurses' competence in anaesthesia nursing care (Table 4). Based on the results of the review, nurses' competence was assessed on the basis of six perspectives: 1) instrument development to measure the competence of nurses (Tengvall, 2010; Gillespie, et al., 2012; Robertson, et al., 2014), 2) development of continuing education curricula (Greenfield, et al., 2014), 3) specific nurse competence (Gaba, et al., 1998; Meretoja, et al., 2004; Henrichs, et al., 2009; Istomina, et al., 2011; Gillespie & Pearson, 2013; Gillespie, et al., 2018; Falk-Brynhildsen, et al., 2019), 4) the effectiveness of an assessment method for

demonstrating nurse competence (Meretoja & Koponen, 2012; Gabriel, 2013), 5) outcomes of nurse anaesthetist education (Cook, et al., 2013), and 6) the effect of associated factors on nurse competence (Gillespie, et al., 2011).

In the studies using the NCS, the OR nurses' self-assessed overall competence was a VAS of 61 (VAS 0=very low to 100=very high) (Meretoja, et al., 2004) and a VAS of 72 (Istomina, et al., 2011). The perioperative nurses' self-assessed competencies (15 items from the NCS) ranged from a VAS of 42 to 81(VAS 0-100) (Meretoja & Koponen, 2012), and the peri-anaesthesia nurses' self-assessed competence in managing situations (one category from NCS) was 8.1 (Min.=1 to Max.=10) (Greenfield, et al., 2014). For the data analysis, the VAS scores reported by nurses (Meretoja, et al., 2004; Istomina, et al., 2011; Meretoja & Koponen, 2012) were divided into quarters: low, rather good, good, and very good. Comparing the competence of nurses among different hospitals, the OR nurses' competence was reported lower than those in different hospital work environments such as intensive care, ward, and emergency/outpatient (Meretoja, et al., 2004). The relatively short contact between OR nurses and patients, and the fact that most patients are anaesthetised might affect the results of the OR nurses' lower level in overall competence (Meretoja, et al., 2004).

In studies using the Perceived Perioperative Competence Scale-Revised (PPCS-R) having 5-point scores (1=never to 5=always/the theoretical scores ranged from 40 to 200), perioperative nurses self-assessed their competence as 174.7 (Gillespie, et al., 2012), 166.2 (Gillespie & Pearson, 2013), and 158.3 (Falk-Brynhildsen, et al., 2019). In the recent Swedish study (Falk-Brynhildsen, et al., 2019), no significant differences have been found in total perioperative competence scores between OR nurses (Scrub and circulation roles) and nurses anaesthetists, but higher scores in the domain of empathy and lower scores in the domain of leadership were observed among the nurse anaesthetists.

Some studies have focused on specific competence assessment such as technical skills (Gaba, et al., 1998; Henrichs, et al., 2009; Gabriel, 2013), non-technical skills (Robertson, et al., 2014) or knowledge (Gabriel, 2013). In terms of technical skill assessment, the performance of nurse anaesthetists when responding to simulated critical events varied (range 10-92%) according to the studies (Gaba, et al., 1998; Henrichs, et al., 2009; Gabriel, 2013). The scores for non-technical skills of OR teams were assessed as 73.4 (min 16- max 128) (Robertson, et al., 2014). In the study of knowledge assessment, the score in a written examination was evaluated as a score of 67% (Gabriel, 2013). Most studies lacked clarity as to what the assessment scores indicate and what levels are satisfactory or expected for nurses in the specific clinical setting.

The factors that connected positively with better nurse competence in anaesthesia nursing care were found to be age (Meretoja, et al., 2004), length of work

experience (Meretoja, et al., 2004; Tengvall, 2010; Istomina, et al., 2011; Gillespie, et al., 2011; Gillespie, et al., 2012; Gillespie, et al., 2018), level of specialty qualification (Gillespie, et al., 2011; Gillespie, et al., 2012; Gillespie, et al., 2018), and surgical specialty (Robertson, et al., 2014) (Table 4). Six studies reported a positive effect of work experience on the levels of nurse competence. In terms of length of work experience, it was noticed that the levels of nurse competence with under five-year OR experience were significantly lower than those of more experienced nurses (over five years). However, the differences in levels between nurses with 5-10 years and nurses with over10 years were subtle (Gillespie, et al., 2011). The performance of OR teams in non-technical skills for elective orthopaedic operations was higher than for trauma orthopaedic operations (Robertson, et al., 2014). However, some studies reported opposite results stating that age (Gabriel, 2013), work experience (Gabriel, 2013), and workplace (Gabriel, 2013; Robertson, et al., 2014) were not connected with higher competence levels in nurses.

Table 4. Competence studies of nurses in anaesthesia nursing care (n=15, 1994-2021).

Author/year/country: Study purpose	**Sample/ Instrument/Scoring**	**Competence level**	**Related factor**
Gaba, et al., 1998 USA: To measure anaesthesia providers' performance on critical events	N=72 participants including 4 CRNAs (18 groups of 4 each)/ Technical action Check-list and Crisis management behaviour tool / 1=poor to 5=outstanding	The technical scores were fairly high (mean 78% for Malignant Hyperthermia and 83% for cardiac arrest). Critical management behaviour ranged from poor to minimally acceptable.	Not reported
Meretoja, et al., 2004 Finland: To develop and test the Nurse Competence Scale (NCS)	N=158 RN working in OR/ NCS (7 domains)/ VAS (0-100) 0=very low level to 100=very high level of competence	OR nurses self-assessed their competence as good (VAS 61). -Managing situation (71) -Helping role (65) -Diagnostic functions (62) -Work role (62) -Teaching-coaching (58) -Therapeutic interventions (59) -Ensuring quality (51)	Age: r=0.39*** Years in OR: r=0.30*** Years as RN: r=0.39*** Years in health care: r=0.34***

Henrichs, et al., 2009 USA: To assess technical skills on critical events of certified registered nurse anaesthetists and anaesthesiologists in simulation	N=26 CRNAs and 35 anaesthesiologists Technical action checklist	Averaged overall scores of the CRNAs was 59.9% of the key action items. CRNAs achieved highest scores in Bronchospasm (92%) and lowest in the Malignant Hyperthermia (10%)	Not reported
Tengvall, 2010 Finland: To monitor professional competence of perioperative and anaesthetist nurses	N=580 (256 OR nurses, 184 anaesthesia nurses, 76 anaesthesiologists, 64 surgeons)/ 91-item survey for anaesthesia nurse professional competence (6 dimensions)/ 1=never, 5=always	Anaesthesia nurses' professional competence performance assessed by perioperative health professionals (Mean): -Anaesthesia medication care (4.1) -Communication and safety (3.6) -Care preparation (3.0) -Induction of anaesthesia care (4.3) -Common activity (3.4) -Teamwork and guidance skill (3.9) -Common responsibility (3.3) -Special activity (2.2)	Years of work experience ($p<0.001$)
Gillespie, et al., 2011 Australia: To identify the effect of work experience and education for specialisation on the perioperative competence of nurses	N=134 perioperative nurses (circulating, scrub, recovery room, anaesthesia roles)/ 98-item Perceived Perioperative Competence Scale/ 1=never, 5=always 8 domains(items): -Professional knowledge (11) -Technical and procedural knowledge (14) -Practical knowledge (11) -Aesthetic knowledge (12) -Teamwork (13) -Communication (11) -Coordination (12) -Clinical leadership (13)	Scores of competence levels perceived by perioperative nurses were Mean 394 (min. 98, max. 485). 8 domains (Mean scores) -Professional knowledge (44.4) -Technical and procedural knowledge (55.9) -Practical knowledge (45.0) -Aesthetic knowledge (52.0) -Teamwork (54.7) -Communication (45.6) -Coordination (48.6) -Clinical leadership (51.5)	The levels of competence of nurses having 5 years of work experience were lower than nurses having over 5 years in eight domains (Kruskal-Wallis test, $p<0.05$). Nurses with specialisation education reported higher levels than those without in eight domains (Mann-Whitney test, $p<0.05$)

Istomina, et al., 2011 Lithuania: To assess the competence of nurses and to describe factors related with the competence	N=247 abdominal perioperative and surgical nurses/ NCS (7 domains)/ VAS (0-100) 0=very low level and 100=very high level of competence	The overall nurse competence was good (VAS 72). -Managing situation (80) -Helping role (72) -Diagnostic functions (72) -Work role (73) -Teaching-coaching (68) -Therapeutic interventions (73) -Ensuring quality (69)	Nurse education, experience, professional development, independence, work satisfaction, and the evaluation of quality of nursing care were related to the competence
Gillespie, et al., 2012 Australia: To develop and validate the Revised Perioperative Competence Scale (PPCS-R)	N=1138 OR nurses (circulating, scrub, recovery room, anaesthesia roles)/ 40-item Perceived Perioperative Competence Scale-Revised (PPSC-R, 6 domains)/1=never to 5=always 6 domains(items): Foundational knowledge and skills (9) -Leadership (8) -Collaboration (6) -Proficiency (6) -Empathy (5) -Professional Development (6)	Total scores of competence levels perceived by perioperative nurses were 174.7. (min.40, max. 200) 6 domains (Mean scores) -Foundational knowledge and skills (39.6) -Leadership (33.5) -Collaboration (27.1) -Proficiency (26.7) -Empathy (22.4) -Professional Development (25.4)	Years of OR experience ($r=.36$, $p<0.001$) Perioperative specialist qualification: $F(1, 1111) = 26.0$, $p<0.001$
Meretoja & Koponen, 2012 Finland: to describe a model development comparing the optimal and actual competencies of nurses	N=87 perioperative nurses and 88 nurse managers/ 15 items (relevant for perioperative settings) from NCS/ VAS (0-100) 0=very low level and 100=very high level of competence	The level of optimal competence was reported as significantly higher when comparing the self-assessed actual competence of nurses or actual competence assessed by nurse managers	Not reported
Cook, et al., 2013 USA: To measure the preparedness and performance of recently graduated nurses	N=569 newly graduated CRNAs and 696 employers/ 17 Professional competencies/ 5-point Likert	98% of the recently graduated nurses self-reported that they were prepared and 97% of the employers agreed it	Not studied

Gabriel, 2013 USA: To investigate relationships of three measurement methods (written examinations, self-report, and performance evaluation in a simulation)	N=18 nurse anaesthetists/ -Technical action Check-list on 8 scenarios -30 item written exam -One-item self-assessment (pre-& post-test)/ 1=unsatisfactory to 9=superior)	Overall critical skills of eight scenarios was 77% (Bronchospasm 80%, acute haemorrhage 81%, right main stem intubation 74%, hyperkalaemia 60%, tension pneumothorax 80%, total spinal 80%, oxygen pipeline loss 79%, malignant hyperthermia 83%) -Written exam 67% -Self-assessment: pre-test 6.5/post-test 5.4	Workplace, age, experience: no significant difference The written examination and performance showed negative correlation (r=-407, p=.094).
Gillespie & Pearson, 2013 UK: To assess operating department practitioners (ODPs) and operating theatre (OT) nurses' competence in perioperative nursing	N=214 Perioperative nurses (circulating, instrument, anaesthetic, educator roles)/ 40-item Perceived Perioperative Competence Scale-Revised (PPSC-R)/ 6 domains, 1=never, 2=sometimes, 3=often, 4=very often, 5=always 6 domains(items): Foundational knowledge and skills (9) -Leadership (8) -Collaboration (6) -Proficiency (6) -Empathy (5) -Professional Development (6)	Scores of competence levels perceived by perioperative nurses were 166.2. (min.40, max. 200) 6 domains (Mean scores): -Foundational knowledge and skills (37.5) -Leadership (28.8) -Collaboration (27.0) -Proficiency (25.6) -Empathy (22.2) -Professional development (24.7)	Not reported
Greenfield, et al., 2014 USA: To develop the curriculum of an obstetric PACU continuing education	N=54 obstetric nurses and 68 peri-anaesthesia Phase I nurses/ 8-items (Managing situation) relevant for post-anaesthesia emergencies drawn from the NCS/1=not at all competent to 10=extremely competent	On average, peri-anaesthesia phase I nurses (8.6) reported higher competence than obstetric nurses (8.1).	Not reported
Robertson, et al., 2014 UK: To test a modified scale (Oxford NOTECHS II)	N=297 OR cases/ 16-item Oxford NOTECHS II/	Average scores of Oxford NOTECHS II was 73 (range 37-92)	There was difference between surgical specialities (P=0.001)

Gillespie, et al., 2018 Australia, Canada, Scotland, Sweden: To assess perioperative nurses' perceptions of competence among four countries and to identify the influence of education for specialisation and work experience	N=768 OR nurses/ PPCS-R/ 5-point 1=never, 2=sometimes, 3=often, 4=very often, 5=always (Min 40-Max 200)	Perceived perioperative competence of nurses with specialist qualification and without -Australia 166.2 vs 161.4 -Canada 166.3 vs 157.9 -Scotland 164.9 vs 163.3 -Sweden 156.3 vs 154.7	Specialist qualification: F (1, 706) =4.0, P=0.047* Year in OR: F (2, 706) =58.5, P=0.001***
Falk-Brynhildsen, et al., 2019 Sweden: To assess and describe competence and self-efficacy among Swedish OR nurses and registered nurse anaesthetists (RNAs)	N=505 OR nurses and 528 RNAs/ PPCS-R (6 domains)/ 5-point 1=never, 2=sometimes, 3=often, 4=very often, 5=always 6 domains(items): Foundational knowledge and skills (9) -Leadership (8) -Collaboration (6) -Proficiency (6) -Empathy (5) -Professional Development (6)	Total scores of competence levels perceived by OR nurses and RNAs were 158.2 and 158.3 respectively. (min.40, max. 200) 6 domains:(Mean scores) OR nurses / RNAs -Foundational knowledge and skills: 38.4/37.5 -Leadership: 27.8/26.7 -Collaboration: 24.6/24.5 -Proficiency: 25.9/25.9 -Empathy:19.3/21.7 -Professional development: 22.3/21.9	No significant correlation between academic degree and competence.

The level of competence of nursing students and related factors in anaesthesia nursing care

A search was made for empirical studies of nursing students in order to describe nursing students' anaesthesia nursing competence and related factors. For preparing and developing competent nurses, it is important to assess the level of competence of nursing students before their graduation (WHO, 2016; Immonen, et al., 2019; Kaihlanen, 2020; Kajander-Unkuri, et al., 2020a). There were very few studies (n=4) conducted among nursing students in anaesthesia nursing care (Table 5). Nursing students' competence was examined in a study focusing on students' performance as an outcome of their nursing education (Murray, et al., 2005; Kibwana, et al., 2016), and in a study on teaching/learning methods in anaesthesia nursing care (Liaw, et al., 2012; Wunder, 2016).

All competence assessment studies of nursing students have been carried out in a simulation environment. In the simulations, three studies assessed nursing students'

technical skills (Murray, et al., 2005; Liaw, et al., 2012; Kibwana, et al., 2016) and one study assessed their non-technical skills (Wunder, 2016). In terms of the technical-skill assessment, the student nurse anaesthetists' overall performance score in acute care skills was 43% (Murray, et al., 2005) and 62% (Kibwana, et al., 2016). In student assessment studies, specific levels were set as criteria to assess student achievement and the levels were different from the purpose of the assessment. Kibwana, et al. (2016) set over 60% as an acceptable level for the overall competence of graduating students by using a technical action check-list from a bachelor's anaesthesia training programme. In the simulation studies, checklists were mainly used to measure nursing students' performance. The checklist refers to an itemisation of each step to measure procedural skills, but there may be limitations in measuring the integration of multidimensional competence (Tavares & Boet, 2016). In order to compensate for this limitation, a one-item Global Rating Scale (GRS) was also used (Murray, et al., 2005; Liaw, et al., 2012). For instance, evaluators agreed that a score of 7 or higher from the 10-point scale (0=unsatisfactory to 10=outstanding) was the expected level when measuring student nurse anaesthetists' acute care skills (Murray, et al., 2005). Two intervention studies assessed nursing students' performance in order to determine the effectiveness of learning programmes (Liaw, et al., 2012; Wunder, 2016).

The factors positively related to the higher performance of nursing students' competence in anaesthesia nursing care were being male (Kibwana, et al., 2016), attending a university training programme (Kibwana, et al., 2016), and having longer education and clinical experience (Murray, et al., 2005) (Table 5). One study reported that gender, age, and years of previous work experience were not related to student nurses' performance (Wunder, 2016).

Table 5. Competence studies of students in anaesthesia nursing care (n=4, 1994-2021).

Author/year/country: Study purpose	Sample/ Instrument	Competence level	Related factor
Murray, et al., 2005 USA: To assess acute care skills of student nurse anesthetists	N=15 student nurse anaesthetists Technical action check-list (6 acute scenarios) GRS (VAS10mm, 0=unsatisfactory, 10=outstanding)	Overall acute skill performance scores of student nurse anaesthetists were 43% and GRS was VAS 5.7. Anaphylaxis (33.8%), Myocardial ischemia (49.5%), Atelectasis (45.7%), Ventricular tachycardia (57.3%), Stroke (21.2%), Aspiration (48.4)	Education and clinical experience received higher scores

Liaw, et al., 2012 Singapore: To investigate self-assessed confidence and knowledge scores as indicators of performance in simulated assessment	N=31 nursing students/ Intervention:6-hour simulation 1) Checklist(31-item) and GRS(1-item) 2) Knowledge test (53 item multiple choice 3) Confidence scale (5 items):10-point scale	Intervention group: Mean performance scores increased from 10 in pre-tests to 20 in post-tests. Mean knowledge scores (from 36 to 43) and self-confidence scores (from18 to 24) increased. No mean differences in performance test and knowledge test between before and after test However, self-confidence scores increased from 14 (pre-test) to 20 (post-test)	Not reported
Kibwana, et al., 2016 Ethiopia: To examine competencies achieved by graduating Bachelor of Science nurse anaesthetist students	N=122 graduating students from anaesthetist training programs Technical action check-list	The overall mean skills score was 61.5%. -Spinal anaesthesia (80%) -Neonatal resuscitation (74%) -Endotracheal intubation (73%) -Laryngeal mask airway insertion check (71%) -Preoperative screening assessment (48%) -Routine anaesthesia machine check (37%)	Gender: Male>female ($p<0.05$) Study place: University>regional health science college ($p<0.05$)
Wunder, 2016 USA: To identify the effectiveness of intervention of non-technical skills of nurse anaesthetist students	N=32 first year CRNA students Intervention: a 3-hour educational instruction of non-technical skills lecture Anaesthetists' Non-Technical Skills (4 domains): -Task management -Teamwork -Situational awareness -Decision making 4-point scoring system (1=poor to 4=good): Min 1 max 16 Technical action check list (1-6 key actions)	CRNA students' non-technical skills increased from 12.7(pre-test) to 13.3(post-test) ($P<0.05$)	No significant difference by gender, age, and years of previous work experience (e.g., ICU)

2.4 Summary of the literature review

Based on the holistic approach of nursing competence, this study describes competence in anaesthesia nursing care as a combination of the necessary knowledge, attitudes, values, and skills in delivering care to patients planning, undergoing and recovering from anaesthesia. Nurses in anaesthesia care need to be experts, professionals, communicators, collaborators, managers, health advocates, and scholars in delivering anaesthesia care. There are variations in anaesthesia nursing education and the scope of anaesthesia practice which are adapted to national needs.

Competence assessment instruments (n=11) used in previous studies have assessed eight competence areas (domains) in anaesthesia nursing care: ethical values, risk management, medical technological skill, collaboration, leadership, anaesthesia nursing skill/therapeutic intervention, professional development, and knowledge. The instruments assessed nurse competence in anaesthesia nursing care by using direct observation, self-assessment, employer'/educators' assessment and a written examination. Some instruments are not sensitive enough to cover the contextual nuances of anaesthetised patient care, some measures only cover part of the competence needed in anaesthesia care (e.g., technical skills, non-technical skills, or knowledge), and some are in the beginning of instrument development. Most of the instruments lack information regarding psychometric properties. Therefore, there is a need to develop anaesthesia nursing competence instruments.

The levels of nurse competence based on self-assessment ranged between a VAS 42-81 using the NCS (0=very low to 100=very high) and 156-174 using the PPCS-R (min=0 to max=200). The technical skill levels of the nurses depended on the simulated scenarios and thus the range of levels was wide (10-92%). Most studies with nurses did not clarify what the assessment scores indicated and what levels were satisfactory/unsatisfactory or expected in the specific clinical settings. Factors related to anaesthesia nursing competence among nurses were age, length of work experience, and the level of their specialty qualification. There were a few empirical competence assessment studies conducted among nursing students. Two studies clarified what the assessment score meant; one study set scores of over 60% as an acceptable level for graduating students' overall competence and another study used a score of 7 or higher as the expected level when measuring nursing students' acute care skills.

3 Aims

The ultimate goal of this study was to develop a competence assessment scale in anaesthesia nursing care to assess nurse competence and to provide future suggestions concerning anaesthesia nursing care and the requirements of continuing nursing education.

The purpose of this study was i) to develop the Anaesthesia Nursing Competence Scale (AnestComp) for competence assessment in anaesthesia nursing care, and ii) to assess the anaesthesia nursing competence of nurses using the AnestComp.

The research questions were as follows:

Phase I Instrument development

1. What is competence in anaesthesia nursing care? (Paper I)
2. What are the psychometric properties of the AnestComp? (Paper II)

Phase II Competence assessment

3. What are the levels of self-assessed anaesthesia nursing competence of anaesthesia nurses and nursing students? (Paper III and Paper IV)
4. What factors are related to the self-assessed levels of competence of anaesthesia nurses and nursing students? (Paper III and Paper IV)

4 Materials and Methods

This chapter describes the design of the study, data gathering, data analysis, and ethical issues dealt with in the study. The study was carried out in two phases (Figure 1): instrument development (Phase I) and competence assessment (Phase II).

4.1 Design, setting, and sampling

In this chapter, the design, setting, and sampling in Phase I have been detailed step by step. Phase I followed four steps to develop the AnestComp: structuring the content of the scale, testing the content validity of the scale, pilot testing, and testing the psychometric properties of the AnestComp (Figure 2) and Phase II focused on competence assessment.

Step 1. Structuring the content of the scale (2014-2017): The content of the anaesthesia nursing competence scale was structured based on a scoping literature review (Paper I) and the descriptions of experts. The scoping literature review investigating competence assessment instruments in anaesthesia nursing care was carried out based on Cinahl, Medline, and Eric in 2015. Single and combined search terms were used: anaesthesia nursing, competence, assessment, evaluation, scale, instrument, validity, and reliability. The search covered all countries, but only those articles published in English from 1994 to 2015. Based on two researchers' independent reviewing, 13 research articles were found; competence areas assessed in previous studies were identified (Paper I).

Seven experts were then asked to describe their opinion about what competence in anaesthesia nursing competence is. The panel of experts was composed of anaesthesia nurses, nurse managers, and clinical specialists who were members of the authors of a clinical nursing book published in Finland. The average age of the panel was 50.3 years old (range 35-62) and their work experience in anaesthesia nursing care was 23.7 years (range 5-38). In January 2016, the data were collected by using an open-ended question asking about the concept of competence in anaesthesia nursing care. Based on data obtained from the scoping review and the experts' descriptions, 109 items were generated in seven competence areas. The items were subject to review by a panel of doctoral candidates in nursing science and

university researchers over several research seminars and the number of items were reduced to 40.

Step 2. Testing the content validity of the scale (2017): The preliminary 40-item AnestComp was submitted to another panel of nursing experts (anaesthesia nurses, anaesthesia nurse managers, and nurse teachers) to test the content validity in March 2017. The age of the nursing experts ranged from 39 to 54 (Mean 48 years old) and their years of experience in health care ranged from 7 to 31 years (Mean 18 years). The experts reviewed the relevance and clarity of the items by using a structured evaluation questionnaire and provided suggestions to improve content validity. The scale was developed to assess the competence of nurses in anaesthesia nursing care. Additionally, this study was designed to use nursing student data as a means of validity testing the developing scale. Therefore, the expert group including nurse teachers determined whether the scale could be applied to the nursing students. Thus, the experts reviewed not only each item in terms of the relevance to anaesthesia nursing care and the clarity but also the applicability to nursing students (Paper II).

Since anaesthesia nursing care usually follows anaesthesia care phases, the preliminary 40-item AnestComp tried to include the concept of the anaesthesia care process (pre-, intra-, and post anaesthesia phase) in each item. However, experts commented that the repeated wordings of pre-, intra-, post- might interfere with the logical flow and the relevancy of the item might be reduced due the limiting the situation. Based on the expert's review and comments, the wording repeating pre, intra-, post- was revised and one item was deleted due to duplication. Finally, the AnestComp had 39 items (Paper II).

Step 3. Pilot testing (2017): The AnestComp was pilot tested in Finland. The pilot test used convenience samples of anaesthesia nurses (n=32) at one university hospital and nursing students (n=17) at one UAS (May 2017). In this step, the AnestComp was also pilot tested in Sweden. Since this study was planned to assess Swedish nurses' competence for a Nordic country comparison; as Swedish is also an official language used in Finland, the AnestComp was translated into Swedish and pilot tested. In Sweden, the pilot testing of the AnestComp used a sample of nurse anaesthetists (n=32) at one university hospital with a paper and pencil questionnaire (December 2017). In the pilot test, respondents were asked to provide additional comments on the instrument freely; no need to modify the instrument was found from the pilot test (Paper II). After conducting the pilot test in Finland and Sweden, this study decided to focus on data collection in Finland in the next step. Because comparative studies between countries require a much more elaborate study design, it was taken into consideration that it would be too early to make comparisons in a situation where the psychometric properties of the newly developing scale have not yet been tested. Therefore, data were not collected in Sweden in Step 4.

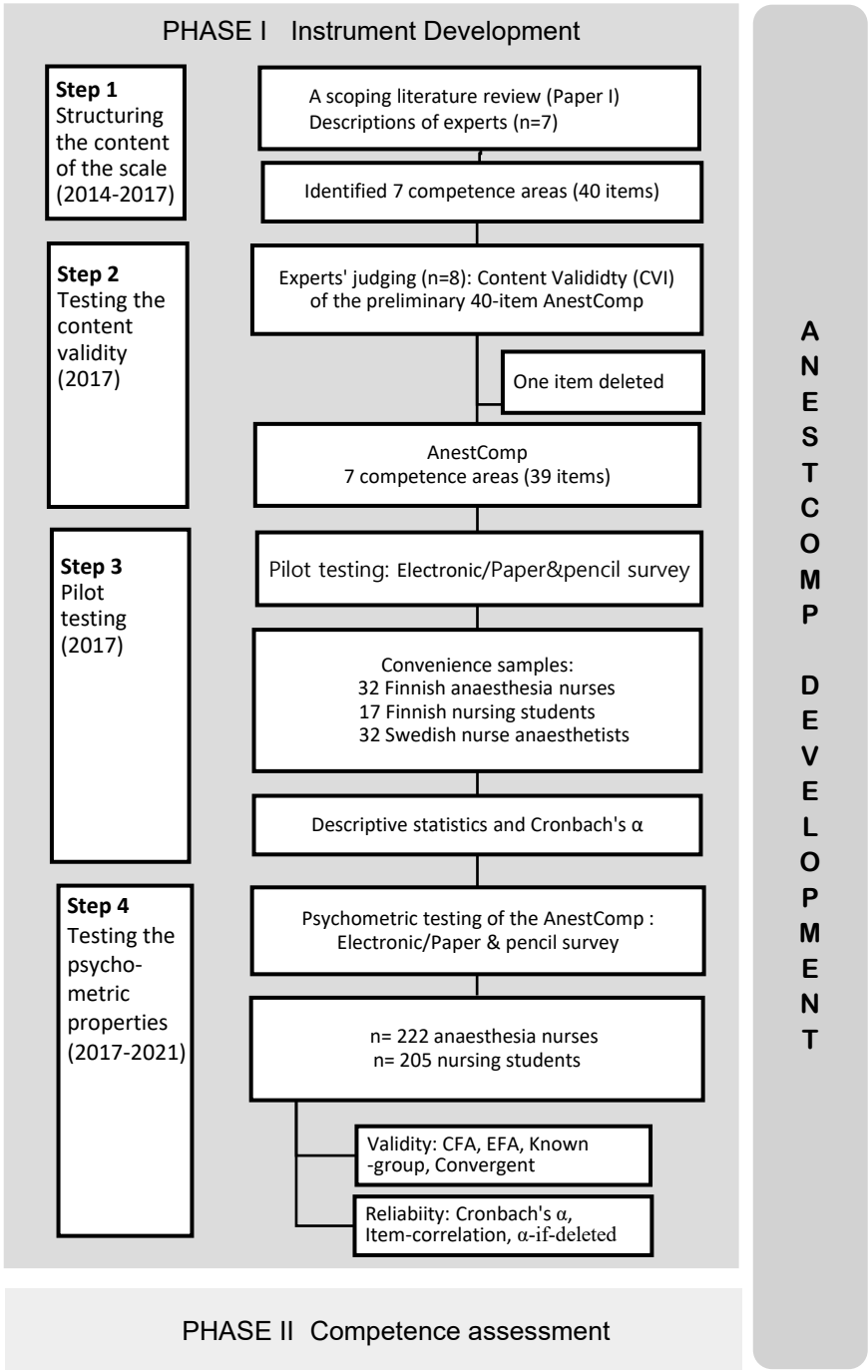

Figure 2. AnestComp development.

Step 4. Testing the psychometric properties (2017-2021): To investigate the validity and reliability of the developed scale, a cross-sectional survey was carried out. The data were collected through convenience sampling of anaesthesia nurses practising in fourteen operating room units in two university hospitals in Finland. First, data were gathered by an electronic survey in May and June 2017. The link to the electronic questionnaire (Webropol 2.0) was emailed to the nurse managers in each operation unit. Then, the nurse managers sent the link to the anaesthesia nurses (N=431). After two reminders, the response rate from anaesthesia nurses was 30.6%. In order to obtain more responses, the target samples were contacted again with a pencil and paper questionnaire in October 2017. In hospitals, the session for data collection for the survey was arranged and copies of a paper and pencil questionnaire were distributed to anaesthesia nurses with a return envelope; the copies were collected with the help of the contact person.

The data of nursing students were also collected from three UASs in the same areas where the two university hospitals are located. The contact persons (nurse teachers) forwarded the link to the nursing students (N=988) in May and June 2017. After two reminders, the students' response rate was 9% and a data collection with a pencil and paper questionnaire was also arranged. In the UASs' data collection with the paper version of the questionnaire, a return envelope was provided and collected with the help of the contact teachers. The target samples were those individuals who did not respond to the electronic survey. The nursing students who were not willing to participate in the survey were informed that they should return a blank questionnaire in the envelope. The response rate of the nurses was 52% (222/431) and the response rate of the nursing students was 21% (205/998). The data was also used to investigate the level of competence in anaesthesia nursing care in Phase II.

4.2 Instruments

In the process of the AnestComp development, several questionnaires/surveys were used in Phase I (Table 6).

1) A survey was used to obtain the experts' description of competence in anaesthesia nursing care. The survey consisted of a cover page, background information (10 questions), and an open-ended question asking their opinion: what is nursing competence in anaesthesia nursing care? The seven experts described what anaesthesia nursing competence was in the form of an essay (Step 1).

2) An electronic questionnaire with the Finnish version of preliminary 40-item AnestComp was submitted to eight experts. The questionnaire consisted of a cover page, background information questions (5 questions), the 40-item AnestComp, and two additional questions. The 40-items AnestComp was comprised of seven

subscales of anaesthesia nursing competence: ethical value (5 items), risk management (5 items), medical technological skills (5 items), collaboration (5 items), medication (5 items), anaesthesia nursing skills/intervention (10 items), and knowledge (5 items). Each subscale has one item regarding the pre-anaesthesia phase, three to eight items required in the intra-anaesthesia phase, and one item regarding the post-anaesthesia phase (Table 6).

Experts were asked to determine each item's relevance in anaesthesia nursing care (4-point scale), clarity (4-point scale), and applicability to nursing students (dichotomous). For instance, the experts evaluated how item 1 (Supporting the patient's decision-making before anaesthesia) is relevant to competence in anaesthesia nursing care from 1 to 4 (1=not relevant, 2=somewhat relevant, 3=quite relevant, 4=highly relevant), and how clear item 1 is in terms of wording (easy to understand) from 1 to 4 (1=not clear, 2=somewhat clear, 3=quite clear, 4=highly clear) and whether item 1 is a suitable question to ask for the nursing student by yes or no. Additional information was sought about a Visual Analogue Scale (VAS) and general comments for the preliminary AnestComp. The preliminary 40-item AnestComp was in English and then translated into Finnish using forward-backward translations by two professional translators; at least two translators were recommended in multiple translations (Mokkink, et al., 2012). The forward translator was Finnish and a language expert who has translation experience in nursing. The back-translator's mother tongue was English and was a professional translator in health care. They were both blind to the original version of the questionnaire. Following this, six native speaking Finnish nurses, nurse teachers, and nurse managers compared and reviewed three versions of the AnestComp translations and came to a consensus as regards the context of Finland (Step 2).

3) The AnestComp was pilot-tested in Finland and Sweden. The questionnaire pilot-tested in Finland (Finnish version) was composed of a cover page, background information questions (14 items), the 39-item AnestComp, four competence questions about anaesthesia care processes (before, induction, during, and after anaesthesia), and one general comment question. The original AnestComp (English) was translated into Swedish too. The Swedish translation also used forward-backward translations involving two professional translators who translated independently. The forward translator and back-ward translator were bilingual professional translators in Swedish and English. After independent translations, the four versions of the instrument (original English version, Finnish version, translated Swedish version, back-translated English version) were reviewed by a researcher, a Swedish-Finnish speaking anaesthesia nurse, and a back-translator. The Swedish version of the questionnaire had the same composition as the Finnish questionnaire and was pilot tested in Sweden (Step 3).

4) The electronic/paper & pencil questionnaire including the AnestComp was used by nurses. The questionnaire was composed of a cover page, background information (age, gender, work experience, educational, and role of practice), the 39-item AnestComp (VAS 0-100 mm), and four competence questions about anaesthesia care processes (*How competent are you? 1) before anaesthesia, 2)* induction phase, 3) during anaesthesia, and 4) after anaesthesia: VAS 0-10mm). The AnestComp comprised seven subscales of anaesthesia nursing competence. The subscales refer to competence areas: ethics of anaesthesia care (5 items), patient risk care (5 items), patient engagement with technology (5 items), collaboration within anaesthesia care (5 items), anaesthesia patient care with medication (5 items), anaesthesia nursing intervention (9 items), and knowledge of anaesthesia care (5 items). The instrument is designed to use a self-assessment test using a VAS from 0 to 100 (100mm). The '0' refers to "I am not competent at all" and '100' refers to "I am excellently competent". For nursing students, the electronic/paper & pencil questionnaire was composed of a cover page, background information (age, gender, credits, courses, experience of clinical practices, and preferred nursing specialty), the 39-item AnestComp, and four competence questions about anaesthesia care processes (Step 4).

4.3 Data analysis

In this study, several data analysis methods were used to develop the AnestComp in Phase I and to assess the competence of nurses in Phase II.

In Phase I, the scoping literature review used inductive content analysis. The inductive content analysis refers to data analysis from a specific code to general categories (Elo & Kyngäs, 2008). In data analysis, the specific codes referred to competence areas used in previous competence assessment instrument studies (Paper I). Eight general categories (competence areas) from the scoping literature review were identified using content analysis inductively (Appendix 2).

Research findings should be as credible as possible in terms of whether the generated findings represent the intended focus (Graneheim & Lundman, 2004). To deal with the credibility, experts' description of anaesthesia nursing competence was sought to confirm how well the categories represented anaesthesia nursing competence, and whether any data had been systematically excluded or irrelevant data included. The experts' descriptions (n=7) were first analysed as to whether those eight categories found in the scoping literature review were also found in the experts' data: from the general categories to a specific code (deductive content analysis). Six competence areas out of the eight were confirmed in the experts' description (Table 6). Then, the experts' data were inductively analysed to find out whether there were missed competence areas; one competence area was found.

Table 6. The structure of the AnestComp (Phase I).

Step1 Competence area	**Step 2** Preliminary AnestComp 40 items	**Step3** AnestComp 39 items	**Step4** AnestComp 39 items*
Ethical value [a,b]	**Ethical value** Pre-Autonomy Intra-Right to know, Advocacy, Dignity, Post-Empowerment	**Ethical value** Autonomy, Right to know, Advocacy, Dignity, Empowerment	**Ethics of anaesthesia care**
Risk management [a,b]	**Risk management** Pre-Anticipating, Intra-Identifying, Assessing, Prioritizing, Post-Evaluating	**Risk management** Anticipating, Identifying, Assessing, Prioritizing, Evaluating	**Patient risk care**
Medical technological skill [a,b]	**Medical technological skills** Pre-Equipment preparation, Intra-Monitoring data, Humanity beyond technology, Technology proficiency, Post-Anaesthesia record	**Medical technological skills** Equipment preparation, Monitoring data, Humanity beyond technology, Technology proficiency, Anaesthesia record	**Patient engagement with technology**
Collaboration [a,b]	**Collaboration** Pre-Patient involvement, Consultation, Intra-Communication, Sharedness, Post-Coordination	**Collaboration** Patient involvement, Consultation, Communication, Sharedness, Coordination	**Collaboration within anaesthesia care**
Medication competence [b]	**Medication** Pre-Planning of medication, Intra-Assessing medication, needs, Safe administration, Evaluation of drug effectiveness, Post-Documentation	**Medication** Planning of medication, Assessing medication needs, Safe administration, Evaluation of drug effectiveness, Documentation	**Anaesthesia patient care with medication**
Anaesthesia nursing skill/therapeutic intervention [a,b]	**Anaesthesia nursing skills/intervention** Pre-Anxiety, Intra-Breathing/ventilation, Blood circulation, Body temperature, Positioning, Depth of anaesthesia, Pain, Neuromuscular relaxation, Post-Pain, Nausea and vomiting	**Anaesthesia nursing skills/intervention** Anxiety, Breathing/ventilation, Blood circulation, Body temperature, Positioning, Depth of anaesthesia, Neuromuscular relaxation, Pain, Nausea and vomiting	**Anaesthesia nursing intervention**
Knowledge [a,b]	**Knowledge** Anaesthesia techniques, Anatomy, Difficult airway, Legislation, Economic efficiency	**Knowledge** Anaesthesia techniques, Anatomy, Difficult airway, Legislation, Economic efficiency	**Knowledge of anaesthesia care**
Professional development [a]			
Leadership [a]			

[a]: Competence area identified by a scoping literature review (Paper I), [b]: Competence area identified by experts'(n=7) descriptions, * Detailed items of the AnestComp can be found in Appendix 4. Pre=before anaesthesia, Intra=during anaesthesia, post=after anaesthesia.

Finally, seven competence areas were structured: ethical value, risk management, medical technological skills, collaboration, medication, anaesthesia nursing skills /intervention, and knowledge (Step 1).

The preliminary 40-item AnestComp was structured in the seven categories and the content validity of the structure of the instrument was tested by eight experts. An item content validity index (I-CVI) and a scale content validity index (S-CVI) were calculated by determining the proportion of experts that gave each item a rating of 3 or 4 (1=not relevant, 2=somewhat relevant, 3=quite relevant, 4=highly relevant). Each item I-CVI ranged 0.88-1: over 0.78 is recommended (Polit & Beck, 2006; Zamanzadeh, et al., 2015). One item (I-CVI 0.75) fell under 0.78 in terms of clarity (range 0.75-1). S-CVI refers to the inter-rater agreement (rating of 3 or 4 by all raters) and is recommended to be over 0.80 in this case (Polit & Beck, 2006; Zamanzadeh, et al., 2015). The S-CVI of relevancy and clarity were 0.98 (39/40) and 0.88 (35/40) respectively (Step 2).

The 39-item AnestComp was pilot-tested by 32 anaesthesia nurses and descriptive statistics and Cronbach's alpha values were calculated by using IBM SPSS statistics version 22.0 and 25.0. The Cronbach's alpha values for the summed variables ranged from 0.62-0.91. The overall competence of the anaesthesia nurses was a VAS of 87 (range 73-99). The responses are considered to have an adequate variance. Additional information about the pilot test of nursing students and Swedish nurse anaesthetists can be found in Appendix 3 (Step 3).

The psychometric properties (validity and reliability) of the AnestComp were tested. Data were analysed statistically with IBM SPSS statistics version 22.0 and 25.0 (IBM Corp., Armonk, NY) and a Lavaan package in R version 3.5.0. The validity testing of this step focused on the construct validity of the scale: confirmatory factor analysis (CFA), exploratory factor analysis (EFA), known-group validity, and convergent validity. 1) CFA tested the theoretical model fit of the seven factors (competence areas) of the AnestComp (see Figure 1 in Paper II). An acceptable model fit referred to three criteria: the ratio of chi-squares to the degree of freedom ($\chi 2/DF \leq 3$), the Comparative Fit Index ($CFI \geq 0.90$) and the Standardised Root Mean Residual ($SRMR \leq 0.08$) (Schreiber, et al., 2006). 2) An EFA was tested in the condition of a fixed-seven factor and maximum likelihood estimation with oblique rotation. 3) The known-group validity was tested with the hypothesis that the levels of competence of nurses would be higher than those of nursing students. The hypothesis was tested by the Mann-Whitney U-test. 4) For the convergent validity between the AnestComp and the four-item anaesthesia care process questions, Pearson's correlation was used (Recommended $r > 0.6$) (DeVon, et al., 2007; Hair, et al., 2014) (Step 4).

For the reliability analysis, Cronbach's alpha, the corrected item-subscale correlation (recommended $0.3 < r < 0.7$), and the α if-item-deleted were calculated

in subscales. For a new instrument, a Cronbach's alpha estimate of over 0.7 is recommended (Polit & Hungler, 1995; DeVon, et al., 2007) (Step 4).

In the phase of the competence assessment (Phase II), the descriptive statistics (frequencies, percentage, mean, median (MDN), standard deviation (SD) interquartile range (IQR), and range) were calculated. The mean scores of the sum variables provided information about competence levels. The acceptable score level might differ in different nursing contexts due to educational levels, organisations, or countries. To describe the levels of anaesthesia nursing competence of anaesthesia nurses in this study, a VAS score of 80 was tentatively defined as an expected level of anaesthesia nursing competence for nurses. A VAS score of 60 was considered a target level for graduating students. The criteria of a VAS of 80 and a VAS of 60 correspond to a score of 8 (good) and 6 (passable) as exemplified in the European Higher Education Area (EC, 2015). In order to identify factors related to anaesthesia nursing competence, inferential statistics (correlation, one-way analysis of variance (ANOVA), Mann-Whitney U-test, and independent T-tests) were used.

4.4 Ethical considerations

This study has followed the ethics for researchers (EC, 2013b), the ethical principles for medical research (WMA, 2013), and the ethical guidelines of the Finnish Advisory Board of Research Integrity (TENK, 2012). This study was approved by the ethical committee of the University of Turku (statement 25/2017, 3rd of May 2017). For the summary, the ethical principles of the study were confirmed by the most recent guidelines in Finland (TENK, 2019). This study did not include vulnerable subjects. The subjects in the study were all adults and were not at significant risk of harm from participating in the study.

In Phase I, the studies used in the scoping literature review (Paper I) were publicly available data. Thus, ethical permission or consent to use the data were not required. During the scoping literature review, all processes followed the ethical guidelines presented in the systematic literature review (CRD, 2009; Aveyard, 2010).

The panel of nursing experts who were authors of a clinical nursing book were contacted via email with the link to the electronic survey; the contact information was publicly available in the nursing book. They were clearly informed of the purpose of the study, the benefit of their participation in the study from the perspective of anaesthesia nursing care, the voluntary basis, the anonymity, and the confidentiality of their participation (Step 1).

Another panel of nursing experts was also required; this panel included persons with over 5 years of clinical work experience in anaesthesia nursing care and nurse teachers who were in charge of perioperative nursing education. The persons who met the criteria for the panel were found based on the researcher's own expertise and

knowledge in the field of anaesthesia nursing care. The researcher informed potential participants about the study verbally or electronically in advance. Then, the participants were emailed the internet link to the electronic questionnaire and written documentation addressing the purpose of the study, the voluntary participation, anonymity, confidentiality, and the right to decline participation (Step 2).

Research permission for an electronic survey to collect data from anaesthesia nurses were obtained from two University hospitals in Finland (235/2017, 26th of April 2017 and 005/17 27th of April 2017). Research permission for a pilot test (a paper and pencil survey, AnestComp-Swedish version) for Swedish nurse anaesthetists was obtained from the head of the operation unit at their University hospital in Sweden (18th of April 2017). On the foundation of Swedish national legislation and directives, research permissions granted by an ethical committee was not needed in Sweden unless it was an intervention study or sensitive information was obtained (Swedish-Constitution, 2003:460). To gather data electronically from nursing students, the directors of three UASs granted permission (3rd of April 2017, 5th of April 2017, and 20th of April 2017). Additional confirmation for a paper and pencil survey was made from each hospital and the UASs (Step3 and Step4).

In Phase II, the data collected from anaesthesia nurses (14 operating rooms in two university hospitals) and nursing students (three UASs) were used to assess anaesthesia nursing competence. Contact information was obtained concerning the nurse managers of the fourteen operating rooms while processing the research permission at the two university hospitals. The researcher contacted each nurse manager and provided the study information. Subsequently, the link to the electronic questionnaire was sent to the nurse managers who forwarded the link to their anaesthesia nurses. In addition, data from anaesthesia nurses were gathered by paper and pencil questionnaire with the help of the nurse managers.

Data from the nursing students (electronic/paper and pencil questionnaire) were collected with a help of three contact teachers in three UASs. Arrangements with the contact teachers were made while processing the research permission with the UASs. The researcher then provided each contact teacher with the study information and the link to the electronic questionnaire. Additional sessions were arranged to collect a paper and pencil questionnaire with the help of the contact teachers.

The participation of nurses and nursing students in the study was anonymous, of a voluntary nature, and subject to confidentiality. The cover page of the electronic/paper and pencil questionnaires stated the nature of the study; the researcher's contact information was also provided on the questionnaire. Returning the form and questionnaires was considered as giving consent to participation in the study.

The anonymity and confidentiality of the participants were protected by not linking their email address and using a collecting box for paper and pencil

questionnaires. All the data were handled confidentially, and no names or identification of the participants were published in any written form. All electronic data are saved using protected passwords and the paper material from the study is currently stored anonymously in safe storage. Only the researcher of this study can access them. The retention of the data for appropriate periods will be determined based on future studies (e.g., a cross-country study of anaesthesia nursing competence assessment). Once the period of retention has been decided and expired, the data will be disposed of securely in an appropriate manner.

5 Results

In this chapter, the results of the two-phase study are presented by the research questions. First, the concept of competence in anaesthesia nursing care (research question 1) that became the structure of the anaesthesia nursing competence scale is described (Paper I). Second, the psychometric properties of the developed instrument (research question 2) are presented (Paper II). Third, the levels of anaesthesia nursing competence for anaesthesia nurses (research question 3) are mainly described (Paper III). This is followed by additional results of the levels of anaesthesia nursing competence of graduating nursing students (Paper IV). Lastly, factors related to the competence of nurses (research question 4) are explained and then the graduating student's results are added (Paper III and Paper IV). The main results of the scoping literature review (Paper I) were included in Chapter 2.2.

5.1 Competence in anaesthesia nursing care

Competence in anaesthesia nursing care is a multi-dimensional conception comprising of seven competence areas. As a result of the scoping literature review (Paper I) and the experts' descriptions, the competence areas needed in anaesthesia nursing care were structured. The structure of the competence areas was verified in the empirical study with the data from the nurses (Paper II). The competence areas in anaesthesia nursing care illustrated in the diagram in Figure 3.

In anaesthesia nursing care, patients usually go through four phases in the anaesthesia care process (before anaesthesia, anaesthesia induction, during anaesthesia, and after anaesthesia). For anaesthesia care of a patient experiencing a sedated/anaesthetised status through these four phases, the competence required in anaesthesia nursing care includes seven competence areas (domains): ethics of anaesthesia care, patient risk care, patient engagement with technology, collaboration within anaesthesia care, anaesthesia patient care with medication, anaesthesia nursing intervention, and knowledge of anaesthesia care.

Ethics of anaesthesia care refers to a competence area which involves taking care of a patient in anaesthesia care ethically; this means viewing the patient as a unique human being. Since patients in anaesthesia care are mostly unable to make their own decisions because of the effects of anaesthesia, ethics (autonomy, patient's

right to know, advocacy, dignity, and empowerment) is an essential competence area.

Patient risk care refers to a competence area which involves predicting and preventing risk factors in anaesthesia patient care. It includes anticipating any potential risk to the patient, and identifying, assessing, and correcting deviations from the patient's normal condition.

Patient engagement with technology refers to a competence area which encompasses the connection between the nurse and the patient. In anaesthesia nursing care, the connectedness is altered through the mediation of the technological support. Being authentically connected with the patient relies on the nurse's competence to utilise the anaesthetic machines/technical equipment and to monitor the patient's parameters.

Collaboration within anaesthesia care refers to a competence area which consists of shared decision-making by facilitating the participation of the patient and significant others in the patient's care. Since patients might not be able to participate in decision makings during most of the anaesthesia care, it is important to consult, communicate, share relevant information and coordinate appropriately with the OR team members for the best care for the patient and their well-being.

Anaesthesia patient care with medication refers to a competence area in which evaluation of the patient's need for medication, the safe delivery of the medication, and documenting this in the right manner is attained. This ability has been emphasised in anaesthesia nursing care because anaesthetic drugs, as well as many other types of drugs, are frequently used, and medication errors may lead to serious situations.

Anaesthesia nursing intervention refers to a competence area that is comprised of supporting a conscious patient to feel comfortable/safe and maintaining the intubated patient's conditions and needs. During all the phases of the anaesthesia process, anaesthesia nursing care requires integrated intervention skills regarding the patient's ventilation, circulation, temperature, positioning, depth of anaesthesia, neuromuscular relaxation, pain, and postoperative nausea and vomiting.

Knowledge of anaesthesia care refers to a competence area based on theoretical knowledge and clinical learning experiences related to the practice of anaesthesia patient care. Anaesthesia nursing care requires relevant knowledge about anaesthesia nursing and medicine such as techniques for various types of anaesthesia care, anatomy and physiology, difficult airway management, and legal and resource allocation in the anaesthesia care process.

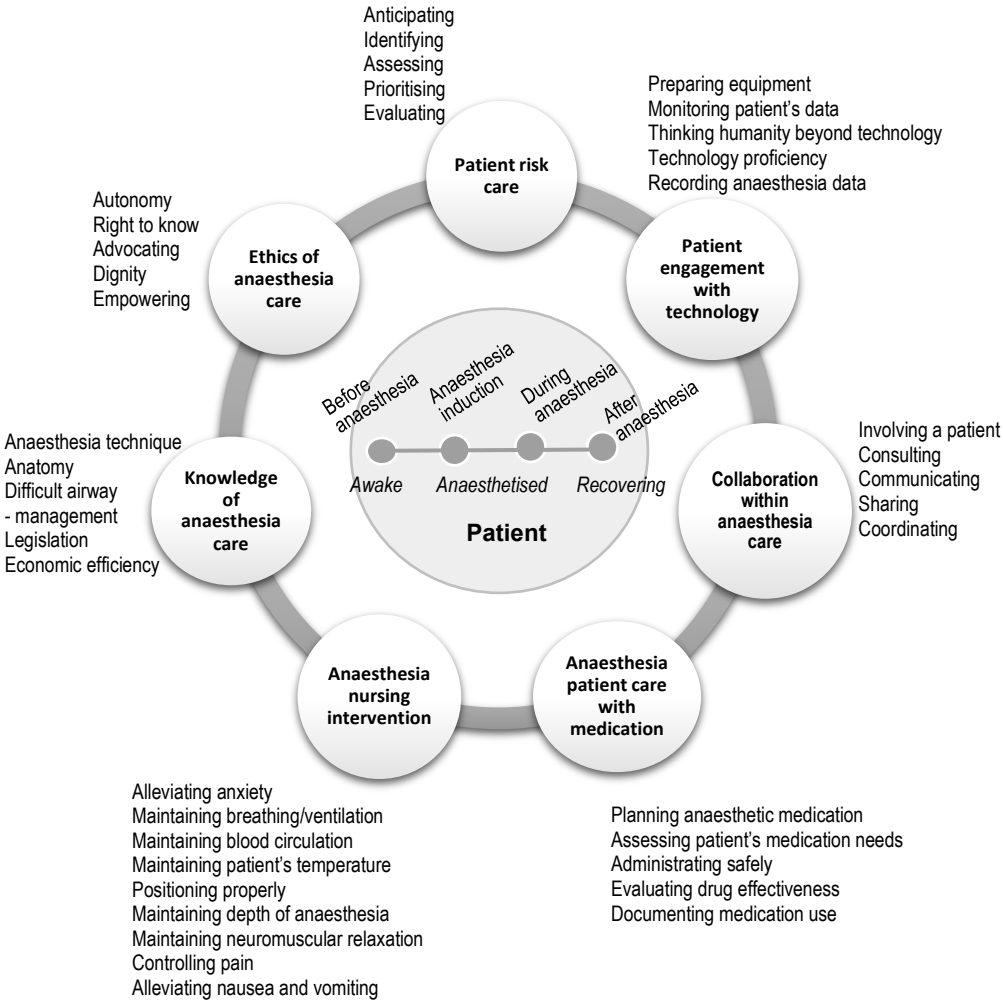

Figure 3. Competence in anaesthesia nursing care.

5.2 The psychometric properties of the Anaesthesia Nursing Competence Scale (AnestComp)

In this study, the AnestComp was developed through several psychometric testing methods. The results of the psychometric properties are presented in Table 7. Based on the results, the AnestComp seems to be a promising instrument for assessing competence in anaesthesia nursing care (Paper II).

Table 7. Instrument development and psychometric testing of the AnestComp.

Anaesthesia Nursing Competence Scale (AnestComp)			
Purpose of measurement	To assess competence in anaesthesia nursing care		
Target population	Nurses in anaesthesia nursing care		
Assessment method	Self-assessment		
7 Domains (39 items)	Ethics of anaesthesia care (5) Patient risk care (5) Patient engagement with technology (5) Collaboration within anaesthesia care (5) Anaesthesia patient care with medication (5) Anaesthesia nursing intervention (9) Knowledge of anaesthesia care (5)		
Scoring	Visual Analogue Scale (0-100mm): 0=Not competent at all, 100=excellently competent		
Instrument Development			
Validity	**Method**	**Details/results**	**Analysis/ Accepted standard**
Face Validity	A scoping literature review	Competence areas described in previous studies	Content analysis
	Experts' opinion	Competence described by experts (n=7): authors of a clinical nursing book	Content analysis
Content Validity	Content Validity Index (CVI)	Expert panel n = 8 Content Validity Index (CVI): 1=not relevant, 2=somewhat, 3=quite, 4=highly relevant (Proportion rated as 3 or 4) Relevancy: Mean I-CVI =0.99, S-CVI =0.98 Clearance: Mean I-CVI=0.98, S-CVI = 0.88	Electronic questionnaire Mean I-CVI > 0.78, S-CVI > 0.80 (Polit & Beck, 2006)
	Pilot testing	Period: April 2017 N=32 Finnish nurses Cronbach's α (range of seven domains): 0.62-0.91	39 item-AnestComp Cronbach's α > 0.7 (DeVellis, 2012)

Testing the psychometric properties of the AnestComp			
	Period	Sample (RR)	Survey
Data Collection	May-Oct 2017	N=222 anaesthesia nurses (RR=52%)	AnestComp Electronic/Paper & pencil survey
Validity	**Method**	**Details/results**	**Accepted standard**
Construct validity	CFA	χ2/DF = 3.28 CFI = 0.82 SRMR = 0.06 Factor loading range: 0.60-0.93	χ2/DF ≤ 3 CFI ≥ 0.90 SRMR≤0.08 Factor loadings > 0.50 (Schreiber, et al., 2006)
	EFA	7-factor solution Cumulative variances 86.7% Factor loadings range 0.21-0.95	Factor loadings > 0.40 (Williams, et al., 2010)
	Known-group validity [a]	Mann-Whitney U test: Nurses' competence levels were significantly higher than nursing students' in all items, domains, and overall (P<0.001)	Nurses' competence > Nursing students' competence (McHugh & Lake, 2010)
	Convergent validity	Correlation with four competence questions in anaesthesia care process (before, induction, during, and after) r=0.74 (P<0.01)	r > 0.6 (DeVon, et al., 2007)
Reliability	**Method**	**Domains/results**	**Accepted standard**
Internal consistency reliability	Cronbach's alpha coefficient	Ethics of anaesthesia care 0.84 Patient risk care 0.94 Patient engagement with technology 0.85 Collaboration within anaesthesia care 0.83 Anaesthesia patient care with medication 0.93 Anaesthesia nursing intervention 0.95 Knowledge of anaesthesia care 0.88	α > 0.70 (DeVon, et al., 2007)

[a]: Nursing students(n=205) were used as a comparison group (Paper II).

Construct Validity of the AnestComp

With data from anaesthesia nurses (n=222), the AnestComp was statistically tested for the construct validity of the seven-structure model (seven competence areas): CFA, EFA, known-group validity and convergent validity.

CFA: Among the three criteria for acceptable model fitness indexes, the overall model fit of the AnestComp was supported by the SRMR fitness index with a value of 0.06 (recommended SRMR≤0.08). The ratio of chi-squares to the degree of freedom ($\chi 2/DF$) was 3.28 (recommended $\leq$ 3) and the CFI was 0.82 (recommended $\geq$ 0.90); however, these two indexes were out of the acceptable range. Each item in the corresponding subscale showed a high factor loading (see Table 3 in Paper II).

EFA: In addition to CFA, the result of a fixed seven factor EFA showed 86.7% of the total variance (see Table 4 in Paper II). Most items of the seven-factor solution in the EFA were well-loaded when compared to the theoretical structure of the AnestComp. However, there were items which were loaded to other structures or cross-loaded: item 1, 12, 13, 16, 21, 26, 31, 32, and 34.

Known-group validity: This tests the capability of the AnestComp to distinguish between two groups. The hypotheses were stated a priori to determine the known-group validity, these were; that the anaesthesia nurses' self-assessed overall anaesthesia nursing competence would be higher than nursing students'; the anaesthesia nurses' self-assessed anaesthesia nursing competence in each competence area would be higher than the nursing students. The results supported the hypotheses that the levels of self-assessed competence of anaesthesia nurses (Mean 87.5, SD 9.0) were significantly higher than those of nursing students (Mean 59.1, SD 16.6) in overall competence as well as in each competence area and each item (Appendix 4). The construct validity of the AnestComp was supported by the result of the known-group validity.

Convergent validity: The overall scores assessed by the AnestComp (VAS 87.5, SD 9.0) were correlated significantly with the overall scores (VAS 88.8, SD 10.4) assessed by four competence questions about anaesthesia care processes ($r=0.74$, $p< 0.01$): before anaesthesia (Mean 88.7, SD 11.3), induction phase (Mean 89.3, SD 11.9), during anaesthesia (Mean 88.1, SD 12.8), and after anaesthesia (Mean 89.2, SD 11.3). The overall competence levels of the AnestComp were almost at the same levels as the results of the anaesthesia care processes. The correlations between the two measurements supported the construct validity of the AnestComp (recommended $\geq$ 0.6) (DeVon, et al., 2007; Hair, et al., 2014).

Reliability

The results based on Cronbach's alpha estimates represented good consistency. The Cronbach's alpha estimate is recommended to be over 0.7 for a new scale (DeVon, et al., 2007; DeVellis, 2012). The alphas in the seven subscales satisfied the recommended level (range 0.83-0.95). The corrected item-subscale correlation were between 0.56 and 0.89 (recommended $0.3<r<0.7$) (see Table 2 in Paper II). The results of α-if-item-deleted indicated that the removal of items would not considerably improve the α values in the subscales except item 15 (Appendix 5).

5.3 Self-assessed anaesthesia nursing competence

In this chapter, the results of the self-assessed anaesthesia nursing competence of the nurses (n=222) are reported (Paper III). In addition, the graduating nursing students' data (n=86) used for construct validity are also addressed (Paper IV)

The mean age of the anaesthesia nurses was 42 years old (range 23-62) (Table 8). The average work experience of nurses was 13 years in anaesthesia nursing (range 0.1-38). In this study, 8% of the nurses (n=18) had under two years of work experience and 15% (n=33) had over 25 years of work experience.

The level of anaesthesia nursing competence was self-assessed with a VAS (0-100 mm). Based on the criteria used in the European Higher Education Area (EC, 2015), VAS 80 was tentatively set as the expected level of anaesthesia nursing competence for nurses. About eighty percent (82%) of anaesthesia nurses assessed their competence as over a VAS of 80 (an expected level), 16% as a VAS between 60-80, and 2% as under a VAS of 60 (Figure 4). Anaesthesia nurses self-assessed their overall level of anaesthesia nursing competence as VAS 87.5 (SD 9.0). The highest competence area for the anaesthesia nurses was collaboration within anaesthesia care (Mean 92.1, SD 7.7) and the lowest competence area was knowledge of anaesthesia care (Mean 79.0, SD 14.7) (Table 9).

The mean age of the graduating nursing students was 28 years old (range 21-51). Graduating nursing students had 2.3 years of work experience in health care (range 0-20) and had completed 190 ECTS (range 180-215) (Table 8). About half (49%) of the graduating students assessed their competence as over VAS 60 (a target level at the point of graduation): 51% as under 60 (Figure 4). Approximately 13% of the graduating students self-assessed their competence as over VAS 80. Graduating nursing students self-assessed their overall anaesthesia nursing competence as a VAS of 59.1.

Table 8. Sample characteristics (Paper III and Paper IV).

		Graduating nursing student (n=86)		Anaesthesia nurses (n=222)	
		N	**%**	**N**	**%**
Age group	<30	61	71.8	29	13.1
	30-39	17	20.0	64	29.0
	40-49	4	4.7	73	33.0
	50-59	3	3.5	43	21.7
	60<	0	0	7	3.2
Gender	Female	70	82.4	191	86.0
	Male	15	17.6	31	14.0
Work experience in anaesthesia nursing	< 2.0	N/A	N/A	18	8.1
	2.0-4.9			32	14.4
	5.0-9.9			44	19.8
	10.0-14.9			44	19.8
	15.0-24.9			51	23.0
	25.0 <			33	14.9
Education	Nursing certificate	N/A	N/A	70	31.5
	Bachelor's degree			139	62.6
	Master's degree			13	5.9
	Doctoral degree			-	0
Specialised anaesthesia nursing education [a]	Yes	N/A	N/A	96	43.2
	No			126	56.8
Continuing education (yearly) [b]	None	N/A	N/A	55	24.8
	1-2days			103	46.4
	3-4days			46	20.7
	Over 5days			18	8.1
Role of practice [c]	A	N/A	N/A	54	24.4
	A + R			114	51.6
	A + R + I			53	24.0
Anaesthesia courses taken	Yes [d]	76	90.5	N/A	N/A
	No	8	9.5		
Clinical placement in anaesthesia	Yes [e]	35	40.7	N/A	N/A
	No	51	59.3		
Preferred nursing speciality	Perioperative nursing	21	24.4	N/A	N/A
	Critical care nursing	14	16.3		
	Psychiatric nursing	7	8.1		
	Internal medicine	6	7.0		
	Paediatric nursing	5	5.8		
	Home care nursing	1	1.2		
	Other	11	12.8		
	No answer	21	24.4		

[a]: Post-registration (Supplementary) nursing education: Duration 1-2 years. 30-60 credits.

[b]: Occasional education such as seminars or conferences.

[c]: A=anaesthesia nurse, R=Recovery room nurse, I=instrumentation nurse (Scrub & Circulating).

[d]: Mean anaesthesia courses taken in nursing school 6.4 ECTS (range 1-20).

[e]: Mean durations of clinical placement 4.5 weeks (range 1-14).

N/A: Not applicable.

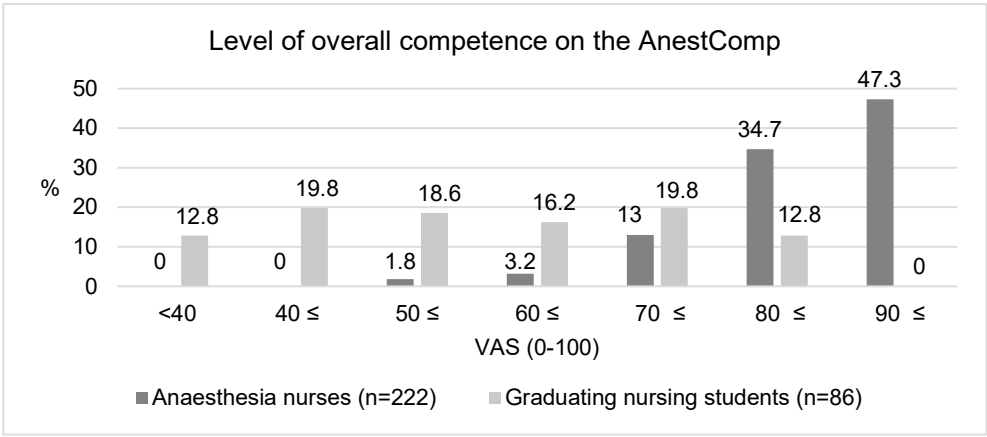

Figure 4. Distributions of the self-assessed overall competence.

The highest and lowest competence area of the graduating students were in the same areas as those reported by the anaesthesia nurses; the highest competence area was 'Collaboration within anaesthesia care' (Mean 72.5, SD 18.4) and the lowest competence area was 'knowledge of anaesthesia care' (Mean 43.3, SD 20.9) (Table 9). Among the competence areas, the graduating students achieved over the target levels in five competence areas but did not reach target levels in two competence areas: patient risk care and knowledge of anaesthesia patient care.

Table 9. Level of competence by the AnestComp: Mean (SD).

Competence areas	Graduating nursing student n=86	Anaesthesia nurse n=222	Anaesthesia nurse group by years of work experience					
			< 2 n=18	2-4.9 n=32	5-9.9 n=44	10-14.9 n=44	15-24.9 n=51	>25 n=33
Ethics of anaesthesia care***	63.0 (15.9)	84.4 (11.2)	77.4 (13.4)	79.9 (12.1)	83.5 (11.5)	85.9 (10.3)	87.4 (10.8)	87.7 (9.1)
Patient risk care***	51.1 (19.4)	82.8 (12.5)	67.4 (17.3)	77.0 (11.5)	82.7 (13.1)	85.1 (9.1)	86.8 (10.3)	88.2 (7.5)
Patient engagement with technology***	62.4 (17.8)	90.3 (9.0)	80.2 (10.4)	87.5 (8.9)	90.7 (8.9)	91.9 (7.6)	92.1 (9.2)	93.8 (5.2)
Collaboration within patient care***	72.5 (18.4)	92.1 (7.7)	84.3 (11.0)	91.4 (7.2)	91.9 (6.9)	93.1 (6.5)	93.6 (7.9)	93.9 (6.1)
Anaesthesia patient care with medication***	61.2 (20.0)	90.6 (8.8)	79.6 (12.6)	88.5 (7.8)	91.0 (6.4)	92.3 (7.8)	92.6 (8.8)	92.3 (7.3)
Peri-anaesthesia nursing intervention***	60.0 (20.5)	90.9 (8.8)	79.1 (13.1)	88.5 (9.7)	90.9 (7.3)	92.3 (6.7)	93.3 (7.9)	94.3 (5.0)
Knowledge of anaesthesia patient care***	43.3 (20.9)	79.0 (14.7)	65.4 (13.1)	69.6 (16.7)	81.2 (13.4)	79.4 (14.2)	82.6 (13.1)	86.3 (8.8)
Overall***	59.1 (16.6)	87.5 (9.0)	75.9 (11.8)	83.8 (8.7)	87.7 (7.4)	88.7 (7.3)	90.1 (8.6)	91.1 (5.8)

***: p<0.001 Group differences between the graduating nursing student group(n=86) and the anaesthesia nurse group (n=222) by the Mann-Whitney U-test.

5.4 Factors related to self-assessed anaesthesia nursing competence

The overall levels of anaesthesia nursing competence for anaesthesia nurses associated positively with age (r=0.31, p<0.001), work experience in anaesthesia nursing (r=0.33, p<0.001) and completion of a specialised anaesthesia nursing education (r=0.24, p<0.001). The mean differences across the seven competence areas in relation to work experience in anaesthesia nursing care showed that the longer work experience the higher competence level in the self-assessment. Anaesthesia nurses with a specialised anaesthesia nursing education reported higher competence levels in seven competence areas than those who did not have a specialised anaesthesia nursing education (see Table 4 in Paper III).

In Figure 5, the levels of anaesthesia nursing competence were showed with the groups categorised by work experience: under 2 years, 2-4.9 years, 5-9.9 years, 10-14.9 years, 15-24.9 years, and over 25 years. Nurses under 2 years' work experience had a mean difference with all the other groups (p<0.001) and no mean differences were found among nurse groups with over 5 years of work experience.

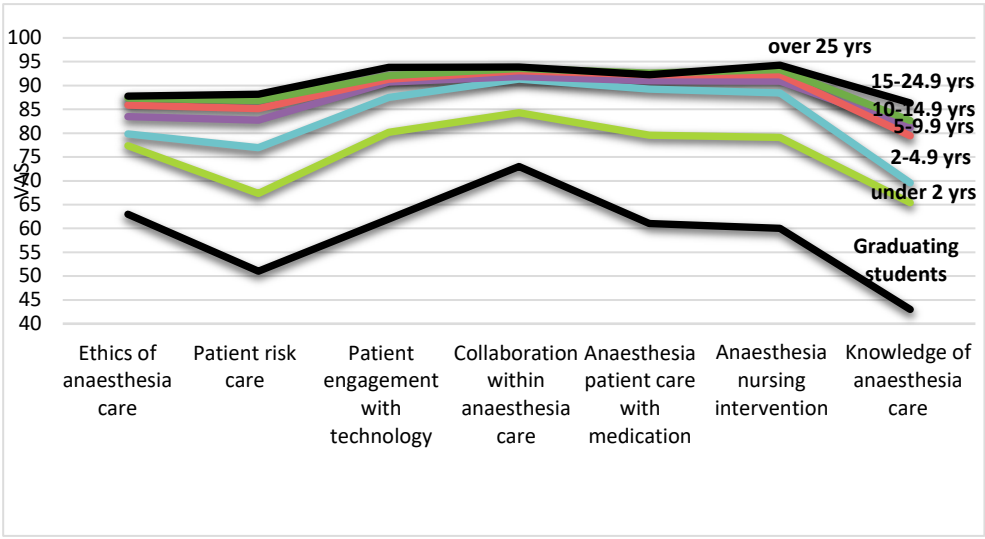

Figure 5. Competence levels by work experience.

The overall level of competence of graduating nursing students associated positively with clinical placement in anaesthesia nursing care (Yes/No, p<0.001) (Paper IV). The level of competence of nursing students with the experience in clinical placement was significantly high when compared with the level of competence of nursing students without the experience of clinical placement (Table 10).

Table 10. Factor related to anaesthesia nursing competence.

	Graduating nursing students	Anaesthesia nurses
Age <30 30-39 40-49 50-59 60<	• No correlations between competence and age†	• Correlation r=0.31, p<0.001) † Ethics of anaesthesia care (p=0.03), Patient risk care (p<0.001), Patient engagement with technology (p<0.05), Anaesthesia patient care with medication (p=0.05), Peri-anaesthesia nursing intervention (p<0.001), knowledge of anaesthesia patient care (p<0.001).††
Gender Female Male	No differences†††	No differences†††
Work experience in anaesthesia nursing < 2.0 2.0-4.9 5.0-9.9 10.0-14.9 15.0-24.9 25.0 <	N/A	• Novice nurses (<2yrs of work experience) and nurse group with 2-4.9yrs self-assessed their competence to be lower than experienced nurse groups (over 5yrs) in all competence areas (p<0.001).†† • No differences within experienced groups with over 5yrs††
Education level Nursing certificate Bachelor's degree Master's degree	N/A	• Nursing certificate group self-assessed their competence in five competence areas to be higher than other groups††: Ethics of anaesthesia care (p=0.15), Patient risk care (p<0.002), Patient engagement with technology (p=0.026), Peri-anaesthesia nursing intervention (p<0.017), knowledge of anaesthesia patient care (p<0.001) †† • No differences within other groups††
Specialised anaesthesia nursing education (Post-registration programme 30-60 ECTS) Yes No	N/A	The nurses with specialised anaesthesia nursing education self-assessed their competence as being significantly higher than those without in all competence areas: ††† Ethics of anaesthesia care (p<0.001), Patient risk care (p<0.001), Patient engagement with technology (p=0.008),Collaboration within patient care (p=0.043),

		Anaesthesia patient care with medication (p=0.018), Peri-anaesthesia nursing intervention (p=0.005), Knowledge of anaesthesia patient care (p<0.001) †††
Continuing education (e.g., seminars or conferences) None 1-2days 3-4days Over 5days	N/A	No differences ††
Role of practice [a] A A + R A + R + I	N/A	No differences ††
Anaesthesia courses taken Yes No	No differences†††	N/A
Clinical placement in anaesthesia nursing care Yes No	Graduating students with clinical placement in anaesthesia nursing care self-assessed higher than those without in six competence areas(p<0.001) and Knowledge of anaesthesia patient care(p=0.008) †††	N/A
Preferred nursing speciality	No differences††	

†: Pearson's correlation.
††One-way ANOVA; significant difference in Bonferroni post-hoc comparisons.
†††: Independent sample T-test.
[a]: A=anaesthesia nurse, R=Recovery room nurse, I=instrumentation nurse (Scrub & Circulating).
N/A: Not applicable.

5.5 Summary of the results

The first phase of the study described competence in anaesthesia nursing care (Paper I) and tested the psychometric properties of the AnestComp (Paper II). The second phase assessed the anaesthesia nursing competence of nurses and identified factors related to their competence (Paper III). Additionally, this study reported the anaesthesia nursing competence of graduating nursing students together with related factors (Paper IV). The main results of this study are summarised in Figure 6.

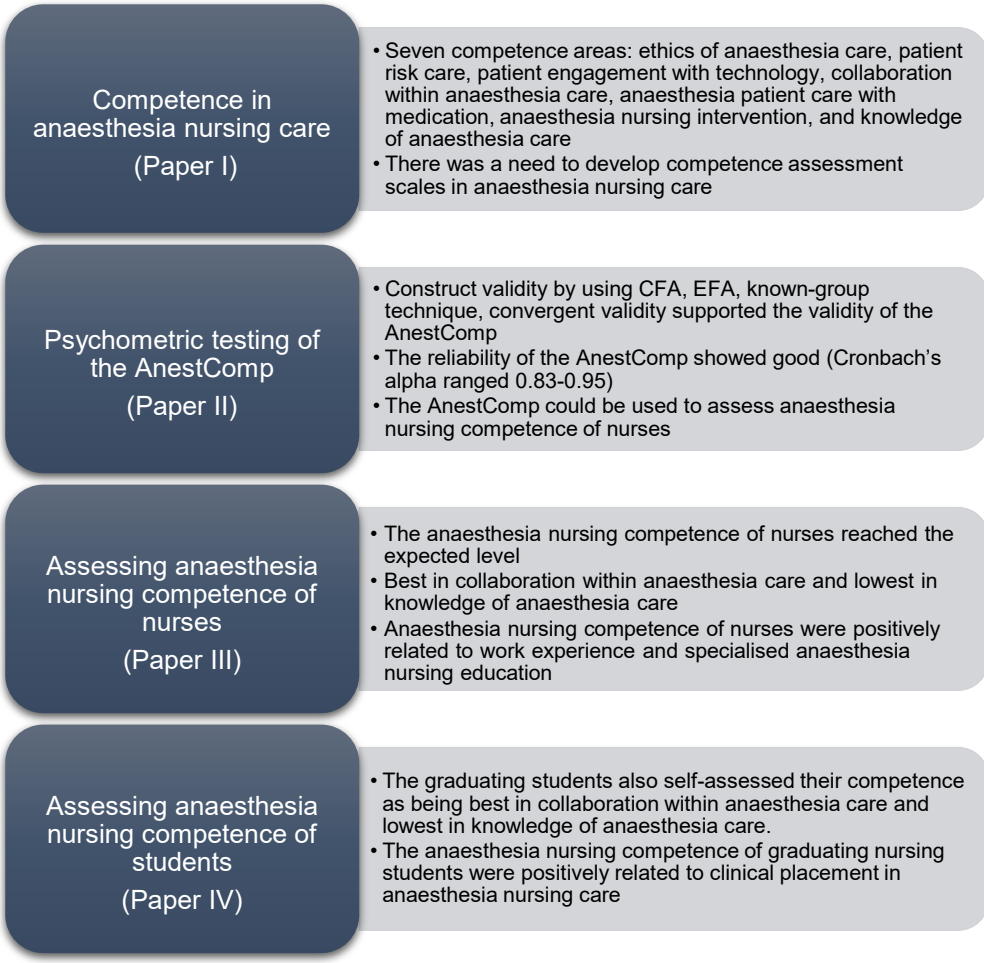

Figure 6. Summary of the main results.

6 Discussion

This study aimed to develop an Anaesthesia Nursing Competence Scale (AnestComp) for competence assessment in anaesthesia nursing care (Phase I) and to assess the anaesthesia nursing competence of nurses using the AnestComp (Phase II). In the discussion, the main results of the study, the validity and reliability of the study, and suggestions for further research are presented. More detailed discussion can be found in the original studies (Paper I - IV).

6.1 Discussion of main results

In current anaesthesia nursing care, there are many challenges related to the rapidly increasing surgical patient population and the growing number of anaesthesia patients with complex health condition (Meara, et al., 2015; Shrime, et al., 2015; WHO, 2019; Gabbard & Smith-Steinert, 2021).

Worldwide, there are variations in the scope of anaesthesia nursing care between highly trained nurse anaesthetists practising independently and trained health professionals assisting anaesthesiologists; these differences also account for the variations in education (Jeon, et al., 2015; Flynn, et al., 2017; Herion, et al., 2019). It is necessary to ensure the competence of nurses to sustain the goals of high quality in anaesthesia patient care (Riddle, et al., 2016; Flynn, et al., 2017). Following the initial licensure or certification, evaluating whether the competence levels of nurses are sufficiently competent when providing anaesthesia care has become an especially important key topic (Riddle, et al., 2016). In such a challenging anaesthesia care environment, psychometrically sound and easily usable instruments to assess nurses' competence are needed.

Previous competence assessments in anaesthesia nursing care have mostly used a simulation environment (Henrichs, et al., 2009; Gabriel, 2013; Robertson, et al., 2014; Wunder, 2016; Lyk-Jensen, et al., 2016; Flynn, et al., 2017). However, this type of simulation-based assessment is difficult for nurses to initiate for themselves. It is beneficial that there are instruments by which nurses can self-evaluate their competence from the perspective of anaesthesia nursing care. In addition, nurse managers or colleague nurses could assess the anaesthesia nursing competence of a nurse; this might help to improve the professional development of nurses.

Similar to the NCS developed to assess the competence of practising nurses regardless of their nursing specialties (Meretoja, et al., 2004; Istomina, et al., 2011; Meretoja & Koponen, 2012; Greenfield, et al., 2014; Flinkman, et al., 2017) and the PPCS-R developed to assess perioperative nursing competence including various roles in the operating room (Gillespie, et al., 2012; Gillespie & Pearson, 2013; Gillespie, et al., 2018; Falk-Brynhildsen, et al., 2019), this study has pursued the development of a scale, the AnestComp, that can be used by any nurses providing anaesthesia care to patients; it is a generic instrument of anaesthesia nursing care embracing various anaesthesia care settings. The initial results of the psychometric testing supported the AnestComp and led to it being considered a relatively valid and promising competence assessment scale for nurses in anaesthesia care; however, further validation and testing has been proposed to improve the limitations of the psychometric properties.

6.1.1 Competence in anaesthesia nursing care

The first of the main results of the study was the conceptualisation of competence in anaesthesia nursing care. Based on a concept of nursing competence viewed from a holistic perspective (McMullan, et al., 2003; Cowan, et al., 2005; Takase & Teraoka, 2011; Smith, 2012; Garside & Nhemachena, 2013), anaesthesia nursing competence can be described as a combination of the necessary knowledge, attitudes, values and skills in delivering care to patients preparing for, undergoing and recovering from anaesthesia. In this study, seven competence areas in anaesthesia nursing care were conceptualised: ethics of anaesthesia care, patient risk care, patient engagement with technology, collaboration within anaesthesia care, anaesthesia patient care with medication, anaesthesia nursing intervention, and knowledge of anaesthesia care.

Among the competence areas, ethics, collaboration, knowledge, leadership, and professional development have already been included as competence areas in earlier competence assessment instruments (Paper I). This study attempted to refine the first three competence areas (ethics, collaboration, and knowledge) and to capture contextual nuances characterised in anaesthesia nursing care.

In this study, however, leadership and professional development were not included as competence areas of anaesthesia nursing care. This is because the nature of nurses in anaesthesia care is based on a close collaboration between patients, the anaesthesiologists and other OR team members (Manser, 2009; Lyk-Jensen, et al., 2014; Larsson, 2017; Falk-Brynhildsen, et al., 2019); therefore, it was considered that leadership might be a difficult characteristic to coexist with collaboration in anaesthesia patient care (Falk-Brynhildsen, et al., 2019). Moreover, professional development (e.g., keeping up to date with the latest knowledge, practice, or technology) was considered to be a common concept covered already in

perioperative nursing competence studies (Gillespie, et al., 2012; Gillespie & Pearson, 2013; Jaensson, et al., 2017; Gillespie, et al., 2018; Falk-Brynhildsen, et al., 2019) and generic nurse competence studies (Meretoja, et al., 2004; Meretoja & Koponen, 2012; Greenfield, et al., 2014).

Based on the results of the scoping review of the literature (Paper I), patient risk care, patient engagement with technology, anaesthesia patient care with medication, and anaesthesia nursing intervention were competence areas that earlier competence assessment instrument studies measured only partly or did not deal with sufficiently from the perspective of anaesthesia nursing care.

In anaesthesia care, sedated or anaesthetised patients cannot cope with their health crisis properly. Thus, nurse's ability to do what the patients are unable to do for themselves is critical (Nilsson & Jaensson, 2016). Competence in anticipating the patient's risk potentiality and coping with adverse events were especially assessed in simulation-based studies (Gaba, et al., 1998; Murray, et al., 2005; Henrichs, et al., 2009; Kibwana, et al., 2016). However, this was not emphasised in the self-assessment instruments as such. Patient risk care is the main concern in anaesthesia nursing care and this study categorised it as one competence area required for anaesthesia nurses.

Anaesthesia nursing care is usually provided in a high-technological environment (Nilsson & Jaensson, 2016; Larsson, 2017). During anaesthesia, nurses maintain patient's condition via technology and monitoring systems but the concern for the patients' wholeness goes beyond technology (Nilsson & Jaensson, 2016). The nurse must follow up on the patient's anxiety, ventilation, circulation, temperature, position, depth of anaesthesia, pain, and nausea and vomiting in anaesthesia care (AINIVA & SSF, 2008; FANA, 2015; IFNA, 2016; AANA, 2019). For an anaesthesia nursing intervention to maintain the patient's optimal condition, the nurse should assess patients' medication needs and evaluate drug effectiveness competently (WHO, 2003; Gabriela, 2013). Patient risk care, patient engagement with technology, anaesthesia nursing intervention, and anaesthesia patient care with medication are unique areas highlighted in this study.

This study included these areas as competences in anaesthesia nursing care and attempted to specify them in order to reflect the aspects of anaesthesia nursing care. In terms of a multidimensional concept of nursing (Watson, et al., 2002; Sturmberg & Hinchy, 2010; Kajander-Unkuri, et al., 2013; Tavares & Boet, 2016; Liu, et al., 2019), the new finding of this study was to identify the seven competence areas as a whole for anaesthesia patient care.

This finding has special importance because not only have the numbers of surgical procedures been increasing globally, but also the concept of anaesthesia nursing care has been extended to patient care in various clinical settings beyond the operating room (Søreide, et al., 2010; Miller, et al., 2015; Meara, et al., 2015; Shrime,

et al., 2015; G4Alliance, 2018; WHO, 2019). For instance, anaesthesia nursing care is needed in such areas as diagnostic procedures, obstetrical procedures, pain management, and critical care settings (Miller, et al., 2015; Debas, et al., 2015; G4Alliance, 2018; Liebenhagen, et al., 2019). In the current COVID-19 pandemic situation, a large number of anaesthesia nurses have been devoted to caring for critically ill COVID-19 patients in ICUs (AANA, 2020a; Chen, et al., 2020b; Ouersighni & Ghazali, 2020; Stannard, 2020) and this phenomenon can be seen as an example of the expansion of the concept of anaesthesia nursing care. Since anaesthesia nurses have expertise in such areas as airway management, monitoring patient condition and emergency response, the role of anaesthesia nurses is globally regarded as very important in caring for COVID-19 patients who require respiratory support and continuous monitoring (Chen, et al., 2020b; Ouersighni & Ghazali, 2020; Stannard, 2020). Anaesthesia nurses' adaptability to other clinical settings has contributed to the care of a great number of patients and a rapid reaction to urgent public health needs (Chen, et al., 2020b; Ouersighni & Ghazali, 2020).

Anaesthesia nursing care is generally based on patient care for general anaesthesia and local anaesthesia/regional anaesthesia patient care; it also includes patient care requiring sedation and pain management (Freeman & Berger, 2014; Falk-Brynhildsen, et al., 2019; Abelsson & Nygårdh, 2020). Among the seven competence areas, however, the degree of competence required for patient care in general anaesthesia might differ from the degree of competence required in local anaesthesia or sedated patient care. Even for general anaesthesia patient care, the competence required for patient care might be different along with the four phases of the anaesthesia care process: before anaesthesia when a patient is conscious, in anaesthesia induction when a patient is being intubated, during general anaesthesia when a patient is unconscious and after anaesthesia when a patient is recovering from anaesthesia. The concept of anaesthesia nursing competence from the perspective of the different anaesthesia modes and by the four phases needs further clarification.

6.1.2 The psychometric properties of the AnestComp

The second of the major results was the development of AnestComp through the diversiform of psychometric testing. Based on the results of the initial psychometric testing, the AnestComp is considered as a reliable and acceptably valid scale for competence assessment of nurses in anaesthesia nursing care.

In Phase I, the face validity and the content validity endeavored to find the right construct of anaesthesia nursing competence and test the appropriateness of the items for the constructs. This phase required time because the highly abstract concepts needed to be validated (DeVon, et al., 2007). In addition, this phase included statistical approaches for construct validity by examining the seven-construct model

of the developed AnestComp. By using three model fitness indexes in CFA, the construct of the AnestComp was supported as a good model by the SRMR index. However, the other two indexes were not acceptable values. The reason why the other fitness indexes did not support the model fit could be understood by the high correlations between factors. It was noted that factor 6 (anaesthesia nursing intervention) showed high correlations with factor 3 (patient engagement with technology) and factor 5 (anaesthesia patient care with medication). Moreover, several items in factor 6 overlapped with factor 3 and factor 5 in the results of the EFA. The multi-dimensional tendency indicates that one factor on the scale was not clearly distinguished from the other factors which affected the overall model fit (Hair, et al., 2014). Other competence studies have also pointed out the difficulty in developing competence scales due to the multidimensional aspects of competence (Gillespie, et al., 2012; Lakanmaa, et al., 2014a). Based on the results of CFA and EFA, for instance, reduction of the items of factor 6 can be considered because factor 6 has high correlations with other factors and has relatively many items (9 items) compared to other factors (5 items). However, it would be circumspect to make an immediate conclusion that the number of items should be reduced based on the results of one test, so this issue should be revisited through subsequent tests.

This study tested the known-group validity of the AnestComp by using a group of nurses and a nursing student group. Due to the fact that the length of work experience of nurses is not necessarily related to higher nursing competence (Meretoja, et al., 2004; McHugh & Lake, 2010; Gillespie, et al., 2011; Takase & Teraoka, 2011; Flinkman, et al., 2017), this study used nursing students. The known-group validity was tested with the hypothesis that the levels of competence of nurses would be higher than those of nursing students. If the anaesthesia nurses' competence was higher than the nursing students', it could be considered a valid measurement scale from a known-group approach. According to the Mann-Whitney U-test, the hypothesised score differences between nurses and graduating students were found statistically in all items, seven subscales, and the overall scale. Thus, the known-group technique supported the construct validity of the AnestComp.

In this study, one of the significant issues was whether a scale developed for nurses could be used for nursing students. According to the results of known-group validity, the AnestComp seems to measure what it should to measure with a group of nursing students. In competence assessment, nursing students logically should have lower levels of nursing competence than qualified nurses (Murray, et al., 2005; McHugh & Lake, 2010). Previous Finnish studies pointed out that students approaching graduation could have overestimated when self-assessing their competence (Kajander-Unkuri, et al., 2014a; Kajander-Unkuri, et al., 2014b; Lakanmaa, et al., 2014b; Kajander-Unkuri, et al., 2016; Kajander-Unkuri, et al., 2020b). If the graduating nursing students in this study had exaggerated their

competence so that no significant difference was seen in the level of competence with nurses, the construct validity of the AnestComp might have been questioned. The fact that graduating students self-assessed their competence level as distinctly lower than the nurses' assessment in each item ($p<0.001$), each subscale ($p<0.001$), and the overall scale ($p<0.001$) showed that it seems to be a valid measure of anaesthesia nursing competence. Therefore, the AnestComp might be a possible scale for use not only among anaesthesia nurses but also nursing students from a known-group validity perspective. It seems to have the potential for use with nursing students and further studies need to define competence requirements in anaesthesia nursing care for nursing students.

AnestComp showed good reliability. Cronbach's alpha estimates in all the subscales were over the value of 0.7 recommended for a new instrument (DeVon, et al., 2007; Oluwatayo, 2012). The high estimates indicate that each subscale had good internal consistency meaning that anaesthesia nurses have responded logically to the questions on the scale. In this study, the subscale of anaesthesia nursing intervention (factor 6) also has high Cronbach's alpha estimates (0.95). Many items in the subscale might be the reason for the high alpha. A reduction in the scale is recommended in the case of Cronbach's alpha estimates over 0.90 (DeVon, et al., 2007). The consideration of item reduction in the subscale is consistent with the results of the validity test. However, instrument development is iterative, and the soundness of the instrument should be determined based on repeated testing (Gillespie, et al., 2012). Reliability can vary and reactive depending on a particular group of measurements (Streiner & Kottner, 2014). Therefore, the AnestComp initial test for reliability requires further repeated testing.

The AnestComp has been used in Finland. Thus, psychometric testing of the AnestComp in an international context is advisable to enable cross-country comparisons. For example, the Nordic countries (Denmark, Iceland, Finland, Norway and Sweden) have provided a similar anaesthesia care model requiring highly educated and trained nursing practises (Meeusen, et al., 2010; Søreide, et al., 2010; Nilsson & Jaensson, 2016; Aagaard, et al., 2017) but each country has different anaesthesia nursing education programmes ranging from a supplementary continuing education programme to a master's degree programme (Jeon, et al., 2015). Different types of education lead to different levels of nurse competence in nursing (Murray, et al., 2005, McHugh & Lake, 2010; Gillespie, et al., 2011; Flinkman, et al., 2017; Gillespie, et al., 2018). Subsequent research on Nordic-country comparisons would provide new knowledge to improve international harmonisation in anaesthesia nursing practice and education.

In the study, the AnestComp was translated into Swedish and pilot tested (n=32) in Sweden. As a further validation study of the AnestComp, psychometric testing of the AnestComp in a Swedish context will be conducted. It is important to confirm

that the AnestComp demonstrates an acceptable model fit in the Swedish context. Since Swedish nurse anaesthetists have post-registration education in anaesthesia care, the validity and reliability of the Swedish context will be especially important to determine whether the AnestComp has the potential to be used as a competence assessment scale for nurse anaesthetists practicing in other Nordic countries and the USA.

6.1.3 Self-assessed anaesthesia nursing competence

The third main result of this study is that the anaesthesia nursing competence of nurse met the expected competence level in anaesthesia nursing care based on their self-assessment. By using the AnestComp, anaesthesia nurses self-assessed their level of overall anaesthesia nursing competence as a VAS of 87.5 (0=not competent at all, to 100 = excellently competent).

Previous competence assessment studies in anaesthesia nursing care were poor at clarifying what levels were acceptable or satisfactory/unsatisfactory in the specific clinical settings (Paper I). Only one study assessing acute performance skills in a simulated setting addressed the score level; suggesting that a score of over 70% was considered the expected level from the perspective of an independent care provider (Murray et al., 2005). In a specialty study of public health nursing, a vaccination competence assessment used 80% as the satisfactory level (Nikula, 2011). In addition, 80% (4 of 5) was used as a target level for basic competence in a test for basic competence of intensive and critical care nursing (Lakanmaa, 2012). For this study, an expected level of anaesthesia nursing competence was operationally defined as a mean of a VAS score of 80 on the self-assessment. The criteria of a VAS of 80 corresponds to a good score (8 of 10) in the European Higher Education Area (EC, 2015).

Based on the criteria, anaesthesia nurses exceeded the expected level of a VAS of 80 in their overall self-assessment and also almost half of the nurses self-assessed their competence close to an excellent competent level (over VAS 90). It can be assumed that the results are related to the nurses' experience. The sample of nurses had an average of 13 years of work experience in anaesthesia nursing care and about 60% of the nurses had over 10 years of work experience (Table 8). Already in the 1980s, Benner (1982b) described that a competence continuum has five stages (novice, advanced beginner, competent, proficient, and expert); thus, nurses who have worked in the same nursing specialty for 2-3 years should be competent (McHugh & Lake, 2010; Alastalo, et al., 2019; Nyikuri, et al., 2020). The results of the study seem to be in line with the Benner's competence continuum. In this study, the overall level of competence reached a VAS of 80 after two years of work experience (2-4.9 years); however, it was noted that two competence areas (patient

risk care and knowledge of anaesthesia care) did not reach the expected level after two years of work experience (Table 9). At least a five-year working period in anaesthesia nursing was required to reach the expected levels in all competence areas; these nurses might be considered to be experts who have a deep understanding of the total situation (Benner, 1982b; McHugh & Lake, 2010; Nyikuri, et al., 2020).

Competence can be ensured when the competence areas are assessed and opportunities for further education are provided (WHO, 2003; Meretoja, et al., 2004; Axley, 2008; Dellai, et al., 2009; Valloze, 2009; Smith, 2012; Church, 2016; Liu, et al., 2019). Among the competence areas, it was shown that collaboration within anaesthesia care was the strongest competence area of the anaesthesia nurses in this study. This can be seen as a positive result. Many studies discuss the importance of collaboration within OR in terms of high-quality anaesthesia care and prevention of critical errors (Manser, 2009; Ead, 2014; Lyk-Jensen, et al., 2014; Larsson, 2017). The high competence levels in the competence area of collaboration among Finnish nurses has also been shown in intensive and critical care nursing (Lakanmaa, 2012). In anaesthesia nursing care, especially, the close collaboration with patients, colleague anaesthesia nurses, other OR team members and anaesthesiologists might play an important role in allowing anaesthesia nurses to take responsibility for safe anaesthesia care in cases where an anaesthesiologist is not present in the same operating room (Vakkuri, et al., 2006; Manser, 2009; Flynn, et al., 2017).

In contrast, ‘patient risk care’ and ‘knowledge of anaesthesia patient care’ were self-assessed as weak competence areas from novice nurses to even experienced anaesthesia nurses. Patient risk care has been frequently measured as an important competence area in previous studies in anaesthesia nursing care (Gaba, et al., 1998; Henrichs, et al., 2009; Gabriel, 2013; Kibwana, et al., 2016; Gabbard & Smith-Steinert, 2021). For instance, nurse anaesthetists were assessed by evaluators with a score of 77% (Gabriel, 2013) and 60% (Henrichs, et al., 2009) in the simulation based-critical skills. In this study, the mean level of competence in patient risk care self-assessed by anaesthesia nurses was good (VAS 83). However, the self-assessed level of competence of nurses with under two-year work experience was a VAS of 67 which is under the expected level. It was reported that the probability of novice nurses being exposed to emergency situations has been reduced through careful anaesthesia care pre-planning to prevent risks and also through advances in technology detecting emergencies (Liaw, et al., 2012; Larsson, 2017). For safe anaesthesia practice, it is important to educate/train novice nurses effectively. For instance, more opportunities in simulation-based risk care (e.g., cardiac life support simulation) and for continuing education might be considered (Gabbard & Smith-Steinert, 2021). This study indicates that the anaesthesia nursing training offered by the hospitals might need to pay more attention to developing nurse’s competence in

patient risk care and knowledge of anaesthesia care (Rosenberg, 2003; Vakkuri, et al., 2006).

In this study, the level of anaesthesia nursing competence of graduating nursing students was assessed as VAS 59. The levels of anaesthesia nursing competence between the graduating nursing students and nurses were statistically different. The limited experience of nursing students in the field of anaesthesia nursing care was considered to be major reason for the difference (Murray, et al., 2005; McHugh & Lake, 2010; Nikula, 2011; Lakanmaa, 2012). Noticeably, the highest competence area (collaboration in anaesthesia care, a VAS of 73) and the lowest competence areas (patient risk care, a VAS of 51 and knowledge of anaesthesia care, a VAS of 43) self-assessed by the graduating nursing students were the same areas as the nurses' results (Figure 5). This result has great implications. The graduating nursing students can enter into anaesthesia nursing practice immediately after their graduation in Finland. For high quality and safe anaesthesia patient care, the level of competence of the newly graduated nurses should be evaluated and discussed with nurse managers and mentor nurses before and after job training.

The lowest assessed competence areas by both nurses and nursing students are considered fields that require an educational approach rather than one that can be naturally obtained through experience. To ensure the anaesthesia nursing competence of nurses having a critical role in safe anaesthesia care, their education should be evidence-based and consistent (Gabbard & Smith-Steinert, 2021).

6.1.4 Factors related to self-assessed anaesthesia nursing competence

The fourth main result was that longer clinical experience and higher education were factors positively related to anaesthesia nursing competence. More experienced anaesthesia nurses represented a higher level of competence. The perioperative nursing study (Gillespie, et al., 2011; Istomina, et al., 2011; Stobinski, 2011; Hamström, et al., 2012), the critical care study (O'Leary, 2012; Lakanmaa, et al., 2014b), and public health nursing (Nikula, et al., 2011) reported the same results and emphasised the relationship between work experience and competence. However, more experience did not guarantee higher competence in this study. The competence of nurses with under two-year experience was statistically different from all the more experienced nurse groups ($p<0.001$). Among experienced nurse groups with over five-years of work experience, the mean differences were subtle; statistically, there were no mean differences. This indicates that the period in which work experience affects the nurses' competence development is seen as up to five years in anaesthesia nursing care. Even the nurse group with over 25 years did not assess their competence as excellent in any of the competence areas. The results should be

further studied whether this is due to the limitation of the self-assessment method, a lack of sensitivity in the scale or actual competence.

Previous studies have emphasised that nurses with higher education possess high levels of problem-solving skills (WHO, 2003; McHugh & Lake, 2010). In this study, higher education was related to a higher level of anaesthesia nursing competence of anaesthesia nurses; nurses who have specialised in anaesthesia nursing education as a post-registration education (perioperative nursing or anaesthesia nursing, 30-60ECTS) showed a higher competence level. Particularly in three competence areas (ethics of anaesthesia care, patient risk care, and knowledge of anaesthesia care), nurses with specialised education self-assessed significantly higher than nurses without ($p<0.001$).

The aim of nursing education is to prepare new graduate registered nurses to play roles as competent registered professional nurses (Valloze, 2009; WHO, 2013; Kaihlanen, 2020) and to direct them to obtain an acceptable level of competence effectively (WHO, 2003). In this study, novice nurses did not meet the expected criteria and the graduating nursing students self-assessed even lower. Since current Finnish nursing education has focused on general nursing education, the low anaesthesia nursing competence of novice nurses and graduating nursing students might be understandable (Jeon, et al., 2015). The average period of job orientation reported by anaesthesia nurses was 3.2 months (range 0-36) in this study. Every anaesthesia unit in the hospitals has allocated human resources to training newly graduated nurses for a considerable period of orientation time; however, there are variations in the quality of the orientation training by mentor nurses, places, and the budget of the hospitals (Vakkuri, et al., 2007). In this study, about 40% of nurses completed a specialised perioperative/anaesthesia nursing programme as post-registered education (continuing education) and they represented a higher competence level. In order to improve the newly graduated nurses' unpreparedness and to provide equivalent anaesthesia nursing care nationally and internationally, it is suggested that a specialised anaesthesia nursing education should be developed as a post-registration education (Salminen, et al., 2010; Lakanmaa, 2012).

6.2 Validity and reliability of the study

In this chapter, the validity and the reliability of the study related to the data and the research process is presented. The validity and reliability of the developed instrument were reported in Chapter 5.2 and Chapter 6.1.2 (Paper II).

The reliability issues of the study are connected to the researchers, the subjects, the circumstance and the tools used; these are, called random errors (Burns & Grove, 2009). This study tried to minimise such random errors during the whole study process. The reliability of the study becomes problematic if random errors occur; for

instance, a biased researcher, de-motivated respondents, disturbance during testing an instrument, and uncertainties connected to the instruments can cause random errors (Polit & Beck, 2006).

In Phase I, since the researcher's own opinion and previous experiences could have an influence on the data selection and analysis in the scoping literature review processes, two researchers independently searched for and discussed the relevant data in order to pursue the neutrality of the selected data. The interpretation of the data analysis could be the researcher's own perception. Therefore, the results of the data were discussed with other researchers, doctoral students in nursing science and statisticians to maintain the objectivity of the study.

The response rate is one of the important elements to determine the credibility of a survey-based study (Baruch & Holtom, 2008). In this study, data were collected from southern Finland and the response rate was 52% for anaesthesia nurses (Phase I). A sampling from one part of Finland might incur some sampling error (statistical error caused by the unrepresentativeness of the sample taken) and possibly also some sampling bias (the sample is out of the population due to the systematically biased participates) (Nulty, 2008). Data was firstly gathered via the electronic survey; the response rates were 30.6%. Because a high response rate can reduce errors and bias arising from sampling (Nulty, 2008), additional efforts were made by using a paper/pencil survey. The final response rate of nurses was 52% (n=222). For most studies, a response rate of approximately 60% is usually the goal of researchers (Fincham, 2008). For the factor analyses (CFA and EFA), at least a sample size of 195 (5 times the number of items, a ratio of 1:5) was required (Watson & Thompson, 2006; Mokkink, et al., 2012). Although the sample size satisfied the minimum requirement from the statistical perspective, there might be some possible sampling bias remaining. Therefore, the regional limitation and representativeness of Finnish anaesthesia nurses should be considered when using the results of this study.

From the perspective of the sample of nursing students, the final response rate was 21% (Phase I). The main reason for this could be due to their low motivation as regards the research (Burns & Grove, 2009). Since the instrument was designed to self-assess the competence of nurses, it was likely that the students lost interest due to their lack of experience in anaesthesia nursing care. It was probably not sufficient to try to persuade the students that their participation is valuable, and their responses would be useful (Nulty, 2008). In addition, once participants had started the electronic survey, they had to complete it. A survey that needs to be completed in one session might prove difficult and inconvenient for participants (Palan & Schitter, 2018). This might be another reason that the response rate was low from the electronic survey. Therefore, in order to motivate respondents, a pre-instruction session (paper and pencil survey only) was prepared before distributing the survey and the importance of participation in the study was emphasised. All pre-instruction

sessions were provided in the same way to all respondents and data were collected in a peaceful environment. More important than the response rate in survey-based studies is the respondents' representativeness of the population group (Baruch & Holtom, 2008). Because the response rate of nursing students was not ideal, further attempts were made to enhance the response rate and to collect data from several areas.

In previous studies measuring anaesthesia nursing competence, evaluators assessed nurses' competence in specific skills such as acute skills in simulated settings (Gaba, et al., 1998; Henrichs, et al., 2009; Gabriel, 2013). In order to overcome the limitation caused by the simulated environment (e.g., not actual competence, not covering wholeness of competence, limitation of a structured instrument), this study used self-assessment to measure anaesthesia nursing competence. Self-assessment was a time-saving and cost-effective measurement (Kajander-Unkuri, et al., 2014a; Lakanmaa, et al., 2014a; Jaensson, et al., 2017; Kajander-Unkuri, et al., 2020b). However, the self-assessed measurement has disadvantages related to subjectivity such as underestimation or overestimation (Watson, et al., 2002; Brazen, 2008; Burns & Grove, 2009; Takase & Teraoka, 2011). For instance, nurses might underestimate their competence through a comparison with other more experienced nurses (Meretoja & Leino-Kilpi, 2003; Lakanmaa, 2012; Jaensson, et al., 2017), whereas graduating students might self-assess their competence higher than their actual competence during the phase of graduation (Kajander-Unkuri, et al., 2014a; Kajander-Unkuri, et al., 2014b; Lakanmaa, et al., 2014b; Kajander-Unkuri, et al., 2020a; Kajander-Unkuri, et al., 2020b). Thus, many studies have suggested combining different assessment methods or tools to ensure accurate assessment data (Henrichs, et al., 2009; Gillespie, et al., 2012; Gabriel, 2013; Lakanmaa, et al., 2014ba). In order to do this, however, it is a precondition that the other tools should also be psychometrically sound. In addition, complications in interpretation might occur when measuring with other tools at the same time (Fotheringham, 2010). Due to the lack of instruments that have been tested and found psychometrically sound in anaesthesia nursing care (Paper I and Paper II), this study did not combine with other tools. The fact of the absence of criterion validity is a limitation of this study. Therefore, further research needs to test the self-assessment of the AnestComp with other measurement methods (e.g., direct observation, employer/educator's assessment, and written exam).

AnestComp was also used by nursing students in this study. Because the AnestComp was developed for use by nurses, nursing students who have insufficient clinical experience might experience difficulty in responding to some items. However, the reliability of the AnestComp by nursing students represented good consistency. The Cronbach's alphas in the subscales were sufficient between 0.86-0.95 (DeVon, et al., 2007; DeVellis, 2012). This implies that nursing students were

consistent in responding to the items. According to the Mann-Whitney U-test for the Known-group validity, the hypothesised score differences between nurses and graduating students were found statistically in all items, subscales, and the overall scale between nurses and nursing students. The fact that there were distinct competence levels of difference between nurses and students showed that this scale might have a potential for use with nursing students as well.

In Phase II, in the evaluation of anaesthesia nursing competence, a score of over VAS 80 for anaesthesia nurses was operationally defined as the expected level in anaesthesia nursing care. Previous research (Kajander-Unkuri, et al., 2014a) using VAS (0-100) described the level of nurse competence with four categories: low (0-25), rather good (25-50), good (50-75), and very good (75-100). A vaccination competence study (Nikula, 2011) used the terminology of satisfactory (80%) for both public health nurses and public health nursing students. If the criteria mentioned in the above studies were applied to this study, the results of the competence assessment of nurses would have been explained by a different approach. Future studies need to clarify the grading scales (e.g., the meaning of scores, satisfactory level, expected level, classifications of the scores) not only for nurses but nursing students.

In both Phases, all the study processes have progressed based on consensus through deep discussion among a multi-professional research group, a biostatistician, and researchers in nursing science. The results of each part of the study were shared and analysed with the research group, a biostatistician, and several researchers. More detailed validity and reliability of each part of the study can be found in Paper I - IV.

6.3 Suggestions for further studies

Based on the results of this study, suggestions for further studies have been included about the concept of competence in anaesthesia care, instrument development, competence assessment, nursing education, and the quality of anaesthesia care.

The conceptualisation of anaesthesia nursing competence should be studied further. In this study, anaesthesia nursing competence was described based on a holistic approach to nursing competence. Anaesthesia nursing competence is a multidimensional concept consisting of seven competence areas. Further clarification of competence areas is important since anaesthesia nursing care evolves with new expertise. For instance, digitalisation in anaesthesia care, cultural competence, and disasters (or a pandemic situation) would be competence areas that need to be further investigated in the future. This study described the competence required by nurses in anaesthesia nursing care. As further research, it would be important to study what anaesthesia nurses' competence is from the patient's point of view (e.g., perspective of patients in general anaesthesia or patients in local anaesthesia). In addition, anaesthesia nursing care is provided in various care settings

from OR to even office setting. It would be important to clarify the concept based on various anaesthesia care environments.

The instrument used to assess anaesthesia nursing competence needs to be developed further in terms of content and structure. In this study, the construct of the AnestComp was developed for nurses' use. In order to use the instrument for nursing students practising in the clinical practice of anaesthesia care, further validating studies are needed; for instance, adding easy and complementary questions for students' self-assessment. As regards validating studies, further competence assessment by nurse managers or peer-group are necessary along with nurses' self-assessment. In this study, the 39 item AnestComp was developed via an electronic and a paper and pencil survey. For a following study, it would be important to develop a more feasible instrument. For instance, the development of applications (instruments) for mobile devices would contribute to increasing a more frequent or regular basis for the use of the instrument. More research needs to be devoted to exploring the quality of anaesthesia care. Since patients in anaesthesia care may have limitations in participating in their own care or decision makings due to medication or anaesthesia, further studies including instrument development in terms of ethical issues or anaesthesia patient satisfaction will be critical in enhancing the quality of anaesthesia care.

More research concerning the competence continuum of nurses in anaesthesia nursing care needs to be explored. This study was based on a cross-sectional survey. A greater variety of approaches to assessing nurse competence need to be conducted. In order to sustain the goal of quality and safety in anaesthesia patient care, further empirical studies should be conducted. In the practice of clinical anaesthesia, job orientation training and anaesthesia nurse educational programmes might be critical to improving nurse competence and to providing competent nurses. To develop effective orientation training programmes or nurse educational programmes, intervention studies assessing nurses' competence pre-/post- orientation training/educational programme needs to be investigated. For instance, longitudinal competence assessment studies following novice nurses until they become expert nurses need to be conducted with systematic measurements. To promote safe anaesthesia care, internal and external factors (e.g., strengths, weaknesses, opportunities, and threats) associated with anaesthesia nurse competence, not only from the current perspective, but also future perspectives will be the areas required in further studies. This study was conducted in Finland. International collaboration studies would be beneficial to clarify the concept of competence is sustainable in other cultures. Cross-country comparisons of the level of nurses' competence would be a good approach to verify a country's quality of care.

Further research needs to explore the impacts of post-registration education on the level of nurse competence not only through a quantitative approach but also a

qualitative approach. This study quantitatively investigated the effect of post-registration education as supplementary continuing education (No official degree granted). Further studies need to be continued to explore the impact of a master's degree or doctoral degree in anaesthesia nursing education on the level of anaesthesia nursing competence. Further qualitative research such as patient interviews to indicate the competence of nurses with post-registration education will be needed. In the European context, where nursing education is governed by the same EU regulations and nurses can move to any country for work, anaesthesia nursing competence assessment among EU countries would produce outcomes of each country's anaesthesia nursing practice and nursing education. Therefore, it would be important to analyse competence as outcomes of nursing education in the EU context as well as the international context.

More research needs to be devoted to gaining a deeper and broader understanding of patients in anaesthesia nursing care. Closer attention should be paid to how to relieve patient's fears and anxiety related to anaesthesia before anaesthesia care at the moment of intubation or during local anaesthesia. Moreover, case studies concerning patient experience after anaesthesia care might be useful in improving the quality of care. Advances in technology have an influence on the quality of anaesthesia care. The effect of digitalisation (e.g., automatic monitoring recording system, electronic patient information and anaesthesia record) on the safety and quality of patient care would be necessary issues to be studied in the current and in future anaesthesia nursing care. Furthermore, research concerning how effectively and systematically nurse managers or administrators assess the competence of nurses would also be important to improving nurse competence and the quality of anaesthesia care. Based on the results of the study, each anaesthesia department trains novice nurses with its own orientation/training programme in Finland. There are variations in the contents of the job training programmes among organisations, and even within organisations. Organisational collaboration studies to develop nurse competence and to provide continuing education would be valuable to provide equivalence and the quality of anaesthesia care nationally. Furthermore, research on ecologically sustainable anaesthesia patient care is of global concern.

Suggestions for further research

A CONCEPT OF COMPETENCE

- Concept analysis and clarification of anaesthesia nursing competence
- Further clarification concerning competence areas for future anaesthesia nursing care (e.g.,
  digitalisation, cultural competence, disaster/pandemic situation)
- Concept studies focusing on patient in various anaesthesia types or care environments

INSTRUMENT DEVELOPMENT

- Further instrument development in terms of content and structure
- Further validating studies for usability to nursing students, nurse managers, or peer-group
- Further research to make more feasible instruments (Simplified versions, mobile applications)
- Instrument development for patient use purpose (e.g., ethical competence, patient satisfaction)

COMPETENCE ASSESSMENT

- More research concerning competence assessment along competence continuum
- Intervention studies concerning orientation training or anaesthesia education programmes
- Longitudinal studies from a novice until becoming an expert
- Studies for internal and external factors associated with anaesthesia nursing competence
- International collaboration studies

NURSING EDUCATION

- Investigation the impact of post-registration nursing education on the nurse competence
- Investigation the impact of post-registration nursing education to patients' satisfaction
- International competence comparative studies as outcomes of nursing education

QUALITY OF ANAESTHESIA CARE

- Studies investigating how to relieve patients fears and anxiety in anaesthesia care
- Case studies of patients' experience concerning anaesthesia care
- Impact of digitalisation on the safety and quality of anaesthesia patient care
- Research about nurse managers' systematic assessment to nurses' competence
- Organisational collaboration studies and ecologically sustainable care
- Global concern for ecologically sustainable anaesthesia patient care

Figure 7. Suggestions for further research.

7 Conclusions

Competence assessment of nurses in anaesthesia nursing care is essential to ensure the quality and safe anaesthesia care for patients. This study aimed to develop an anaesthesia nursing competence scale (AnestComp) and to assess the anaesthesia nursing competence of nurses. This study can be concluded as follows:

1) Anaesthesia nursing competence is a multidimensional concept and incorporates seven competence areas: the ethics of anaesthesia care, patient risk care, patient engagement with technology, collaboration within anaesthesia care, anaesthesia patient care with medication, anaesthesia nursing intervention, and knowledge of anaesthesia care.
2) The AnestComp is regarded as a promising new scale to assess the competence of anaesthesia nurses in Finland. Additionally, there is a possibility to use the scale for nursing students. Instrument development is iterative and further research refining the psychometric properties is needed. As international collaboration studies, the psychometric testing of the AnestComp in a Swedish context will be continued.
3) The anaesthesia nursing competence of nurses exceeded the expected level of competence in their self-assessment; in this study, the expected level was set as a mean of a VAS of 80 (0-100mm). However, novice nurses who had under two years of work experience did not meet the expected level of competence. Patient risk care and knowledge of anaesthesia care were especially identified as weak competence area. Moreover, these were the competence areas in which the graduating nursing students did not reach the target levels (a VAS of 60, passable level) at the point of graduation. Nurse competence in these two areas could be strengthened by using appropriate learning methods such as IT technology/simulation and by providing continuing education opportunities. Moreover, the competence of novice nurses in the two competence areas should be ensured during job training through regular competence assessments. A nurse's competence could be

discussed with a nurse manager to identify areas that need more training or additional education and be used to evaluate salary levels.

4) Self-assessed anaesthesia nursing competence of nurses was significantly related to work experience and specialised nursing education. This study proposes that post-registration education for anaesthesia nursing care (a master's degree) might not only solve the problem of the lack of competence of newly graduated nurses and but also contribute to the provision of equivalent anaesthesia care throughout Finland. Therefore, further studies need to investigate the impact of post-registration anaesthesia nursing education on nurse competence as well as the quality of anaesthesia patient care.

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References

Aagaard, K., Sørensen, EE., Rasmussen, BS. & Laursen, BS., 2017. Identifying nurse anesthetists' professional identity. *Journal of Perianesthesia Nursing,* 32(6), p. 619-630.

AANA, 2019. Standards for nurse anesthesia practice. Available at: https://www.aana.com/docs/default-source/practice-aana-com-web-documents-(all)/standards-for-nurse-anesthesia-practice.pdf?sfvrsn=e00049b1_18 [Accessed 2 April 2020].

AANA, 2020a. CRNAs as advanced practice providers in critical care settings. Available at: https://www.aana.com/docs/default-source/practice-aana-com-web-documents-(all)/crnas-as-advanced-practice-providers-in-clinical-care-settings.pdf?sfvrsn=da009643_6 [Accessed 2 April 2020].

AANA, 2020b. Scope of nurse anesthesia practice. Available at: https://www.aana.com/docs/default-source/practice-aana-com-web-documents-(all)/professional-practice-manual/scope-of-nurse-anesthesia-practice.pdf?sfvrsn=250049b1_6 [Accessed 2 February 2021].

Abelsson, A. & Nygårdh, A., 2020. The nurse anesthetist perioperative dialog. *BMC Nursing*, 19(37), doi:10.1186/s12912-020-00429-7.

Alastalo, M., Salminen, L., Jeon, Y., Vahlberg, T. & Leino-Kilpi, H., 2019. Critical care nurses' self-assessed patient observation skills: a cross-sectional survey study. *Nursing in Critical Care*, 24(5), p. 268-275.

ANMAC, 2010. National competency standards for the registered nurse. Australian Nursing and Midwifery Accreditation Council. Available at: https://www.nursingmidwiferyboard.gov.au/documents/default.aspx?record=WD10%2F1342&dbid=AP&chksum=N5ws04xdBlZijTTSdKnSTQ%3D%3D [Accessed 29 October 2020].

ANA, 2017a. Recognition of a nursing specialty, approval of a specialty nursing scope of practice statement, acknowledgement of specialty nursing standards of practice, and affirmation of focused practice competencies. Available at: https://www.nursingworld.org/~4989de/globalassets/practiceandpolicy/scope-of-practice/3sc-booklet-final-2017-08-17.pdf [Accessed 29 October 2020].

ANA, 2017b. Advanced practice Registered Nurses (APRN). Available at: https://www.nursingworld.org/practice-policy/aprn/ [Accessed 02 June 2020].

ANIVA & SSF, 2008. Description of competence for registered nurse with graduate diploma in specialist nursing-anaesthesia care. Available at: https://www.swenurse.se/globalassets/01-svensk-sjukskoterskeforening/publikationer-svensk-sjukskoterskeforening/kompetensbeskrivningar-publikationer/anestesi.eng.komp.pdf [Accessed 23 February 2020].

Armstrong, R., Hall, BJ., Doyle, J. & Waters, E., 2011. Cochrane Update 'Scoping the scope' of a Cochrane review. *Journal of Public Health*, 33(1), p. 147-150.

ASA, 2018. Position on monitored anesthesia care. Available at: https://www.asahq.org/standards-and-guidelines/position-on-monitored-anesthesia-care [Accessed 22 March 2020].

Aveyard, H., 2010. Doing a literature review in health and social care: a practical guide, 2rd ed. Berkshire: Open University Press.

Axley, L., 2008. Competency: a concept analysis. *Nursing Forum*, 43(4), p. 214-222.

Baruch, Y. & Holtom, BC., 2008. Survey response rate levels and trends in organizational research. *Human Relations*, 61(8), p. 1139-1160.

Benner, P., 1982a. Issues in competency-based testing. *Nursing Outlook*, 30(5), p. 303-309.

Benner, P., 1982b. From Novice to Expert. *The American Journal of Nursing*, 82(3), p. 402-407.

Bokken, L., Rethans, J., Scherpbier, A. & van der Vleuten, C., 2008. Strengths and weaknesses of simulated and real patients in the teaching of skills to medical students: a review. *Simulation in Healthcare*, 3(3), p. 161-169.

Brazen, L., 2008. Competence, nursing practice, and safe patient care. *Perioperative Nursing Clinics*, 3(4), p. 297-303.

Burns, N. & Grove, SK., 2009. The practice of nursing research: appraisal, synthesis, and generation of evidence. 6th ed. St. Louis: Saunders Company.

Chen, X., Liu, Y., Gong, Y., Guo, X., Zuo, M., Li, J., Shi, W., Li, H., Xu, X., Mi, W. & Huang, Y., 2020a. Perioperative management of patients infected with the novel Coronavirus: Recommendation from the joint task force of the Chinese Society of Anesthesiology and the Chinese Association of Anesthesiologists. *Anesthesiology*, 132(6), p. 1307-1316.

Chen, Q., Lan, X., Zhao, Z., Hu, S., Tan, F., Gui, P. & Yao, S., 2020b. Role of anesthesia nurses in the treatment and management of patients with COVID-19. *Journal of Perianesthesia Nursing*, 35, p. 453-456.

Church, C. D., 2016. Defining competence in nursing and its relevance to quality care. *Journal for Nurses in Professional Development*, 32(5), p. 9-14.

COACRNA, 2019. Standards for accreditation of nurse anesthesia educational programs, Pak Ridge: Council on Accreditation of Nurse Anesthesia Educational Programs. Available at: https://www.coacrna.org/wp-content/uploads/2020/01/2004-Standards-for-Accreditation-of-Nurse-Anesthesia-Educational-Programs-revised-October-2019.pdf [Accessed 22 March 2020].

Collins, S. & Callahan, M., 2014. A call for change: clinical evaluation of students registered nurse anesthetists. *AANA J*, 82(1), p. 65-72.

Colman, A., 2014. A dictionary of psychology. 3rd ed. Oxford: Oxford University Press.

Cook, KA., Marienau, MS., Wildgust, B., Gerbasi, F. & Watkins, J., 2013. Assessment of recent graduates preparedness for entry into practice. *AANA J*, 81(5), p. 341-345.

Cowan, D., Norman, I. & Coopamah, VP., 2005. Competence in nursing practice: A controversial concept - A focused review of literature. *Nurse Education Today*, 25(5), p. 355-362.

CRD, 2009. Systematic reviews-CRD's guidance for undertaking reviews in health care. Centre for Reviews and Dissemination. York: York Publishing Services LTD. Available at:https://www.york.ac.uk/media/crd/Systematic_Reviews.pdf [Accessed 21 February 2021].

Dahlberg, K., Brady, JM., Jaensson, M., Nilsson, U. & Odom-Forren, J., 2020. Education, competence, and role of the nurse working in the PACU: An international survey. *Journal of Perianesthesia nursing*, doi:10.1016/j.jopan.2020.08.002.

Dalton, DL., Gee, T. & Levett-Jones, PT., 2015. Using clinical reasoning and simulation-based education to 'flip' the enrolled nurse curriculum. *Australian Journal of Advanced Nursing*, 33(2), p. 28-34.

Das, S. & Ghosh, S., 2015. Monitored anesthesia care: An overview. *Journal of Anaesthesiology Clinical Pharmacology*, 31(1), p. 27-29.

Debas, HT., Donkor, P., Gawande, A., Jamison, DT., Kruk, ME. & Mock, CN., 2015. Essential surgery: disease control priorities, 3rd ed. (Volume 1). Washington: The World Bank.

Dellai, M., Mortari, L. & Meretoja, R., 2009. Self-assessment of nursing competencies-validation of the Finnish NCS instrument with Italian nurses. *Scandinavian Journal of Caring Sciences*, 23(4), p. 783-791.

DeVellis, R., 2012. Scale development: Theory and applications. 3rd ed. Los Angeles: SAGE.

DeVon, HA., Block, ME., Moyle-Wright, P., Ernst, DM., Hayden, SJ., Lazzara, DJ., Savoy, SM. & Kostas-Polston, E., 2007. A psychometric toolbox for testing validity and reliability. *Journal of Nursing Scholarship*, 39(2), p. 155-164.

Dunn, SV., Lawson, D., Robertson, S., Underwood, M., Clark, R., Valentine, T., Walker, N., Wilson-Row, C., Crowder, K. & Herewane, D., 2000. The development of competency standards for specialist critical care nurses. *Journal of Advanced Nursing*, 31(2), p. 339-346.

Ead, H., 2014. Perianesthesia nursing-beyond the critical care skills. *Journal of Perianesthesia Nursing*, 29(1), p. 36-49.

EC, 2005. DIRECTIVE 2005/36/EC of the European parliament and of the council on the recognition of professional qualifications. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32005L0036&from=EN [Accessed 22 March 2020].

EC, 2013a. DIRECTIVE 2013/55/EU of the European parliament and of the council amending Directive 2005/36/EC. Available at: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:354:0132:0170:en:PDF [Accessed 22 March 2020].

EC, 2013b. Ethics for researchers - Facilitating research excellence in FP7. Available at: https://ec.europa.eu/research/participants/data/ref/fp7/89888/ethics-for-researchers_en.pdf [Accessed 23 February 2020].

EC, 2015. ECTS User's guide 2015. Available at: https://ec.europa.eu/education/ects/users-guide/docs/ects-users-guide_en.pdf [Accessed 29 July 2019].

EC, 2017. The European qualification framework for lifelong learning. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017H0615(01)&from=EN [Accessed 25 October 2018].

Elisha, S., Bonanno, L., Porche, D., Mercante, DE. & Gerbasi, F., 2020. Development of a Common Clinical Assessment Tool for evaluation in nurse anesthesia education. *AANA Journal*, 88(1), p. 11-17.

Elo, S. & Kyngäs, H., 2008. The qualitative content analysis process. *Journal of Advanced Nursing*, 62(1), p. 107-115.

Ensio, A., Lammintakanen, J., Härkönen, M. & Kinnunen, J., 2019. Strengthening health systems through nursing: Evidence from 14 European countries. Copenhagen: European Observatory on Health Systems and Policies. Available at: https://apps.who.int/iris/bitstream/handle/10665/326183/9789289051743-eng.pdf?sequence=1&isAllowed=y [Accessed 29 July 2019].

Eriksson, E., Korhonen, T., Merasto, M. & Moisio, E., 2015. Sairaanhoitajan ammatillinen osaaminen-Sairaanhoitajakoulutuksen tulevaisuus-hanke, Porvoo: Ammattikorkeakoulujen terveysalan verkosto ja Suomen sairaanhoitajaliitto ry, Bookwell Oy.

Eva, KW. & Regehr, G., 2005. Self-assessment in the health professions: a reformulation and research agenda. *Academic Medicine,* 80(10), p. 46-54.

Falk-Brynhildsen, K., Jaensson, M., Gillespie, B. & Nilsson, U., 2019. Swedish operating room nurses and nurse anesthetists' perceptions of competence and self-efficacy. *Journal of Perianesthesia Nursing,* 34(4), p. 842-850.

FANA, 2015. Competence requirement. Available at: https://sash.fi/julkaisut/osaamisvaatimukset [Accessed 23 February 2020].

Fincham, JE., 2008. Response rate and responsiveness for surveys, standards, and the journal. Americal Journal of Pharmaceutical Education, 72(2), p 1-3.

Finlex, 2014. Ammattikorkeakoululaki. Available at: https://www.finlex.fi/fi/laki/ajantasa/2014/20140932#a28.12.2018-1368 [Accessed 28 March 2020].

Finlex, 2015. Laki terveydenhuollon ammattihenkilöistä. Available at: https://www.finlex.fi/fi/laki/ajantasa/1994/19940559#L1P2 [Accessed 22 March 2020].

Finlex, 2017. Valtioneuvoston asetus tutkintojen ja muiden osaamiskokonaisuuksien viitekehyksestä. Available at: https://www.finlex.fi/fi/laki/ajantasa/2017/20170120 [Accessed 22 March 2020].

Flinkman, M., Leino-Kilpi, H., Numminen, O., Jeon, Y., Kuokkanen, L. & Meretoja, R., 2017. Nurse Competence Scale: a systematic and psychometric review. *Journal of Advanced Nursing*, 73(5), p. 1035-1050.

Flynn, FM., Sandaker, K. & Ballangrud, R., 2017. Aiming for excellence – A simulation – based study on adapting and testing an instrument for developing non-technical skills in Norwegian student nurse anaesthetists. *Nurse Education in Practice*, 22, p. 37-46.

Fotheringham, D., 2010. Triangulation for the assessment of clinical nursing skills: a review of theory, use and methodology. *International Journal of Nursing Studies*, 47(3), p. 386-391.

Fotheringham, D., Lamont, D., Macbride, T. & Mackenzie, L., 2015. Linking theory to practice in introductory practice learning experiences. *Nurse Education in Practice*, 15(2), p. 97-102.

Freeman, BS. & Berger, JS., 2014. Anesthesiology core review: Part one basic exam. McGraw-Hill Education.

Fukada, M., 2018. Nursing competency: Definition, structure and development. *Yonago Acta Medica*, 61, p. 1-7.

G4Alliance, 2018. Global surgery & anaesthesia statistics - the importance of data collection, New York: The G4 Alliance.

Gaba, DM., Howard, SK., Flanagan, B., Smith, BE., Fish, KJ. & Botney, R., 1998. Assessment of clinical performance during simulated crises using both technical and behavioral ratings. *Anesthesiology*, 89(1), p. 8-18.

Gabbard, KL. & Smith-Steinert, RM., 2021. Advanced cardiac life support simulation for nurse anesthetists and student nurses anesthetists. *Clinical Simulation in Nursing*, 50, p. 65-73.

Gabriel, N., 2013. A study of relationships among three assessment methods for nurse anesthetists (Doctoral dissertation). San Francisco: University of California.

Garside, J.R. & Nhemachena, J.Z.Z., 2013. A concept analysis of competence and its transition in nursing. *Nurse Education Today*, 33(5), p. 541-545.

Ghisi, D., Fanelli, A., Tosi, M., Nuzzi, M. & Fanelli, G., 2005. Monitored anesthesia care. Minerva *Anesthesiologica*, 71(9), p. 533-538.

Gillespie, BM., Chaboyer, W., Wallis, M. & Werder, H., 2011. Education and experience make a difference: results of a predictor study. *AORN Journal*, 94(1), p. 78-90.

Gillespie, BM., Polit, D., Hamlin, L. & Chaboyer, W., 2012. Developing a model of competence in the operating theatre: psychometric validation of the perceived perioperative competence scale-revised. *International Journal of Nursing Studies*, 49(1), p. 90-101.

Gillespie, BM. & Pearson, E., 2013. Perceptions of self-competence in theatre nurses and operating department practitioners. *ACORN*, 26(1), p. 29-34.

Gillespie, BM., Harbeck, EB., Falk-Brynhildsen, K., Nilsson, U. & Jaensson, M., 2018. Perceptions of perioperative nursing competence: a cross-country comparison. *BMC Nursing*, doi:10.1186/s12912-018-0284-0.

Girot, E.A., 1993. Assessment of competence in clinical practice – a review of the literature. *Nurse Education Today*, 13, p. 83-90.

Gombkoto, RL., Walker, J., Horton, BJ., Martin-Sheridan, D., Yablonky, MJ. & Gerbasi, FR., 2014. Council on accreditation of nurse anesthesia educational programs adopts standards for the practice doctorate and post-graduate CRNA fellowships. *AANA Journal*, 82(3), p. 177-183.

Gonczi, A., Hager, P. & Oliver, L., 1990. Establishing Competency-based standards in the professions. *NOOSR Research Paper* no. 1, AGPS: Canberra.

Gonczi, A., 1994. Competency based assessment in the professions in Australia. *Assessment in Education,* 1(1), p. 27-44.

Graneheim, U. & Lundman, B., 2004. Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. *Nurse Education Today*, 24(2), p. 105-112.

Greenfield, M., O'brien, D., Kofflin, S. & Mhyre, J., 2014. A cross-sectional survey study of nurses' self-assessed competencies in obstetric and surgical postanesthesia care units. *Journal of Perianesthesia Nursing*, 29(5), p. 385-396.

Greenway, K., Butt, G. & Walthall, H., 2019. What is a theory-practice gap? An exploration of the concept. *Nurse Education in Practice*, 34, p. 1-6.

Hair, JF., Black, WC., Babin, BJ. & Anderson, RE., 2014. Multivariate data analysis. 7th ed. Essex: Pearson Education Limited.

Halbeis, C., Cvachovec, K., Scherpereel, P., Mellin-Olsen, J., Drobnic, L. & Sondore, A., 2007. Anaesthesia workforce in Europe. *European Journal of Anaesthesiology,* 24, p. 991-1007.

Hamström, N., Kankkunen, P., Suominen, T. & Meretoja, R., 2012. Short hospital stays and new demands for nurse competencies. *International Journal of Nursing Practice*, 18(5), p. 501-508.

Hedenskog, C., Nilsson, U. & Jaensson, M., 2017. Swedish-registered nurse anesthetists' evaluation of their professional self. *Journal of Perianesthesia Nursing*, 32(2), p. 106-111.

Helminen, K., 2017. Nursing students' final assessment in clinical practice - Perceptions of teachers, students and mentors (Doctoral dissertation), Kuopio: University of Eastern Finland.

Helminen, K., Johnson, M., Isoaho, H., Turunen, H. & Tossavainen, K., 2017. Final assessment of nursing students in clinical practice: Perspectives of nursing teachers, students and mentors. *Journal of Clinical Nursing*, 26(23-24), p. 4795-4803.

Henderson, A., Ossenberg, C. & Tyler, S., 2015. 'What matters to graduates': An evaluation of a structured clinical support program for newly graduated nurses. *Nurse Education in Practice*, 15(3), p. 225-231.

Henrichs, BM., Avidan, MS., Murray, DJ., Boulet, JR., Kras, J., Krause, B., Snider, R. & Evers, AS., 2009. Performance of certified registered nurse anesthetists and anesthesiologists in a simulation-based skills assessment. *Anesthesia & Analgesia,* 108(1), p. 255-262.

Herion, C., Egger, L., Greif, R. & Violato, C., 2019. Validating international CanMEDS-based standards defining education and safe practice of nurse anesthetists. *International Nursing Review,* 66, p. 404-415.

ICN, 2009. ICN framework of competencies for the nurse specialist, Geneva: International Council of Nurses. Available at: https://siga-fsia.ch/files/user_upload/08_ICN_Framework_for_the_nurse_specialist.pdf [Accessed 23 January 2020].

IFNA, 2016. Code of ethics, standards of practice, monitoring, and education. Available at: file:///F:/IFNA/IFNA%20STANDARDS%20FINAL%202016.pdf [Accessed 23 January 2020].

Immonen, K., Oikarainen, A., Tomietto, M., Kääriäinen, M., Tuomikoski, A.M., Kaučič, BM., Filej, B., Riklikiene, O., Vizcaya-Moreno, M.F., Perez-Cañaveras, R.M., Raeve, P.D. & Mikkonen, K., 2019. Assessment of nursing students' competence in clinical practice: A systematic review of reviews. *International Journal of Nursing Studies*, doi:10.1016/j.ijnurstu.2019.103414.

Istomina, N., Suominen, T., Razbadauskas, A., Martinkėnas, A., Meretoja, R. & Leino-Kilpi, H., 2011. Competence of nurses and factors associated with it. *Medicina (Kaunas*), 47(4), p. 230-237.

Jaensson, M., Falk-Brynhildsen, K., Gillespie, BM., Wallentin, FY. & Nilsson, U., 2017. Psychometric validation of the perceived perioperative competence scale-revised in the Swedish context. *Journal of Perianesthesia Nursing*, 33(4), p. 499-511.

James, J., 2014. Anesthesia clinical core competencies and high-fidelity human simulation (Doctoral dissertation), Knoxville: University of Tennessee.

Jeon, Y., Lahtinen, P., Meretoja, R. & Leino-Kilpi, H., 2015. Anaesthesia nursing education in the Nordic countries: Literature review. *Nurse Education Today*, 35(5), p. 680-688.

Kaihlanen, AM., 2020. From nursing students to a registered nurse – final clinical practicum facilitating the transition (Doctoral dissertation). *Annales Universitatis Turkuensis* D1466. Turku: University of Turku.

Kajander-Unkuri, S., Salminen, L., Saarikoski, M., Suhonen, R. & Leino-Kilpi, H., 2013. Competence areas of nursing students in Europe. *Nurse Education Today*, 33(6), p. 625-632.

Kajander-Unkuri, S., Meretoja, R., Katajisto, J., Saarikoski, M., Salminen, L., Suhonen, R. & Leino-Kilpi, H., 2014a. Self-assessed level of competence of graduating nursing students and factor related to it. *Nurse Education Today*, 34(5), p. 795-801.

Kajander-Unkuri, S., Suhonen, R., Katajisto, J., Meretoja, R., Saarikoski, M., Salminen, L. & Leino-Kilpi, H., 2014b. Self-assessed level of graduating nursing students' nursing skills. *Journal of Nursing Education and Practice,* 4(12), p. 51-64.

Kajander-Unkuri, S., 2015. Nurse competence of graduating nursing students (Doctoral dissertation). *Annales Universitatis Turkuensis* D1158. Turku: University of Turku.

Kajander-Unkuri, S., Leino-Kilpi, H., Katajisto, J., Meretoja, R., Räisänen, A., Saarikoski, M., Salminen, L. & Suhonen, R., 2016. Congruence between graduating nursing students' self-assessments and mentors' assessments of students' nurse competence. *Collegian*, 23(3), p. 303-312.

Kajander-Unkuri, S., Koskinen, S., Brugnolli, A., Cerezuela Torre, MA., Elonen, I., Kiele, V., Lehwaldt, D., Loyttyniemi, E., Nemcova, J., de Oliveira, CS., Palese, A., Rua, M., Salminen, L., Satekova, L., Stubner, J., Sveinsdottir, H., Visiers-Jimenez, L. & Leino-Kilpi, H., 2020a. The level of competence of graduating nursing students in 10 European countries – Comparison between countries. *Nursing Open*, 2020-11-25, doi:10.1002/nop2.712.

Kajander-Unkuri, S., Meretoja, R., Katajisto, J., Leino-Kilpi, H. & Suikkala, A., 2020b. Students' self-assessed competence levels during nursing education continuum- A cross-sectional survey. *International Journal of Nursing Education Scholarship*, 17(1), doi:10.1515/ijnes-2019-0050.

Kane, M., 1992. The assessment of professional competence. *Evaluation & the Health Professions*, 15(2), p. 163-182.

Kharasch, E. & Jiang, Y., 2020. Novel Coronavirus 2019 and anesthesiology. *Anesthesiology*, 132(6), p. 1289-1291.

Kibwana, S., Woldemariam, D., Misganaw, A., Teshome, M., Akalu, L., Kols, A., Kim, YM., Mengistu, S., van Roosmalen, J. & Stekelenburg, J., 2016. Preparing the health workforce in Ethiopia: A cross-sectional study of competence of anesthesia graduating students. *Education for Health*, 29(1), p. 3-9.

Koivusipilä, A., Tarnanen, K., Jalonen, J. & Mattila, V., 2015. Leikkaukseen valmistautuminen-lisätietoa potilaalle (Finnish). Available at: https://www.kaypahoito.fi/khp00089 [Accessed 23 March 2020].

LAB AMK, 2020. Anestesiahoitotyöhon erikoistunut osaaja 30 op - anesthetic Nurse Specialist (Finnish). Available at: https://lab.fi/fi/koulutus/anestesiahoitotyohon-erikoistunut-osaaja-30-op-anesthetic-nurse-specialist [Accessed 9 November 2020].

Lahti AMK, 2019. Anestesiahoitotyöhön erikoistunut osaaja 30 op (Finnish). Available at: https://www.lamk.fi/sites/default/files/2019-04/LAMK_anestesia_A4_0119.pdf [Accessed 3 June 2020].

Lahtinen, P., Leino-Kilpi, H. & Salminen, L., 2014. Nursing education in the European higher education area - variations in implementation. *Nurse Education Today*, 34(6), p. 1040-1047.

Lakanmaa, RL., 2012. Competence in intensive and critical care nursing – development of a basic assessment scale for graduating nursing students (Doctoral dissertation). *Annales Universitatis Turkuensis* D1014. Turku: University of Turku.

Lakanmaa, RL., Suominen, T., Perttilä, J., Ritmala-Castrèn, M., Vahlberg, T. & Leino-Kilpi, H., 2014a. Basic competence in intensive and critical care nursing: development and psychometric testing of a competence scale. *Journal of Clinical Nursing*, 23(5-6), p. 799-810.

Lakanmaa, RL., Suominen, T., Perttilä, J., Ritmala-Castrèn, M., Vahlberg, T. & Leino-Kilpi, H., 2014b. Graduating nursing students' basic competence in intensive and critical care nursing. *Journal of Clinical Nursing*, 23(5-6), p. 645-653.

Lapland AMK, 2020. Sairaanhoitotyön syventävät opinnot, perioperatiivinen hoitotyö 2020(monimuoto-opinnot, Rovaniemi). Available at: https://meerkado.fi/apply/2855561/sairaanhoitotyon-syventavat-opinnot-perioperatiivinen-hoitotyo-2020-monimuoto-opinnot-rovaniemi [Accessed 9 November 2020].

Larsson, J., 2017. Monitoring the anaesthetist in the operating theatre - professional competence and patient safety. *Anaesthesia*, 72(Suppl. 1), p. 76-83.

Lee, J. & Sim, I., 2019. Gap between college education and clinical practice: experience of newly graduate nurses. Nursing Open, 7, p. 449-456, doi:10.1002/nop2.409.

Levac, D., Colquhoun, H. & O'Brien, K., 2010. Scoping studies: advancing the methodology. *Implementation Science*, 5(69), doi:10.1186/1748-5908-5-69.

Liaw, SY., Scherpbier, A., Rethans, J. & Klainin-Yobas, P., 2012. Assessment for simulation learning outcomes: a comparison of knowledge and self-reported confidence with observed clinical performance. *Nurse Education Today*, 32(6), doi:10.1016/j.nedt.2011.10.006.

Liebenhagen, A., Forsberg, A. & Kristensson, J., 2019. Development and psychometric exploration of the anesthesia surrendering instrument. *Journal of Perianesthesia Nursing*, 34(1), p. 169-179.

Liu, Y., Jensen, D., Chan, C., Wei, C., Chang, Y., Wu, C. & Chiu, C., 2019. Development of a nursing-specific Mini-CEX and evaluation of the core competencies of new nurses in postgraduate year training programs in Taiwan. *BMC Medical Education*, 19(1), doi:10.1186/s12909-019-1705-9.

Lyk-Jensen, HT., Jepsen, RM., Spanager, L., Dieckmann, P. & Østergaard, D., 2014. Assessing nurse anaesthetists' non-technical skills in the operating room. *Acta Anaesthesiologica Scandinavica*, 58(7), p. 794-801.

Lyk-Jensen, HT., Dieckmann, P., Konge, L., Jepsen, RM., Spanager, L. & Østergaard, D., 2016. Using a structured assessment tool to evaluate nontechnical skills of nurse anesthetists. *AANA J*, 84(2), p. 122-127.

Lynn, MR., 1986. Determination and quantification of content validity. *Nursing Research*, 35(6), p. 382-385.

Mamaril, M., 2003. Standards of perianesthesia nursing practice: advocating patient safety. *Journal of Perianesthesia Nursing*, 18(3), p. 168-172.

Manser, T., 2009. Teamwork and patient safety in dynamic domains of healthcare: a review of the literature. *Acta Anaesthesiologica Scandinavica*, 53(2), p. 143-151.

Martin, E. & McFerran, T., 2008. A dictionary of nursing. 5th ed. Oxford: Oxford University Press.

Martland, AM., Huffines, M. & Henry, K., 2020. Surge Priority Planning COVID-19: Critical care staffing and Nursing considerations. Available at: http://www.chestnet.orgww.chestnet.org/Guidelines-and-Resources/Resources/Surge-Priority-Planning-COVID-19-Critical-Care-Staffing-and-Nursing-Considerations [Accessed 2 April 2020].

McHugh, MD. & Lake, ET., 2010. Understanding clinical expertise: nurse education, experience, and the hospital context. *Research in Nursing and Health*, 33(4), p. 276-287.

McMullan, M., Endacott, R., Gray, M.A., Jasper, M., Miller, C., Scholes, J. & Webb, C., 2003. Portfolios and assessment of competence: a review of the literature. *Journal of Advanced Nursing*, 41(3), p. 283-294.

Meara, JG., Leather, AJ., Hagander, L., Alkire, BC., Alonso, N., Ameh, EA., Bickler, SW., Conteh, L., Dare, AJ., Davies, J., Mérisier, ED., El-Halabi, S., Farmer, PE., Gawande, A., Gillies, R., Greenberg, S., Grimes, CE., Gruen, RL., Ismail, EA., Kamara, TB., Lavy, C., Lundeg, G., Mkandawire, NC., Raykar, NP., Riesel, JN., Rodas, E., Rose, J., Roy, N., Shrime, MG., Sullivan, R., Verguet, S., Watters, D., Weiser, TG., Wilson, IH., Yamey, G. & Yip, W., 2015. Global surgery 2030: evidence and solutions for achieving health, welfare, and economic development. *The Lancet*, 386(9993), p. 569-624.

Meeusen, V., Zundert, A., Hoekman, J., Kumar, C., Rawal, N. & Knape, H., 2010. Composition of the anaesthesia team: a European survey. *European Journal of Anaesthesiology*, 27(9), p. 773-779.

Mellin-Olsen, J., O'Sullivan, E., Balogh, D., Drobnik, L., Knape, J., Petrini, F. & Vimlati, L., 2007. Guidelines for safety and quality in anaesthesia practice in the European Union: section and board of anaesthesiology, European Union of medical specialists. *European Journal of Anaesthesiology*, 24(6), p. 479-482.

Meretoja, R. & Leino-Kilpi, H., 2003. Comparison of competence assessments made by nurse managers and practising nurses. *Journal of Nursing Management,* 11, p. 404-409.

Meretoja, R., Leino-Kilpi, H. & Kaira, AM., 2004. Comparison of nurse competence in different hospital work environments. *Journal of Nursing Management,* 12(5), p. 329-336.

Meretoja, R. & Koponen, L., 2012. A systematic model to compare nurses' optimal and actual competencies in the clinical setting. *Journal of Advanced Nursing*, 68(2), p. 414-422.

Miller, R., Cohen, N., Eriksson, L., Fleisher, L., Wiener-Kronish, J., Cohen, N. & Young, W., 2015. Miller's anesthesia. 8th ed. Philadelphia: Elsevier Saunders.

Mokkink, LB., Terwee, CB., Knol, DL., Stratford, PW., Alonso, J., Patrick, DL., Bouter, LM. & De Vet, HC., 2010. The COSMIN checklist for evaluating the methodological quality of studies on measurement properties: A clarification of its content. *BMC Medical Research Methodology*, 10(22), doi:10.1186/1471-2288-10-22.

Mokkink, LB., Terwee, CB., Patrick, DL., Alonso, J., Stratford, PW., Knol, DL., Bouter, LM. & De Vet, HC., 2012. COSMIN checklist manual. Available at: http://fac.ksu.edu.sa/sites/default/files/cosmin_checklist_manual_v9.pdf [Accessed 23 February 2020].

Mooney, M., 2007. Facing registration: the expectations and the unexpected. *Nurse Education Today*, 27(8), p. 840-847.

Murray, DJ., Boulet, JR., Kras, JF., McAllister, JD. & Cox, TE., 2005. A simulation-based acute skills performance assessment for anesthesia training. *Anesthesia and analgesia*, 101(4), p. 1127-1134.

Nagelsmith, L., 1995. Competence: An evolving concept. *The Journal of continuing Education in Nursing*, 26(6), p. 245-245.

NCNZ, 2012. Code of conduct for nurses. Nursing Council of New Zealand. Available at: file:///C:/Users/echo2/Downloads/Code%20of%20Conduct%20Booklet%20full.pdf [Accessed 29 October 2020].

NMC, 2010. Standards for pre-registration nursing education. Nursing and Midwifery Council. Available at: https://www.nmc.org.uk/globalassets/sitedocuments/standards/nmc-standards-for-pre-registration-nursing-education.pdf [Accessed 29 October 2020].

Nikula, A., 2011. Vaccination Competence - The concept and Evaluation (Doctoral dissertation). *Annales Universitatis Turkuensis, D995.* Turku: University of Turku.

Nikula, A., Nohynek, H., Puukka, P. & Leino-Kilpi, H., 2011. Vaccination competence of graduating public health nurse students. *Nurse Education Today*, 31(4), p. 361-367.

Nilsson, U. & Jaensson, M., 2016. Anesthetic nursing: keep in touch, watch over, and be one step ahead. *Journal of Perianesthesia Nursing*, 31(6), p. 550-551.

Notarnicola, I., Petrucci, C., De Jesus Barbosa, MR., Giorgi, F., Stievano, A. & Lancia, L., 2016. Clinical competence in nursing: A concept analysis. *Professioni infermieristiche*, 69(3), p. 174-181.

Nulty, DD., 2008. The adequacy of response rates to online and paper surveys: what can be done? *Assessment & Evaluation in Higher Education*, 33(3), p. 301-304.

Nyikuri, M., Kumar, P., English, M. & Jones, C., 2020. "I train and mentor, they take them": A qualitative study of nurses' perspectives of neonatal nursing expertise and its development in Kenyan hospitals. *Nursing Open,* 7(3), p. 711-719.

O'Leary, J., 2012. Comparison of self-assessed competence and experience among critical care nurses. *Journal of Nursing Management,* 20(5), p. 607-614.

Oluwatayo, JA., 2012. Validity and reliability issues in educational research. *Journal of Educational and Social Research*, 2(2), p. 391-400.

OPH, 2017. Qualification frameworks. Available at: https://www.oph.fi/en/education-and-qualifications/qualifications-frameworks [Accessed 22 March 2020].

OPH & OKM, 2018. Report on the referencing of the Finnish National Qualifications Framework to the European Qualifications Framework and the Framework for Qualification of the European Higher Education Area. Available at: https://www.oph.fi/sites/default/files/documents/190482_report_on_the_referencing_of_the_finnish_national_qualifications_framework.pdf [Accessed 22 March 2020].

Ouersighni, A. & Ghazali, DA., 2020. Contribution of certified registered nurse anaesthetists to the management of the COVID-19 pandemic health crisis. *Intensive & Critical Care Nursing*, 60, 102888. doi:10.1016/j.iccn.2020.102888.

Palan, S. & Schitter, C., 2018. Prolific.ac-a subject pool for online experiments. *Journal of Behavioral and Experimental Finance*, 17, p. 22-27.

Plaus, K., Muckle, T. & Henderson, J., 2011. Advancing recertification for nurse anesthetists in an environment of increased accountability. *AANA Journal*, 79(5), p. 413-418.

Polit, DF. & Beck, CT., 2006. The content validity index: are you sure you know what's being reported? Critique and recommendations. *Research in Nursing & Health*, 29(5), p. 489-497.

Polit, DF. & Beck, CT., 2010. Essentials of nursing research – appraising evidence for nursing practice. Philadelphia: Wolter Kluwer, Lippincott Williams & Wilkins.

Polit, DF. & Hungler, BP., 1995. Nursing research: Principles and methods. 5th ed. Philadelphia: J.B. Lippincott company.

Rafiee, G., Moattari, M., Nikbakht, AN., Kojuri, J. & Mousavinasab, M., 2014. Problems and challenges of nursing students' clinical evaluation: a qualitative study. *Iranian Journal of Nursing and Midwifery Research,* 19(1), p. 41-49.

Riddle, D., Baker, K. & Sapp, A., 2016. Evaluation of testing as a method to assess continued competency in nurse anesthesia practice: A systematic review. *AANA Journal*, 84(4), p. 239-245.

Robertson, E., Mohammed, H., Morgan, L., Pickering, S., Collins, G., New, S., Griffin, D., McCulloch, P. & Catchpole, K., 2014. Oxford NOTECHS II: a modified theatre team non-technical skills scoring system. *PLoS One*, 9(3), e90320, doi:10.1371/journal.pone.0090320.

Rosenberg, P., 2003. Sopiiko skandinaavien anestesiahoitajamalli Suomeen? (Finnish). *Finnanest*, 36(1), p. 21-23.

Rosenberg, P., Alahuhta, S., Lindgren, L., Olkkola, K. & Ruokonen, E., 2014. Anestesiologia ja tehohoito. 3rd ed. Helsinki: Duodecim.

Ross, JA., 2006. The reliability, validity, and utility of self-assessment. *Practical Assessment, Research and Evaluation,* 11(10), doi:10.7275/9wph-vv65.

Rutkowski, K., 2007. Failure to fail: assessing nursing students' competence during practice placements. *Nursing Standard*, 22(13), p. 35-40.

Salah, AA., Aljerjawy, M. & Salama, A., 2018. Gap between theory and practice in the nursing education: the role of clinical setting. *JOJ Nursing & Health Care*, 7(2), doi: 10.19080/JOJNHC.2018.07.555707.

Salmenperä, M., Hynynen, M., Kuosa, R., Kuusniemi, K., Niskanen, M., Rautiainen, H., Scheinin, H., Tuominen-Salo, H., Ylitalo-Airo, ML. & Pyhälä, S., 2019. Suomen Anestesiologiyhdistyksen suositus anestesiatoiminnan järjestämisestä (Finnish). *Finnaest*, 52(4), p. 314-322.

Salminen, L., Stolt, M., Saarikoski, M., Suikkala, A., Vaartio, H. & Leino-Kilpi, H., 2010. Future challenges for nursing education - a European perspective. *Nurse Education Today*, 30(3), p. 233-238.

Savonia AMK, 2018. Perioperatiivinen hoitotyö 30 op (Finnish). Available at: https://taydennys.savonia.fi/index.php/koulutukset/sosiaali-ja-terveysala/perioperatiivinen-hoitotyo [Accessed 09 November 2020].

Schreiber, J., Nora, A., Stage, F., Barlow, E. & King, J., 2006. Reporting structural equation modeling and confirmatory factor analysis results: A review. *Journal of Educational Research*, 99(6), p. 323-338.

Shorthouse, J., 2017. A dictionary of anaesthesia. 2nd ed. Oxford: Oxford University Press.

Shrime, MG., Bickler, SW., Alkire, B. & Mock, C., 2015. Global burden of surgical disease: an estimation from the provider perspective. *The Lancet Global Health*, 3(52), p. 58-59.

Sipe, T., Fullerton, J. & Schuiling, K., 2009. Demographic profiles of certified nurse-midwives, certified registered nurse anesthetists, and nurse practitioners: reflections on implications for uniform education and regulation. *Journal of Professional Nursing*, 25(3), p. 178-185.

Sjöholm, M., 2018. Sairaaloiden ja sairaanhoitopiirien tammi-joulukuu 2017 - Yhteenvetoa kysynnästä, tuotannosta ja taloudesta, Kuntaliitos (Finnish). Available at: https://www.kuntaliitto.fi/sites/default/files/media/file/Sairaaloiden%20ja%20sairaanhoitopiirien%20tammi-joulukuu%202017.pdf [Accessed 22 March 2020].

Skogsaas, R. & Valeberg, BT., 2017. The contribution of a master's degree to clinical practice. *Norwegian Journal of Clinical Nursing*,11/29/2017, p 1-14, doi:10.4220/Sykepleienf.2017.63495en.

Smith, SA., 2012. Nurse competence: A concept analysis. *International Journal of Nursing Knowledge*, 23(3), p. 172-182.

Sohn, H. & Ryu, J., 2016. Monitored anesthesia care in and outside the operating room. *Korean Journal of Anesthesiology*, 69(4), p. 319-326.

Sorbello, M., EL-Boghdadly, K., Di Giacinto, I., Cataldo, R., Esposito, C., Falcetta, S., Merli, G., Cortese, G., Corso, RM., Bressan, F., Pintaudi, S., Greif, R., Donati, A. & Petrini, F., 2020. The Italian coronavirus disease 2019 outbreak: recommendations from clinical practice. *Anaesthesia*, 75(6), p. 724-732.

Søreide, E., kalman, S., Åneman, A., Nørregaard, O., Pere, P. & Mellin-Olsen, J., 2010. Shaping the future of Scandinavian anaesthesiology: a position paper by the SSAI. *Acta Anaesthesiologica Scandinavica,* 54(9), p. 1062-1070.

Stannard, D., 2020. COVID-19: Impact on perianesthesia nursing areas. *Journal of Perianesthesia Nursing*. 35, 237-238.

Starnes-Ott, K., Arnaud, M., Rooney, L. & Lewis, M., 2020. Using complex adaptive systems theory to guide the transition to DNP nurse anesthesia education. *Journal of Professional Nursing*, 36, p. 123-127.

Streiner, D. & Kottner, J., 2014. Recommendations for reporting the results of studies of instrument and scale development and testing. *Journal of Advanced Nursing*, 70(9), p. 1970-1979.

Sturmberg, JP. & Hinchy, J., 2010. Borderline competence – from a complexity perspective: conceptualization and implementation for certifying examinations. *Journal of Evaluation in Clinical Practice*, 16(4), p. 867-872.

Sundqvist, A. & Carlsson, A.A, 2014. Holding the patient's life in my hands: Swedish registered nurse anaesthetist' perspective of advocacy. *Scandinavian Journal of Caring Sciences,* 28(2), p. 281-288.

Sundqvist, A., Nilsson, U., Holmefur, M. & Anderzèn-Carlsson, A., 2018. Promoting person-centred care in the perioperative setting through patient advocacy: An observational study. *Journal of Clinical Nursing*, 27(11-12), p. 2403-2415.

Stobinski, J., 2011. Competency and work environments among military and civilian perioperative registered nurses: A predictive model (Doctoral dissertation). Cypress: TUI University. USA.

Swedish-Constitution, 2003. Law (2003:460) on ethical review of research concerning people. Available at: http://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/lag-2003460-om-etikprovning-av-forskning-som_sfs-2003-460 [Accessed 11 Oct 2016].

Takase, M. & Teraoka, S., 2011. Development of the holistic nursing competence scale. *Nursing & Health Sciences*, 13, p. 396-403.

Tavares, W. & Boet, S., 2016. On the assessment of paramedic competence: a narrative review with practice implications. *Prehospital and Disaster Medicine*, 31(1), p. 64-73.

Tengvall, E., 2010. Professional competence of perioperative and anesthetist nurse: A questionnaire research to perioperative and anesthetist nurses, anesthesiologists and surgeons (Finnish) (Doctoral dissertation). Kuopio: University of Eastern Finland.

TENK, 2012. Responsible conduct of research and procedures for handling allegations of misconduct in Finland - Finnish Advisory Board on Research Integrity. Available at: https://www.tenk.fi/sites/tenk.fi/files/HTK_ohje_2012.pdf [Accessed 27 July 2016].

TENK, 2019. The ethical principles of research with human participants and ethical review in the human sciences in Finland - Finnish National Board on Research Integrity. Available at:

https://www.tenk.fi/sites/tenk.fi/files/Ihmistieteiden_eettisen_ennakkoarvioinnin_ohje_2019.pdf [Accessed 26 June 2020].

Tilley, DS., 2008. Competency in nursing: a concept analysis. *Journal of continuing Education in Nursing,* 39(2), p. 58-64.

Vakkuri, A., Niskanen, M., Meretoja, O. & Alahuhta, S., 2006. Allocation of tasks between anesthesiologists and anesthesia nurses in Finland. *Acta Anaesthesiologica Scandinavica*, 50(6), p. 659-663.

Valloze, J., 2009. Competence: A concept analysis. *Teaching and Learning in Nursing*, 4(4), p. 115-118. doi:10.1016/j.teln.2009.02.004.

Watson, R., Stimpson, A., Topping, A. & Porock, D., 2002. Clinical competence assessment in nursing: A systematic review of the literature. *Journal of Advanced Nursing*, 39(5), p. 421-431.

Watson, R. & Thompson, D., 2006. Use of factor analysis in Journal of Advanced Nursing: literature review. *Journal of Advanced Nursing*, 55(3), p. 330-341.

Wax, R. & Christian, M., 2020. Practical recommendations for critical care and anesthesiology teams caring for novel coronavirus (2019-nCoV) patients. *Canadian Journal of Anesthesia*, 67, p. 568-576.

WHO, 2003. WHO Europe anaesthetic nursing curriculum - WHO European strategy for continuing education for nurses and midwives, Denmark: World Health Organization. Available at: https://apps.who.int/iris/bitstream/handle/10665/107518/E81550.pdf?sequence=1&isAllowed=y [Accessed 25 March 2020].

WHO, 2013. Transforming health workforce education in support of universal health coverage. Available at: https://apps.who.int/gb/ebwha/pdf_files/WHA66/A66_R23-en.pdf [Accessed 25 March 2020].

WHO, 2015. Sixty-eighth World Health Assembly Provisional agenda, Geneva: World Health Organization. Available at: https://www.who.int/surgery/WHA2015_provisional-agenda.pdf?ua=1 [Accessed 25 March 2020].

WHO, 2016. Nurse educator core competencies. Available at: https://www.who.int/hrh/nursing_midwifery/nurse_educator050416.pdf [Accessed 10 November 2020].

WHO, 2019. Total number of inpatient surgical procedures per year. Available at: https://gateway.euro.who.int/en/indicators/hfa_539-6031-total-number-of-inpatient-surgical-procedures-per-year/ [Accessed 18 July 2020].

Williams, B., Brown, T. & Onsman, A., 2010. Exploratory factor analysis: A five-step guide for novices. *Journal of Emergency Primary Health Care*, 8(3), 990399.

WMA, 2013. WMA declaration of Helsinki-Ethical principles for medical research involving human subjects 2013 World Medical Association. Available at: https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects [Accessed 13 June 2018].

Wunder, L., 2016. Effect of a nontechnical skills intervention on first-year student registered nurse anesthetists' skills during crisis simulation. *AANA J,* 84(1), p. 46-51.

Wu, X., Enskär, K., Lee, C. & Wang, W., 2015. A systematic review of clinical assessment for undergraduate nursing students. *Nurse Education Today*, 35(2), p. 347-359.

Yanhua, C. & Watson, R., 2011. A review of clinical competence assessment in nursing. *Nurse Education Today,* 31(8), p. 832-836.

Zamanzadeh, V., Ghahramanian, A., Rassouli, M., Abbaszadeh, A., Alavi-Majd, H. & Nikanfar, A., 2015. Design and implementation content validity study: Development of an instrument for measuring patient-centered communication. *Journal of Caring Sciences*, 4(2), p. 165-178.

Appendices

Appendix 1. Updated studies for competence instruments used in anaesthesia nursing care (n=8, 2015-2021): Phase I

Authors year country	purpose	Design/Sample (participant) *Ethics*	Instrument	Key Findings
Kibwana, et al., 2016 Ethiopia	To examine competence achieved by graduating anaesthesia students in bachelor of science from direct observations of student performance	Objective structured clinical examination (OSCE) approach and structured interviews /N=122 graduating anaesthesia students in universities and regional health science colleges N=12 university instructors(evaluators) *Ethical issues*: Ethics committee's approval and informed oral consent	Technical action - checklist: 6-16 items (yes/no) in each scenario (10 OSCE stations. Structured interview tool regarding the adequacy of the learning environment (12 questions)	Overall skills were 61.5% (Cut-off score: 60%). Scores were highest for spinal anaesthesia (80%) and lowest for routine anaesthesia machine check (37%). Male students (63%) were better than female (57%) and university students (65%) were better than regional college students (56%).
Wunder, 2016 USA	To identify the effect of an educational intervention on non-technical skills to the performance in anaesthesia crisis simulation	Quasi-experimental study/N=32 first-year students and N=4 educators(evaluators) *Ethical issues*: Voluntary nature	Technical action check-list (1-6 item, yes/no) and Non-technical skills (ANTS, 15 items - 4 point scoring system) in 6 simulated crisis scenarios: 3 scenarios before intervention and 3 after the intervention	3-hour intervention on non-technical skills resulted in significant improvement during anaesthesia crisis simulation.

Lyk-Jensen, et al., 2016 Denmark	To test the reliability and validity of the Nurse Anaesthetists' Non-technical skill system(N-ANTS)	Methodological study N=22 nurse anaesthetist supervisors Ethical issues: written informed consent, Voluntary nature, anonymity	N-ANTS (4 categories, 15 items, 5-point scale 1(poor performance) to 5(excellent) and a global rating score with a 7 point	Interrater reliability was high. There was no statistically significant effect on training.
Jaensson, et al., 2017 Sweden	To test psychometric property of the PPCS-R in the Swedish context	Methodological study and cross-sectional design/N=1033 registered nurse anaesthetists (RNA) and OR nurses *Ethical issues:* Formal approval from ethics committee is not required in Sweden. Voluntary and anonymous nature of participation	PPCS-R	Swedish PPCS-R showed acceptable Cronbach alpha for sub scales (0.79-0.88 among RNA) and six factor construct validity was supported with Swedish RNAs and OR nurses.
Flynn, et al., 2017 Norway	To describe the development of NANTS-Norway in student nurse anaesthetists (SNA)	Quasi-experimental study used a pre& post-test design based on high fidelity simulation, N=14 SNA, 2 evaluators *Ethical issues:* Written and oral consent-voluntary participation, confidentiality, anonymity and right to withdraw	NANTS-Norwegian (situation awareness, decision making, task management, teamworking) 4h training course relating patient safety 3 different scenarios	NANTS-Norway showed high inter-rater reliability (0.91) and test-retest reliability (0.94) and good internal consistency (0.85-0.92). A significant improvement across all categories of non-technical skills

Gillespie, et al., 2018 Australia, Canada, Scotland, and Sweden	To investigate perioperative nurses' perceptions of competence in four countries and to identify effect of specialist education and years of experience in the OR	A secondary analysis of cross-sectional design from 4 countries including Australia (N=175 RNs practising in the OR), Canada (N=132 RNs practising in the OR), Scotland (N=212 RNs practising in the OR) and Sweden (N=249 RNAs and OR nurses). *Ethical issues:* Participants' Approval by ethical committees from Australia, Canada and Scotland	PPCS-R	Specialist education was related to higher competence in four countries. In comparing nurses with over 10 years of experience in the OR, Swedish nurses showed lower competence when compared to rest countries
Falk-Brynhildsen, et al., 2019 Sweden	To compare perceived competence and self-efficacy in Sweden	Cross-sectional design/N=1033 registered nurse anaesthetists (RNA) and OR nurses/ *Ethical issues:* Formal approval from ethics committee is not required in Sweden. Voluntary and anonymous nature of participation	PPCS-R and General self-efficacy (GSE) scale	No differences were seen in total PPCS-R scores between RNAs and OR nurses. The empathy scores of the RNA group were higher than OR nurses.

Elisha, et al., 2020 USA	To describe development of a Common Clinical Assessment Tool (CCAT) for evaluation in student registered nurse anesthesia education on doctoral level (SRNA)	Exploratory study:3-round Delphi study/N=93 experts (nurse anaesthesia programme administrators, faculty members, clinical educators, SRNAs *Ethical issues:* experts' participation was voluntary nature	Content validity test (CVI) for CCAT: 4 domains, 25 competences, 5 progression indicators)	Based on CVI calculation, CCAT is anticipated for nurse anaesthesia programs to use on a voluntary basis for the clinical evaluation of SRNAs.

See Table 2. (1994-2015) in Paper I

Appendix 2. Competence areas of anaesthesia nursing care (Paper I, n=13 studies).

Competence area	Titles of competence areas	Reference
Ethical value	Humanistic qualities Empathy Ensuring quality, Helping role	Gabriel, 2013 Gillespie, et al., 2011; Gillespie, et al., 2012; Gillespie, and Pearson, 2013 Meretoja, et al., 2004; Meretoja & Koponen, 2012; Greenfield, et al., 2014
Risk management	Clinical judgement Diagnostic function, Managing situation Judgment/Critical thinking Anticipation, Vigilance, re-evaluation Situation awareness Acute care	Gabriel, 2013 Meretoja, et al., 2004; Meretoja & Koponen, 2012; Greenfield, et al., 2014 Cook, et al., 2013 Gaba, et al., 1998 Robertson, et al., 2014 Henrichs, et al., 2009
Medical technological skill	Equipment	Collins & Callahan, 2014
Collaboration	Counselling skills Collaboration Teamwork Teamwork and cooperation Communication skills Communication, Group climate	Gabriel, 2013 Gillespie, et al., 2011; Gillespie, et al., 2012; Gillespie and Pearson, 2013 Cook, et al., 2013, Robertson, et al., 2014 Collins & Callahan, 2014 Gaba, et al., 1998
Leadership	Organization, efficiency Leadership Work-load distribution Leadership, Management	Gabriel, 2013 Gillespie, et al., 2011; Gillespie, et al., 2012; Gillespie and Pearson, 2013 Gaba, et al., 1998 Robertson, et al., 2014
Anaesthesia nursing skill/therapeutic intervention	Medical intervention skills, examination skills Foundational skills, Proficiency Therapeutic intervention, Work role Clinical practice Patient assessment and planning, Peri-anaesthetic management Problem solving, Decision-making Technical skill	Gabriel, 2013 Gillespie, et al., 2011; Gillespie, et al., 2012; Gillespie and Pearson, 2013 Meretoja, et al., 2004; Meretoja & Koponen, 2012; Greenfield, et al., 2014 Cook, et al., 2013 Collins & Callahan, 2014, Robertson, et al., 2014 Henrichs, et al., 2009
Professional development	Professionalism Professional development Teaching-coaching Professional role	Gabriel, 2013 Gillespie, et al., 2011; Gillespie, et al., 2012; Gillespie and Pearson, 2013 Meretoja, et al., 2004; Meretoja & Koponen, 2012; Greenfield, et al., 2014 Collins & Callahan, 2014
Knowledge	Knowledge	Gillespie, et al., 2011; Gillespie, et al., 2012; Gillespie and Pearson, 2013, Cook, et al., 2013, Gabriel, 2013

Appendix 3. Cronbach's alpha and the levels of competence (Pilot test): Phase I.

AnestComp	Finnish anaesthesia nurses (n=32)		Finnish nursing students (n=17)		Swedish nurse anaesthetists (n=32)	
Subscale	Cronbach's α	Mean (SD)	Cronbach's α	Mean (SD)	Cronbach's α	Mean (SD)
Ethical value	0.80	83.8 (11.0)	0.86	54.1 (16.7)	0.90	76.2 (14.6)
Risk management	0.90	81.4 (11.9)	0.90	46.7 (17.9)	0.93	72.4 (17.1)
Technological skills	0.70	90.5 (7,4)	0.89	63.6 (20.4)	0.91	82.4 (13.7)
Collaboration	0.62	91.2 (6.8)	0.88	49.5 (20.5)	0.81	77.9 (14.2)
Medication	0.83	88.5 (8.0)	0.93	54.3 (21.2)	0.89	83.3 (12.2)
Anaesthesia nursing skills/intervention	0.91	90.2 (7.3)	0.97	48.9 (21.4)	0.96	83.1 (12.5)
Knowledge	0.84	77.9 (13.3)	0.87	38.8 (17.1)	0.91	68.4 (19.3)
Overall		86.6 (7.6)		50.7 (17.9)		78.1 (13.1)

VAS score (0-100mm): 0=I am not competent at all, 100=I am excellently competent

Appendix 4. Self-assessed competence of nurses and nursing students by items: Phase II.

Subscale & Abbreviated item	Graduating nursing students (n=86) Mean	SD	Anaesthesia nurses (n=222) Mean	SD	P-value[a]
Ethics of anaesthesia care	**63.0**	**15.9**	**84.4**	**11.2**	**<.0001**
1. Supporting a patient's decision-making	45.3	21.9	79.3	18.0	<.0001
2. Providing information to a patient	61.0	19.9	84.2	13.7	<.0001
3. Advocating for the patient's safety	56.4	22.6	85.2	14.6	<.0001
4. Protecting the patient's privacy	79.9	18.3	87.7	12.2	<.001
5. Empowering the patient	72.4	18.1	85.6	14.1	<.0001
Patient risk care	**51.1**	**19.4**	**82.8**	**12.5**	**<.0001**
6. Anticipating the patient's risk potentiality	50.3	21.2	84.1	13.8	<.0001
7. Identifying patient's acute adverse event	52.8	21.2	82.8	13.4	<.0001
8. Assessing how severe an acute adverse event is in a patient	48.5	21.5	79.4	14.8	<.0001
9. Prioritizing actions immediately	47.7	21.7	83.1	14.2	<.0001
10. Following up the patient's condition	55.6	20.4	84.7	13.9	<.0001
Patient engagement with technology	**62.4**	**17.8**	**90.3**	**9.0**	**<.0001**
11. Checking anaesthesia-machines/technologies required for a patient	48.9	25.7	91.7	10.4	<.0001
12. Identifying the patient's needs through monitoring	61.6	20.4	90.9	9.1	<.0001
13. Seeing the patient as a human being, not just as a part of technology	83.7	14.8	91.0	11.7	<.0001
14. Using a technical equipment to meet the patient's needs	55.3	22.3	89.3	10.9	<.0001
15. Checking the accuracy of documented patient data	62.8	26.9	88.1	14.6	<.0001
Collaboration within anaesthesia care	**72.5**	**18.4**	**92.1**	**7.7**	**<.0001**
16. Doing checklist with a patient	77.7	18.2	89.9	12.6	<.0001
17. Seeking assistance from your anaesthesia colleagues	86.3	16.9	94.2	8.0	<.0001
18. Communicating professionally with an anaesthesiologist	67.2	27.2	93.6	7.4	<.0001
19. Sharing patient's information with OR team	68.3	24.5	91.9	9.4	<.0001
20. Coordinating patient's care with PACU team	62.8	24.8	90.5	12.6	<.0001
Anaesthesia patient care with medication	**61.2**	**20.0**	**90.6**	**8.8**	**<.0001**
21. Planning patient's anaesthesiological medication needs	44.4	26.2	88.6	11.8	<.0001
22. Assessing patient's needs for medication	50.8	26.0	89.2	9.9	<.0001
23. Administrating anaesthesiological medication safely for patient	71.0	22.1	92.5	8.6	<.0001
24. Evaluating anaesthesiological medication's effectiveness	64.3	22.6	90.0	10.1	<.0001
25. Documentation of medication in the correct manner	74.8	20.1	92.7	9.1	<.0001
Anaesthesia nursing intervention	**60.0**	**20.5**	**90.9**	**8.8**	**<.0001**
26. Relieving patient's anxiety related to anaesthesia	69.3	21.0	88.8	12.0	<.0001
27. Maintaining patient's breathing/ventilating	60.0	24.4	91.7	9.5	<.0001
28. Maintaining patient's blood circulation	58.2	22.7	91.8	9.5	<.0001
29. Maintaining patient's body temperature	63.6	23.8	90.0	11.7	<.0001
30. Maintaining patient's position	63.0	21.8	88.3	12.6	<.0001
31. Maintaining patient's depth of anaesthesia	47.9	29.0	91.3	10.5	<.0001
32. Maintaining patient's neuromuscular relaxation	46.3	28.8	91.8	9.6	<.0001
33. Relieving patient's pain	66.4	23.5	92.4	8.3	<.0001
34. Relieving patient's nausea and vomiting	65.2	22.8	91.9	9.2	<.0001
Knowledge of anaesthesia care	**43.3**	**20.9**	**79.0**	**14.7**	**<.0001**
35. Knowledge of different types of anaesthesia techniques	58.4	26.1	87.9	11.4	<.0001
36. Knowledge of anatomy relevant to anaesthesia techniques	46.9	25.7	81.8	15.4	<.0001
37. Knowledge of difficult airway management	42.1	24.6	83.7	15.7	<.0001
38. Knowledge of legislation relevant to anaesthesia	33.7	23.9	68.1	23.3	<.0001
39. Knowledge of economic efficiency in anaesthesia care	35.5	25.8	73.1	21.4	<.0001
Overall competence	**59.1**	**16.6**	**87.5**	**9.0**	**<.0001**

[a]: Mann-Whitney U-test

Appendix 5. Cronbach's α if-item-deleted: Phase I.

Subscale & Abbreviated item	Nurses (n=222)
Ethics of anaesthesia care (5 items Cronbach's α)	**0.84**
1. Supporting a patient's decision-making	0.82
2. Providing information to a patient	0.79
3. Advocating for the patient's safety	0.81
4. Protecting the patient's privacy	0.81
5. Empowering the patient	0.80
Patient risk care (5 items Cronbach's α)	**0.94**
6. Anticipating the patient's risk potentiality	0.92
7. Identifying patient's acute adverse event	0.92
8. Assessing how severe an acute adverse event is in a patient	0.92
9. Prioritizing actions immediately	0.91
10. Following up the patient's condition	0.93
Patient engagement with technology (5 items Cronbach's α)	**0.85**
11. Checking anaesthesia-machines/technologies required for a patient	0.81
12. Identifying the patient's needs through monitoring	0.80
13. Seeing the patient as a human being, not just as a part of technology	0.84
14. Using a technical equipment to meet the patient's needs	0.78
15. Checking the accuracy of documented patient data	0.86
Collaboration within anaesthesia care (5 items Cronbach's α)	**0.83**
16. Doing checklist with a patient	0.81
17. Seeking assistance from your anaesthesia colleagues	0.81
18. Communicating professionally with an anaesthesiologist	0.77
19. Sharing patient's information with OR team	0.76
20. Coordinating patient's care with PACU team	0.83
Anaesthesia patient care with medication (5 items Cronbach's α)	**0.93**
21. Planning patient's anaesthesiological medication needs	0.92
22. Assessing patient's needs for medication	0.90
23. Administrating anaesthesiological medication safely for patient	0.91
24. Evaluating anaesthesiological medication's effectiveness	0.91
25. Documentation of medication in the correct manner	0.92
Anaesthesia nursing intervention (9 items Cronbach's α)	**0.95**
26. Relieving patient's anxiety related to anaesthesia	0.95
27. Maintaining patient's breathing/ventilating	0.94
28. Maintaining patient's blood circulation	0.94
29. Maintaining patient's body temperature	0.95
30. Maintaining patient's position	0.95
31. Maintaining patient's depth of anaesthesia	0.94
32. Maintaining patient's neuromuscular relaxation	0.94
33. Relieving patient's pain	0.94
34. Relieving patient's nausea and vomiting	0.94
Knowledge of anaesthesia care (5 items' Cronbach's α)	**0.88**
35. Knowledge of different types of anaesthesia techniques	0.88
36. Knowledge of anatomy relevant to anaesthesia techniques	0.84
37. Knowledge of difficult airway management	0.85
38. Knowledge of legislation relevant to anaesthesia	0.85
39. Knowledge of economic efficiency in anaesthesia care	0.86

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