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Current methods of nurse-surgeon training and education: Systematic review

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ABSTRACT

Background: The role of nurse-surgeons has recently emerged to meet patient and health system surgical demands. However, methods of nurse-surgeon training and education requirements are unclear.

Objective: To identify and describe the current methods of nurse-surgeon training and education worldwide.

Design: Systematic review.

Method: An electronic search was conducted using Cumulative Index to Nursing and Allied Health, Cochrane Library, Medical Literature Analysis and Retrieval System Online, Public Medical Literature Analysis and Retrieval System Online, and Google Scholar databases. Key words included nurse-surgeon, training, education, and perioperative. Following screening for inclusion, a mixed methods critical appraisal tool was used to ascertain methodological rigour and the Grading of Recommendations, Assessment, Development and Evaluations framework to assess confidence in the evidence. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram and checklist for reporting systematic reviews were used.

Results: A total of 18 studies was included in this review. Current methods of nurse-surgeon training were identified as surgical speciality specific (n = 18). Most training courses were at least one year in length (n = 4) with a theoretical component (n = 15). All studies included a practical requirement (n = 18), which was generally supervised by a physician (n = 16). A competency assessment was required by 15 programmes, with nine (9) using a formative assessment approach. The evidence available for this review is low in quality and certainty.

Conclusions: Current methods of nurse-surgeon training have been identified to be specific to speciality areas. Overall, training has required nurse-surgeons to undergo andragogical education in theory, supervision in practice by a surgeon and assessment of competency. An implication for practice is a streamlined nursing pathway to surgical residency training which would improve global surgical health outcomes and retain young perioperative nurses.

Contribution of the paper What is already known?

1. Nurse-surgeons perform safe and effective surgeries on par with their medical counterparts.
2. Nurse-surgeons are valuable in emergency surgery, cancer diagnoses, and rural and remote health.

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What this paper adds

1. This review found that the current methods of nurse-surgeon training are surgical specialty-specific and have three components in common: theory teaching; physician-supervised practicum; and surgical competency assessment.
2. With the negative impact of coronavirus restrictions on face-to-face training and education of surgical interns and medical students, this review provided an alternative to surgical capacity optimisation in the post-pandemic era through internal upskilling of experienced perioperative nurses to perform surgeries independently.
3. This review highlighted the lack of high-quality research in nurse-surgeon training and education, and in nurse-led surgery models of care as a whole.

1. Background

Almost five billion people or 62% of the world population do not have access to emergency and essential surgeries (Alkire et al., 2015; Chamie, 2020; Meara et al., 2015). As a result, 18 million lives are lost every year from surgically treatable conditions (Reddy et al., 2020). In 2014, the World Health Organisation, 2014 highlighted the critical need to strengthen the delivery of emergency and essential surgical services as a vital component of universal health care. However, a major barrier in achieving universal access to surgical care is in itself a global challenge that many health systems have grappled with for decades – the chronic shortage of fully trained surgeons (Holmer et al., 2015).

In 2008, the World Health Organisation, 2008 launched the strategy Task Shifting which aimed to improve public access to essential health services by redistributing specific tasks within healthcare for a more efficient use of the available clinical human resources (World Health Organisation, 2008). In the intraoperative and surgical context, this meant training nurses to perform surgeries autonomously in surgical specialties where surgeons were scarce (Burton, 2017; Chu et al., 2009).

Nurse-performed surgery is not a novel concept as it predates the Task Shifting strategy of the World Health Organisation (2008) by at least 60 years (White et al., 1987). In the 1950s, the first documented nurse-surgeon was trained by an American missionary surgeon to perform obstetric surgeries in sub-Saharan Africa (White et al., 1987). The decision to train this nurse-surgeon emerged from the same problem still experienced today, the need to redesign surgical capacity to meet surgical demands with limited physicians (Bath et al., 2019; World Health Organisation, 2014).

From the 1950s to early 2000s, nurse-surgeons were increasingly used in the United States (Giramonti and Kogan, 2018; Sprout, 2000; Spencer and Ready, 1977), United Kingdom (Moshakis et al., 1996) and many African countries (Gichangi et al., 2015) in the fields of general, obstetric and gynaecological surgery (White et al., 1987), ophthalmology (Gallagher, 2017), interventional radiology (Dryer, 2006), vascular surgery (Hickey and Cooper, 2009), and diagnostic cancer screening in gastroenterology (Wright, 2000), gynaecology (Bodle et al., 2008), urology (Gidlow et al., 2000) and dermatology (Godsell, 2005). In the past decade, Australia (Duncan et al., 2017), Canada (Smith, 2010), Denmark, Ireland, Netherlands (Pfeifer and Schilling, 2016), Hong Kong (Hui et al., 2015), Indonesia (Sediyo et al., 2018), New Zealand (Doughty and Watkins, 2018) and Spain (Lujan et al., 2013) have also developed their own nurse-led surgery models of care.

The global contribution of nurse-surgeons has been extensive. They performed emergency caesarean sections and hysterectomies that saved the lives of mothers and infants at risk (White et al., 1987). Nurse-surgeons have diagnosed and removed life-threatening blood clots through angiograms and percutaneous thrombectomies (Dryer, 2006). They improved patient access to urgently needed diagnostic screening of many gynaecological conditions (Bodle et al., 2008) and cancers of the bowel (Wright, 2000), skin (Godsell, 2005) and bladder (Gidlow et al., 2000) in rural (Redwood et al., 2009) and urban settings. Cancers of the bowel, skin and bladder are the most common cancers in the world (World Health Organisation, 2021). Bowel cancer, in particular, is the world's second deadliest cancer (World Health Organisation, 2021) yet one of the most treatable if detected early. Collectively, nurse-surgeons' contributions ultimately led to shortened wait times for essential surgical services across many specialties, improved patient access to essential surgeries in remote, rural, and indigenous areas, and prevention of deaths from numerous surgically treatable conditions.

The field of surgery has traditionally been defined by modern healthcare as an exclusive domain of physicians (Gough, 2009). However, there is now a growing body of evidence that this is no longer the case. Nurse-surgeons can perform safe and effective surgeries on par with their medical counterparts. This has been proven consistently over the past 70 years. Hence, with the support of the World Health Organisation and many health systems worldwide, there is now a compelling need to redesign the surgical workforce to address the global health challenges and therefore fully achieve universal access to surgical care (World Health Organisation, 2014).

Nurses are at the forefront of this innovation in surgery. However, as in any other innovations in health care, with the concept and utilisation of nursing practice in surgery continuously evolving, gaps in its development are also arising concurrently (Bartels, 2005). One major gap in the efficient delivery of nurse-led surgeries is the lack of a standard method of nurse-surgeon training and education (Bath et al., 2019). Although there is literature available, to the authors' best knowledge, there is no known study yet that synthesised the data from extant literature to benchmark the surgical training and education of nurse-surgeons. While physicians wanting to become surgeons undergo a defined surgical training and education set by national medical boards (Gough, 2009), nurses on the other hand, do not currently have a recognised pathway to surgical specialisation. Therefore, this systematic review aims to identify and describe the methods used to train and educate nurse-surgeons.

2. Methods

The methods of this systematic review were reported based on the Preferred Reporting Items for Systematic Reviews and Meta-analyses statement checklist (Page et al., 2021).

2.1. Eligibility criteria

The authors collectively developed detailed study eligibility criteria (Higgins et al., 2021; Aromataris and Munn, 2020) as shown in supplementary material 1. Population was practicing nurse-surgeons regardless of titles and surgical specialties. Interventions were the methods of training and education with training referring to the practical components and education as the theoretical components of the programme. The outcome was to enable nurse-surgeons to have the knowledge, skills, and competence to practice. Contexts were perioperative department, operating room, operating theatre, day surgery unit or outpatient clinic, endoscopy unit, catheterisation laboratory or interventional radiology, and nurse-led surgical service or clinic. Articles included were published in the English-language, qualitative, quantitative, and mixed methods studies with no date restriction. The authors have excluded grey literature and systematic reviews. Any surgical assisting roles were also excluded, including but not limited to Perioperative Nurse Surgeon's Assistant, Non-Medical Surgical Assistant, Registered Nurse First Surgical Assistant, and Registered Nurse First Assistant. Surgical assistants were excluded as they do not perform surgeries independently. For the purpose of this review, the authors adapted the World Health Organisation definition of surgery as invasive procedures that is performed aseptically, and usually with the use of appropriate anaesthesia, by trained surgeons, other physicians, nurses, and other non-physicians to investigate and/or treat surgical conditions (Debas et al., 2006).

2.2. Search strategy

A search strategy (Aromataris and Munn, 2020) was identified and the search undertaken in April 2021. The authors have considerable knowledge and experience in nursing education and perioperative nursing (Aromataris and Munn, 2020). The search terms included a combination of Medical Subject Headings, phrases, and keywords for each database (see supplementary material 2). The information sources were Cumulative Index to Nursing and Allied Health, Cochrane Library, Medical Literature Analysis and Retrieval System Online, Public Medical Literature Analysis and Retrieval System Online, Google Scholar and handsearching.

2.3. Selection process

The Preferred Reporting Items for Systematic Reviews and Meta-analyses flow diagram was used to guide the search results (Page et al., 2021). All articles were imported to Covidence®, an online platform that streamlines systematic reviews (Covidence, 2021). Covidence® was also the automation tool for duplicate detection. One author (TG) conducted the title and abstract screening. Two of four authors (TG, VB, AB, EJ) assessed the articles for full text eligibility. Disagreements were resolved by discussion or a third reviewer where necessary.

2.4. Quality assessment

The Mixed Methods Appraisal Tool was used for quality and risk of bias assessment (Hong et al., 2018). The tool was also used as an inclusion criterion. The remaining articles from the full text review were critically appraised independently by two of four authors (TG, EJ, VB, AB) in Covidence®. This was followed by the decision from two of four authors (TG, EJ, VB, AB) to include or exclude the studies that were critically appraised. Studies that did not qualify as research papers or did not explain the training and education method were excluded. Consensus was required to complete the quality assessment and inclusion of each article. Disagreements were resolved by discussion, or a third reviewer where necessary.

2.5. Certainty assessment

Certainty assessment of the included studies was performed by one author (TG) and validated by a second author (one of EJ, VB, AB). Disagreements were resolved by discussion or a third reviewer where necessary. The authors have rated theory teaching, practicum, and surgical competency assessment as the critical outcomes of this systematic review. Training eligibility, training duration and clinical supervision were rated as important outcomes of this review. Grading of Recommendations, Assessment, Development and Evaluations framework was used to assess confidence in the body of evidence for the abovementioned critical and important outcomes (Schünemann et al., 2013). The strength of recommendation was then offered based on the overall Grading of Recommendations, Assessment, Development and Evaluations certainty assessment (Schünemann et al., 2013). The results of the certainty assessment were tabulated using GRADEpro® (GRADE Working Group 2020), a software for summarising evidence in compliance with the Grading of Recommendations, Assessment, Development and Evaluations methodology (Schünemann et al., 2013).

2.6. Data extraction and synthesis

Included studies were extracted for the following data: author/s; publication year; country; design; aim; surgical speciality; nurse-surgeon role; participant; number of nurse-led surgeries; setting; peer review; possible conflict of interest; inclusion and exclusion criteria; and findings. Data extraction was performed independently by one author (TG) and validated by a second author (one of VB, AB, EJ) in Covidence®. Disagreements were resolved by discussion or a third reviewer where necessary. The extracted data was then exported from Covidence® as a comma-separated values file and converted into an evidence matrix. All authors (TG, EJ, VB, AB) concurred that a narrative synthesis should be used to report the findings as meta-analysis was not possible due to the heterogeneity in design and characteristics of the included studies (Deeks et al., 2021). One (TG) of the four authors synthesised the extracted data which was then collectively evaluated by the remaining three authors (VB, AB, EJ) throughout the selection, extraction, and synthesis stages of the review.

3. Results

3.1. Search results

Initial searches yielded 465 results (see Fig. 1). Covidence® found 85 duplicates which were immediately removed. The remaining 380 studies were screened against titles and abstracts. A total of three hundred and four articles were excluded on title and abstract review and 76 were assessed for full-text eligibility. Full text screening returned 27 articles for quality assessment.

3.2. Result of quality and certainty assessment

The remaining twenty-seven articles were appraised in Covidence® (2021) using Mixed Methods Appraisal Tool (Hong et al., 2018) as shown in Table 1. Following the quality and risk of bias assessment, nine articles were removed. Seven articles were classified as non-research papers, and two articles (Bodle et al., 2008; Fletcher et al., 2019) did not explain the training and education methods. No studies were excluded due to low quality (Hong et al., 2018). A final sample of 18 articles was included.

The results of the certainty assessment are outlined in Table 2. Using the Grading of Recommendations, Assessment, Development and Evaluations approach (Schünemann et al., 2013), the authors' confidence in the body of evidence available in this review for the critical and important outcomes are the following: low for education or theory teaching; low for training or the practical component; very low for surgical competency assessment; low for training eligibility; very low for training duration; and low for clinical supervision.

3.3. Study characteristics

The characteristics of the included studies are outlined in Table 3. Eighteen studies published between 1984 and 2020 met the eligibility criteria. The majority of the studies were conducted in the United States ($n = 7$) and United Kingdom ($n = 7$) followed by Hong Kong ($n = 2$), Australia ($n = 1$) and Congo ($n = 1$). Eleven of the included articles were quantitative descriptive, three were non-randomised controlled trials, two were randomised controlled trials, one was qualitative, and one was mixed methods. Peer review was reported in only one of the 18 articles. All studies were conducted in the hospital setting: 13 in endoscopy unit; two in day surgery; two in the operating theatre and one combined hospital endoscopy unit and rural health endoscopy service. Fourteen (78%) of the 18 studies stated that the training and education were organised either by the training hospital ($n = 12$) or the host country ($n = 2$) to address the need for additional surgical providers in their health systems. Training of nurse-surgeons was undertaken by surgeons in 15 (83%) of the 18 included studies.

A total of 5450 surgeries were performed by nurses in the included studies across a range of surgical specialties including gastroenterology ($n = 14$), ophthalmology ($n = 2$), vascular ($n = 1$) and a combined obstetric, gynaecological, and general surgery ($n = 1$).

3.4. Nurse-surgeon training and education

A variety of nurse-surgeon training and education methods was reported in the 18 included articles (see Table 4). These methods were grouped into six components representing the critical and important outcomes of this review: (1) training eligibility; (2) training duration; (3) theory teaching; (4) practicum; (5) clinical supervision; and (6) surgical competency assessment.

3.5. Training eligibility

Seventeen (94%) studies specified the background of the trainees as nurse ($n = 6$), Nurse Practitioner ($n = 5$), Registered Nurse ($n = 5$) and Surgical Care Practitioner ($n = 1$). In the Nurse Practitioner group, one allowed qualified Nurse Practitioners or Physician Assistants to train. In the Registered Nurse group, one recommended a master's degree, one recommended prescribing rights, and one allowed trainees with Registered Nurse or Licenced Practical Nurse qualification. One article (6%) did not state the trainee backgrounds.

Eleven studies (61%) noted that relevant experience is essential prior to nurse-surgeon training. Of these, five were satisfied with a

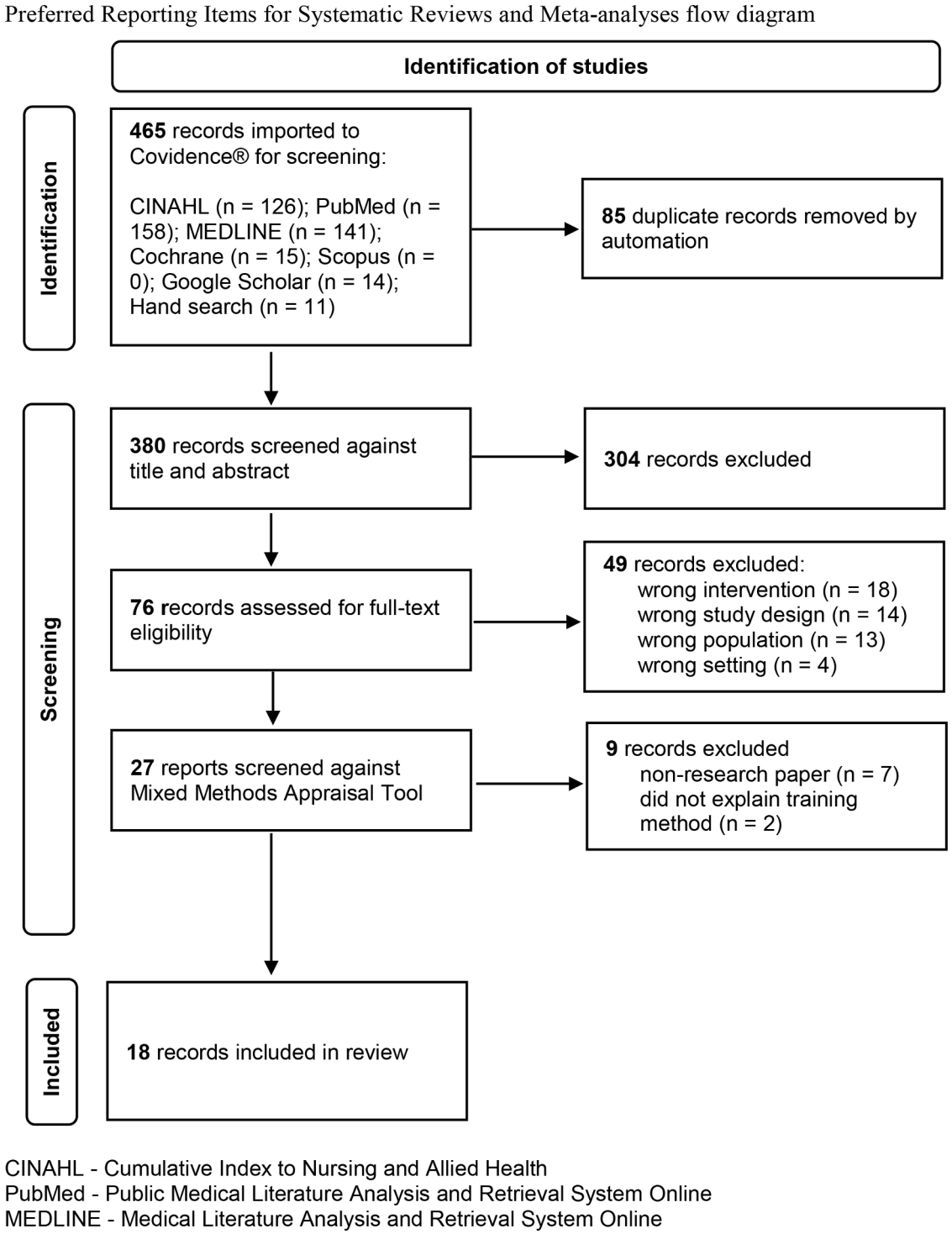

Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-analyses flow diagram
CINAHL - Cumulative Index to Nursing and Allied Health
PubMed - Public Medical Literature Analysis and Retrieval System Online

Table 1
Quality assessment.

Author	Reviewer	Overall appraisal	Category of study designs																						
			1. Qualitative					2. Quantitative randomised controlled trial					3. Quantitative non-randomised controlled trial					4. Quantitative descriptive					5. Mixed methods				
			1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	3.5	4.1	4.2	4.3	4.4	4.5	5.1	5.2	5.3	5.4	5.5
Cash et al., 1999	TG, EJ	Include																Y	Y	Y	N	Y					
Chapman et al., 2009	TG, EJ	Include	C	C	C	C	C																				
DiSario et al., 1993	TG, EJ	Include						Y	C	Y	N	Y															
Duncan et al., 2017	TG, EJ	Include	N	N	Y	C	C											Y	Y	Y	C	Y	N	Y	N	Y	C
Duthie et al., 1998	TG, VB	Include																N	N	Y	C	Y					
Gallagher, 2017	TG, VB	Include																Y	Y	Y	N	Y					
Goodfellow et al., 2003	TG, VB	Include																Y	Y	Y	N	Y					
Hasan et al., 2020	TG, VB	Include																C	C	Y	C	Y					
Hickey et al., 2009	TG, VB	Include																Y	Y	Y	Y	Y					
Hui et al., 2015	TG, VB	Include						Y	Y	Y	N	Y															
Maule, 1994	TG, AB	Include											Y	Y	Y	Y	Y										
Moshakis et al., 1996	TG, AB	Include											Y	C	C	C	Y										
Redwood et al., 2009	TG, AB	Include																Y	Y	C	C	C					
Rosevelt et al., 1984	TG, AB	Include											Y	Y	Y	C	Y										
Shum et al., 2010	TG, AB	Include																Y	Y	Y	Y	Y					
Spiegel, 1995	TG, AB	Include																C	Y	C	C	C					
White et al., 1987	TG, AB	Include																C	Y	Y	Y	C					
Wright, 2000	TG, AB	Include																Y	C	Y	C	C					
Abraham, 2019	TG, EJ	Exclude	not a research paper																								
Beck, 2013	TG, EJ	Exclude	not a research paper																								
Bodle, 2008	TG, EJ	Exclude	did not explain the training method															Y	Y	Y	C	Y					
Doughty et al., 2018	TG, EJ	Exclude	not a research paper																								
Dryer, 2006	TG, EJ	Exclude	not a research paper																								
Fletcher et al., 2019	TG, VB	Exclude	did not explain the training method															Y	C	Y	C	Y					
Godsell, 2005	TG, VB	Exclude	not a research paper																								
Gruber, 1996	TG, VB	Exclude	not a research paper																								
Hough, 2012	TG, VB	Exclude	not a research paper																								

Y – yes; **N** – no; **C** – can't tell

1.1. Is the qualitative approach appropriate to answer the research question? **1.2.** Are the qualitative data collection methods adequate to address the research question? **1.3.** Are the findings adequately derived from the data? **1.4.** Is the interpretation of results sufficiently substantiated by data? **1.5.** Is there coherence between qualitative data sources, collection, analysis, and interpretation? **2.1.** Is randomization appropriately performed? **2.2.** Are the groups comparable at baseline? **2.3.** Are there complete outcome data? **2.4.** Are outcome assessors blinded to the intervention provided? **2.5.** Did the participants adhere to the assigned intervention? **3.1.** Are the participants representative of the target population? **3.2.** Are measurements appropriate regarding both the outcome and intervention (or exposure)? **3.3.** Are there complete outcome data? **3.4.** Are the confounders accounted for in the design and analysis? **3.5.** During the study period, is the intervention administered (or exposure occurred) as intended? **4.1.** Is the sampling strategy relevant to address the research question? **4.2.** Is the sample representative of the target population? **4.3.** Are the measurements appropriate? **4.4.** Is the risk of nonresponse bias low? **4.5.** Is the statistical analysis appropriate to answer the research question? **5.1.** Is there an adequate rationale for using a mixed methods design to address the research question? **5.2.** Are the different components of the study effectively integrated to answer the research question? **5.3.** Are the outputs of the integration of qualitative and quantitative components adequately interpreted? **5.4.** Are divergences and inconsistencies between quantitative and qualitative results adequately addressed? **5.5.** Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?

Table 2
Grading of Recommendations, Assessment, Development and Evaluations certainty assessment (narrative table).

Certainty assessment № of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Narrative description	Certainty	Importance
Theory teaching 15	Mixed (1 randomised controlled trial)	serious [a]	not serious	not serious	serious [b]	publication bias strongly suspected [c]	12 (80%) in the teaching hospital, 2 (13%) as formal university course, 1 (7%) did not explain in detail	⨁⨁◯◯ LOW	CRITICAL
Practicum 18	Mixed (2 randomised controlled trials)	serious [d]	not serious	not serious	serious [b]	publication bias strongly suspected [c]	11 (61%) included a series of observations and supervised procedures (median = 35 observations and 35 procedures), 6 (33%) did not explain in detail, and 1 apprenticeship style (6%). Surgeries performed by nurses (n = 5450)	⨁⨁◯◯ LOW	CRITICAL
Surgical competency assessment 15	Mixed (2 randomised controlled trials)	serious [e]	serious [f]	not serious	serious [b]	publication bias strongly suspected [c]	9 (60%) trainees deemed competent upon completion of training and performance of procedures (median = 57), 2 (13%) used an external assessment tool for assessing physicians, 2 (13%) were dependant on the clinical supervisor, 1 (7%) assessed by an independent physician, and 1 (7%) used a 50-single best answer examination.	⨁◯◯◯ VERY LOW	CRITICAL
Training eligibility 17	Mixed (2 randomised controlled trials)	serious [g]	not serious	not serious	serious [b]	publication bias strongly suspected [c]	Background: 6 (35.2%) nurses, 5 (29.4%) Nurse Practitioners, 5 (29.4%) Registered Nurses, 1 (6%) Surgical Care Practitioner.		
Relevant experience was essential prior to training in 11 studies: 5 (45.5%) Registered Nurse with relevant experience, 3 (27.3%) Nurse Practitioner with relevant	⨁⨁◯◯ LOW	IMPORTANT							

(*continued on next page*)

Table 2 (*continued*)

Certainty assessment N° of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Narrative description	Certainty	Importance
experience, 2 (18.2%) prescribing rights and relevant experience, 1 (9%) relevant experience and master's degree.									
Training duration 11	Mixed (1 randomised controlled trial)	serious [h]	very serious [f]	not serious	serious [b]	publication bias strongly suspected [c]	4 (36.4%) were one year, 2 (18.2%) were 1 month, 2 (18.2%) were varied, 1 (9.1%) was 1–2 years, 1 (9.1%) was 8 months, 1 (9.1%) was 3 months. Median = 1 year	⨁x̂x̂x̂ VERY LOW	IMPORTANT
Clinical supervision 16	Mixed (2 randomised controlled trials)	serious [i]	not serious	not serious	serious [b]	publication bias strongly suspected [c]	15 (94%) were physicians, 1 (6%) was either nurse or physician	⨁⨁x̂x̂ LOW	IMPORTANT

Certainty rating.
⨁x̂x̂x̂ very low – the true effect is probably markedly different from the estimated effect.
⨁⨁x̂x̂ low – the true effect might be markedly different from the estimated effect.
⨁⨁⨁x̂ moderate – The authors believe that the true effect is probably close to the estimated effect.
⨁⨁⨁⨁ high – The authors have a lot of confidence that the true effect is similar to the estimated effect.
Explanations.
a. 9 quantitative descriptive, 2 non-randomised controlled trials, 1 randomised controlled trial, 1 qualitative, 1 mixed methods.
b. Limited estimates of effect across the studies.
c. not reported.
d. 11 quantitative descriptive, 3 non-randomised controlled trials, 2 randomised controlled trials, 1 qualitative, 1 mixed methods.
e. 10 quantitative descriptive, 2 non-randomised controlled trials, 2 randomised controlled trials, 1 qualitative.
f. studies show mixed results.
g. 11 quantitative descriptive, 2 non-randomised controlled trials, 2 randomised controlled trials, 1 qualitative, 1 mixed methods.
h. 7 quantitative descriptive, 2 non-randomised controlled trials, 1 randomised controlled trial, 1 mixed methods.
i. 10 quantitative descriptive, 3 non-randomised controlled trials, 2 randomised controlled trials, 1 mixed methods.

Table 3
Characteristics of included studies.

Author (year)	Country	Study design	Aim of study	Participant	Surgeries performed by nurse	Setting	Training organised by	Surgical speciality (procedure performed by nurse-surgeon)	Peer review
Cash et al. (1999)	United States	Quantitative descriptive	To assess the state board of nursing guidelines about the performance of flexible sigmoidoscopy by nurses and to determine the current use and training of paramedical personnel in flexible sigmoidoscopy at gastroenterology fellowship programs in the United States	50/50 US Boards of Nursing; 162/164 US Gastroenterology Fellowship Training Programs	Not stated	Hospital Endoscopy Unit	Not stated	Gastroenterology (flexible sigmoidoscopy, colonoscopy, polypectomy, oesophageal banding, sclerotherapy)	Not stated
(Chapman and Cooper, 2009)	United Kingdom	Qualitative	To examine perceptions of United Kingdom nurse endoscopists regarding their experience of the role	8 nurses with at least one year experience as endoscopist	Not stated	Hospital Endoscopy Unit	Not stated	Gastroenterology (6/8 perform upper gastrointestinal endoscopy, 7/8 perform lower gastrointestinal endoscopy)	Not stated
DiSario et al. (1993)	United States	Quantitative Randomised Controlled Trial	To look at appropriate training programs for nonphysician personnel	246 patients scheduled for sigmoidoscopy	246	Hospital Endoscopy Unit	Training hospital	Gastroenterology (flexible sigmoidoscopy)	Not stated
Duncan et al. (2017)	Australia	Mixed methods	To describe the preparation, introduction, and evaluation of the Nurse Endoscopist role in Monash Health, Australia	40 patients who had colonoscopy performed by a nurse endoscopist	40	Hospital Endoscopy Unit	Australian government	Gastroenterology (colonoscopies to the terminal ileum, snare polypectomies, biopsy and tattooing, flexible sigmoidoscopy, and carbon dioxide insufflation of the bowel)	Not stated
Duthie et al. (1998)	United Kingdom	Quantitative descriptive	To design and evaluate a training programme for nurse endoscopists	215 colorectal patients examined by trained nurse practitioner	215	Hospital Endoscopy Unit	Training hospital	Gastroenterology (flexible sigmoidoscopy)	Not stated
Gallagher (2017)	United Kingdom	Quantitative descriptive	To determine the patient satisfaction of patients having nurse led intravitreal therapy	100 patients undergoing nurse led intravitreal therapy	100	Hospital Day Surgery	Training hospital	Ophthalmology (intravitreal therapy)	Not stated
Goodfellow et al. (2003)	United Kingdom	Quantitative descriptive	To describe the first full year of independent practice by a newly appointed nurse endoscopist in a district general hospital in the United Kingdom	282 patients who underwent nurse-led flexible sigmoidoscopy	282	Hospital Endoscopy Unit	Training hospital	Gastroenterology (flexible sigmoidoscopy)	Not stated
Hasan et al. (2020)	United Kingdom	Quantitative descriptive	To describe the Swindon model of training nurses to be independent intravitreal therapy injectors	22 ophthalmic nurses	Not stated	Hospital Day Surgery	Training hospital	Ophthalmology (intravitreal therapy)	Not stated
Hickey et al. (2009)	United Kingdom	Quantitative descriptive	To assess whether a Surgical Care Practitioner operating at advanced level could make a major contribution to day-case varicose vein surgery	1 Surgical Care Practitioner with theatre nursing background	152 sapheno-femoral disconnections (minus 1 where surgeon took over), 91 leg avulsions, 191 groin wound closure	Hospital Operating Theatre	Training hospital	Vascular (sapheno-femoral disconnection, long saphenous vein stripping, avulsions, and wound closure)	Not stated
Hui et al. (2015)	Hong Kong		To test the hypothesis that trained nurse endoscopists are not	787 patients undergoing colonoscopy but only	364	Hospital Endoscopy Unit	Not stated	Gastroenterology (colonoscopy and polypectomy)	Yes

(*continued on next page*)

Table 3 (*continued*)

Author (year)	Country	Study design	Aim of study	Participant	Surgeries performed by nurse	Setting	Training organised by	Surgical speciality (procedure performed by nurse-surgeon)	Peer review
		Quantitative Randomised Controlled Trial	inferior to medical endoscopists in finding adenomas during colonoscopy	731 were used for analysis due to protocol deviation -					
Maule (1994)	United States	Quantitative non-Randomised Controlled Trial	To determine whether screening by flexible sigmoidoscopy could be performed safely and accurately by nurses	Patients undergoing flexible sigmoidoscopy – 1881 examined by nurses and 730 examined by physicians	1881	Hospital Endoscopy Unit	Training hospital	Gastroenterology (flexible sigmoidoscopy)	Not stated
Moshakis et al. (1996)	United Kingdom	Quantitative non-Randomised Controlled Trial	To compare the performance of flexible sigmoidoscopy by a nurse (trainee) vs a physician (trainer)	100 patients who had flexible sigmoidoscopy performed by nurse trainee or physician trainer	100	Hospital Endoscopy Unit	Training hospital	Gastroenterology (flexible sigmoidoscopy and clinical coloproctology)	Not stated
Redwood et al. (2009)	United States	Quantitative descriptive	To describe the development, implementation, and outcome of a program to train rural nurse practitioners and physician assistants to perform flexible sigmoidoscopy in rural Alaska	3 flexible sigmoidoscopy trainees – 3 nurse practitioners, 2 physician assistants, and 1 osteopathic doctor	419	Hospital Endoscopy Unit (Stage 1); Rural health endoscopy service (Stage 2)	State of Alaska	Gastroenterology (flexible sigmoidoscopy)	Not stated
Rosevelt et al. (1984)	United States	Quantitative non-Randomised Controlled Trial	Not stated	825 patients who underwent flexible sigmoidoscopy by trained nurse practitioner	825	Hospital Endoscopy Unit	Training hospital	Gastroenterology (flexible sigmoidoscopy, superficial biopsies)	Not stated
Shum et al. (2010)	Hong Kong	Quantitative descriptive	To describe the process and explore the feasibility of training a colorectal nurse in Hong Kong to perform flexible sigmoidoscopy.	119 patients who underwent flexible sigmoidoscopy by the trained nurse endoscopist	119	Hospital Endoscopy Unit	Training hospital	Gastroenterology (flexible sigmoidoscopy)	Not stated
Spiegel (1995)	United States	Quantitative descriptive	To describe a flexible sigmoidoscopy training program for nurses in an American hospital	100 patients who underwent sigmoidoscopy by nurse endoscopist	100	Hospital Endoscopy Unit	Training hospital	Gastroenterology (flexible sigmoidoscopy and biopsies)	Not stated
White et al. (1987)	Congo	Quantitative descriptive	To describe the performance of emergency obstetric surgeries by nurses in Congo	390 patients who had surgery – 326 performed by nurses, 64 performed by physicians	326	Hospital Operating Theatre	Training hospitals (Karawa and Wasolo hospitals)	Obstetrics and Gynaecology (caesarean section, supracervical hysterectomy for ruptured uterus, dilatation and curettage, symphysiotomy, suction extraction and episiotomy) / General (laparotomy and hernia repair)	Not stated
Wright (2000)	United States	Quantitative descriptive	To investigate the role and experiences of gastroenterology nurse endoscopists in the United States and their opinions regarding basic job and curriculum requirements for further developing this advanced practice role	17 practicing nurse endoscopists	Not stated	Hospital Endoscopy Unit	Not stated	Gastroenterology (flexible sigmoidoscopy)	Not stated

Table 4
Summary of nurse-surgeon training and education.

Author, year (Country)	Procedures performed by nurse-surgeon	Eligibility to commence training	Duration of training	Theory	Practicum	Competency assessment
Cash et al., 1999 (United States)	Flexible sigmoidoscopy, colonoscopy, polypectomy, oesophageal banding, sclerotherapy	10/50 States explicitly approve the practice by Registered Nurses. 25/50 States explicitly approve the practice by Nurse Practitioners. 48/50 States permit practice by Registered Nurses and/or Nurse Practitioners (based on explicit advisory opinions or decision-making models for the scope of nursing practice)	Not stated	None of the United States boards of nursing has a specific training program that must be completed before a nurse can perform flexible sigmoidoscopy independently	None of the United States boards of nursing has a specific training program that must be completed before a nurse can perform flexible sigmoidoscopy independently. 24/24 teaching hospitals have surgeons supervising the practical training	21/24 teaching hospitals require completion of at least 25 supervised flexible sigmoidoscopies as recommended for physicians by the American Society for Gastrointestinal Endoscopy or the American College of Physicians.
(Chapman and Cooper, 2009) (United Kingdom)	6/8 perform upper gastrointestinal endoscopy, 7/8 perform lower gastrointestinal endoscopy	2/8 have prescribing rights 4/8 recommend trainees to be Registered Nurse 5/8 recommend trainees to have endoscopy experience	Not stated	Variable – majority (specific number not stated) had gone degree-level Nurse Endoscopist courses. 2/8 did not complete degree-level Nurse Endoscopist courses.	Participants described a variety of education and training experiences (details not provided)	Not stated
DiSario et al., 1993 (United States)	Flexible sigmoidoscopy	Experience in gastroenterology nursing	Not stated	Written and video materials, didactic sessions and use of plastic colon models	Surgeon supervised all aspects of practical training	A mean of 20 supervised procedures was necessary to reach proficiency. 1/10 Registered Nurse did not achieve proficiency after 35 procedures
Duncan et al., 2017 (Australia)	Colonoscopies to the terminal ileum, snare polypectomies, biopsy and tattooing, flexible sigmoidoscopy, and carbon dioxide insufflation of the bowel	Grade 5 Clinical Nurse Consultant	12 months	Theoretical classes from the University of Hull in the United Kingdom, Master's degree on completion of training	Surgeon supervised the practical training	Competency is achieved after 100 unassisted, supervised colonoscopies and at least 90% caecal intubation rate
Duthie et al., 1998 (United Kingdom)	Flexible sigmoidoscopy	Colorectal Nurse Practitioner	Variable	Study days covering a broad spectrum of theoretical, moral, and legal issues relating to colorectal disease and flexible sigmoidoscopy	Surgeon supervised practicum involving 35 observations, 35 withdrawals, 35 full examinations.	Independent practice was permitted only when the clinical supervisor was satisfied with the competence of trainee, and theory and practicum had been completed successfully. The trainee should be able to identify both normal and abnormal anatomy and complete the examination

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Table 4 (*continued*)

Author, year (Country)	Procedures performed by nurse-surgeon	Eligibility to commence training	Duration of training	Theory	Practicum	Competency assessment
						within 20 min without assistance
Gallagher, 2017 (United Kingdom)	Intravitreal therapy	Extensive clinical expertise in ophthalmic patient care (specific length of experience not stated) and a prescribing qualification	Not stated	Anatomy and physiology of the eye, and medical retinal pathophysiology, clinical trials, pharmacology, and ocular coherence tomography interpretation.	Surgeon supervised consisting of wet lab training, 50 observations and 50 procedures.	Clinical supervisor (consultant ophthalmologists) assessed the competency using protocols and criteria approved by the local quality improvement team.
Goodfellow et al., 2003 (United Kingdom)	Flexible sigmoidoscopy	Colorectal Nurse Practitioner in first year of independent practice	1 year	Delivered by the University of Hull in the United Kingdom	Surgeon supervised involving 35 observations, 35 withdrawals, and 35 full procedures	Surgical competency was achieved on completion of the training
Hasan et al., 2020 (United Kingdom)	Intravitreal therapy	Ophthalmic Nurse Practitioner	12 weeks	There is a theoretical component, but details were not provided	Surgeon supervised involving 50 observations and 50 procedures	50 single best-answer questions (pass mark 100%), all competencies must be signed off prior to independent practice
Hickey et al., 2009 (United Kingdom)	Sapheno-femoral disconnection, long saphenous vein stripping, avulsions, and wound closure	Qualified Surgical Care Practitioner with a Master of Science qualification in Advanced Nursing Practice and completed Royal College of Surgeons of Edinburgh Basic Surgical Skills and Anatomy courses	Not stated	Skills in varicose vein surgeries were taught by a consultant surgeon in six training modulesduring surgical lists	Practicum based on the same standard set for surgical trainees. A surgeon supervised all aspects of the training.	Competency assessment was based on the same standard set for surgical trainees. Competencies in: (a) duplex-assisted marking achieved in three hours and 15 supervised practices; (b) varicose vein avulsions after 2 cases; (c) sapheno-femoral ligation after 7 cases; (d) long saphenous vein stripping after 5 cases
Hui et al., 2015 (Hong Kong)	Colonoscopy and polypectomy	At least 10 years' experience in endoscopy nursing	1 year	Not stated	Observation and hands-on experience and a documented assessment of proficiency based on the Joint Advisory Group on Gastrointestinal Endoscopy requirements; presence of a clinical supervisor not stated	A documented assessment of proficiency based on the Joint Advisory Group on Gastrointestinal Endoscopy requirements.
Maule, 1994 (United States)	Flexible sigmoidoscopy	Licensed Practical Nurse or Registered Nurse	Variable	Each nurse read a standard textbook on the rationale for screening and the technique of sigmoidoscopy and	3–5 weeks of practical training supervised by a surgeon involving 35	Independent practice was permitted on completion of practical training

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Table 4 (*continued*)

Author, year (Country)	Procedures performed by nurse-surgeon	Eligibility to commence training	Duration of training	Theory	Practicum	Competency assessment
				reviewed a collection of 35 mm slides showing endoscopic anatomy.	observations, 30 withdrawals, and 35 examinations.	
Moshakis et al., 1996 (United Kingdom)	Flexible sigmoidoscopy and clinical coloproctology	Not stated	Not stated	Anatomy, physiology, pathology, and clinical aspects of gastrointestinal disease, with special emphasis on the colorectum, general endoscopy equipment training covered the mechanisms, cleaning, and maintenance of flexible sigmoidoscopes. The principles and practice of infection control and the function and organization of endoscopy units were also taught	50 observations, 50 supervised procedures, and 50 procedures with the surgeon mentor immediately available. Trainee also learnt to use the proctoscope and inject haemorrhoids.	An independent consultant gastroenterologist compared the endoscopic performances of the surgeon mentor and the Nurse Endoscopist trainee. Pupil was considered competent when her assessment scores were equal to or within 15% of those of the surgeon mentor
Redwood et al., 2009 (United States)	Flexible sigmoidoscopy	Nurse Practitioner or Physician Assistant	4 weeks	Based on the Society of Gastroenterology Nurses and Associates' Core Curriculum and Competencies and the American Academy of Family Physicians flexible sigmoidoscopy curriculum. Trainees used a computer-based endoscopy simulator to develop familiarity with scope manipulation, the sensation of scope behaviour such as looping and resistance, and recognition of abnormal pathology. The simulator also indicated patient discomfort through a computer-generated voice.	At least 25 independent procedures	Surgical competency assessments involved pre and post-tests, at least 25 independent procedures, and quarterly logs.
Rosevelt et al., 1984 (United States)	Flexible sigmoidoscopy, superficial biopsies	Nurse Practitioner	1 month	Not stated	Four surgeons supervised the training involving 50 examinations	Not stated

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Table 4 (*continued*)

Author, year (Country)	Procedures performed by nurse-surgeon	Eligibility to commence training	Duration of training	Theory	Practicum	Competency assessment
Shum et al., 2010 (Hong Kong)	Flexible sigmoidoscopy	Advanced practice nurse level	1 year	Weekly sessions conducted by one of the trainers. The training process included theoretical component but was not described in detail	Surgeon supervised involving 75 observations, 36 withdrawals, and 35 advancements and manipulations	There is final assessment process but was not explained in detail
Spiegel, 1995 (United States)	Flexible sigmoidoscopy and biopsies	3 years' experience as Registered Nurse inclusive of at least one year in gastroenterology nursing	8 months	8 weeks of theory and two weeks of simulated sigmoidoscopy training	5.5 months supervised practicum consisting of 35 withdrawals and 50 complete examinations. A gastroenterologist supervised the practical training of the two nurse trainees.	Deemed competent for independent practice on completion of training. For continued evaluation of competence, the nurse endoscopist is required to perform five sigmoidoscopies each quarter under the direct observation of the gastroenterologist
White et al., 1987 (Congo)	Caesarean section, supracervical hysterectomy for ruptured uterus, dilatation, and curettage, symphysiotomy, suction extraction, episiotomy, laparotomy, and hernia repair	A3 nurse (completed three years of secondary school followed by two years of nursing training)	1–2 years	Not stated	Nurse work primarily with one doctor (apprenticeship)	Not stated
Wright, 2000 (United States)	Flexible sigmoidoscopy	6/17 – a minimal requirement of licensure as a registered nurse, 5/17 – Bachelor of Science in Nursing degree, 7/17 specified Bachelor of Science in Nursing preferred, and 5/17 Master of Science in Nursing as a minimal requirement. 7/17 five years of general nursing experience. Subjects thought a nurse endoscopist should have gastroenterology experience and knowledge before endoscopic training ($n = 6$; mode = 2 years; range, 2–5 years)	Not stated	Review of gastroenterology anatomy and physiology ($n = 4$), reading related literature ($n = 4$),	observation of endoscopic procedures ($n = 6/17$), and hands-on practice ($n = 11/17$). 12/17 were taught by a physician, 3/17 were trained by a nurse or nurse/physician team, 2/17 did not identify their trainers.	The number of supervised endoscopies required before independent practice as an endoscopist ranged from 10 to 104.

Registered Nurse qualification and relevant experience to commence training, while six recommended further qualifications as a Nurse Practitioner ($n = 3$), prescriber ($n = 2$), or a master's degree holder ($n = 1$). Seven studies (39%) did not mention relevant experience as a component of their nurse-surgeon training.

3.6. Training duration

Training duration was stated in 11 (61%) of the 18 included studies (median = 1 year). Of these, four were one year, two were one month, one was varied from one to two years, one was eight months, and one was three months. The remaining seven (39%) articles did not report the training duration.

3.7. Theory teaching

Theory teaching was described in 15 (83%) of the 18 included studies: 12 were conducted in the training hospital with four of these studies reporting simulation training included; two were taught as a formal university course; and one was not explained in detail albeit was present in the training programme. Three (17%) studies did not state the theoretical component of the training.

3.8. Practicum

All studies indicated practicum or a practical section as a component of nurse-surgeon training. Eleven (61%) included a series of observations and supervised performance of surgical procedures (median = 35 observations and 35 procedures). Distribution of these 11 studies showed a majority of 50 observations and 50 procedures ($n = 3$) and 35 observations and 35 procedures ($n = 3$). The number ranged from 25 to 75 required observations and 25 to 35 required procedures.

One (6%) of the 18 articles described an apprenticeship style while six (33%) did not explain the practical component of the training in detail albeit present in the training programme.

3.9. Clinical supervision

Sixteen (89%) of the 18 studies had a supervisor during the practical training. Of these, 15 were physicians and one was either a nurse or a physician. Two (11%) articles did not confirm the availability of a clinical supervisor during training.

3.10. Surgical competency assessment

Fifteen (83%) of the 18 studies described the process of assessing the trainees' surgical competency. Nine (60%) of these 15 studies deemed the trainees as competent upon completion of training, and performance of a set number of procedures. The remaining six (40%) of the 15 studies that described surgical competency assessment had miscellaneous explanations: two used an external tool for assessing surgical competence of physicians; two was through the trainees' clinical supervisors with one using protocols and criteria approved by the training hospital's quality team and one using the supervisors' judgement only; one was through an independent physician that is not part of the training; and one was through a 100% mark on a 50-single best answer questions. Three (17%) of the 18 studies did not state surgical competency assessment as a component of their nurse-surgeon training.

The number of surgeries that nurse-surgeons needed to perform to attain surgical competence was dependant on surgical speciality. Eight (44%) of the 18 included studies stated a number of surgeries that ranged from 10 to 104; all of which were under the surgical speciality of gastroenterology. The nurse-surgeons that trained in the surgical specialties of vascular, obstetrics and gynaecology, ophthalmology and general surgery did not state a specific number of procedures to be performed to achieve surgical competence. These surgical procedures were stratified by surgical speciality in supplementary material 3.

4. Discussion

To the authors' knowledge, this systematic review is the first of its kind worldwide that investigated nurse-surgeon training and education. In the context of education, the closest study that we found is a scoping review by Hains et al., 2017 which reported the lack of a standardised approach to the education of non-medical surgical assistants in the United States, Canada, United Kingdom and New Zealand. In terms of training, a systematic review by Kogan et al., 2009 indicated the use of formative assessment, supervision, and direct observation as essential during practical training and assessment of the medical interns' clinical skills. Although Hains et al., 2017 and Kogan et al., 2009 were not representative of nurse-surgeon training and education, both studies were conducted within the perioperative context and reported similar findings to our review.

4.1. Implementation of nurse-led surgery models of care

The nurse-surgeon training and education in the included studies were organised either internally by the hospital or externally by the government as a healthcare initiative to address the need to expand the delivery of their surgical capacity. One study (Redwood et al., 2009) resulted in the successful implementation of a training and education programme for nurse-surgeons to provide essential cancer screening surgical services in the remote and indigenous communities of Alaska. Another study (Duncan et al., 2017) that was

conducted in Australia found that through the government initiative to train nurses to perform endoscopic procedures, a successful expansion of their surgical capacity ensued. Furthermore, the results of the 12 studies that initiated a local nurse-surgeon training and education programme within their hospitals were consistent in reporting the positive impact of nurse-led surgery models of care in terms of the improvement in the surgical waitlist and the timely provision of essential surgical services (Hasan et al., 2020; Gallagher, 2017; Shum et al., 2010; Hickey et al., 2009; Goodfellow et al., 2003; Duthie et al., 1998; Moshakis et al., 1996; Spiegel, 1995; Maule, 1994; DiSario and Sanowski, 1993; White et al., 1987; Rosevelt et al., 1984). Although the aim of our review was to identify and describe the current methods of nurse-surgeon training and education, the discussion of our findings regarding its implementation history is also vital particularly in leveraging the potential of nurse-surgeons to the international and national key stakeholders.

4.2. Training eligibility

Our findings suggest that it would be beneficial for nurse-surgeon trainees to have a relevant nursing background and experience in the surgical speciality that they aspire to train in. Further qualifications as a Nurse Practitioner (Hasan et al., 2020; Goodfellow et al., 2003; Redwood et al., 2009; Cash et al., 1999; Duthie et al., 1998; Rosevelt and Frankl, 1984), master's degree holder (Hickey et al., 2009; Wright, 2000) or prescriber (Gallagher, 2017) can also help particularly in clinical situations where state-regulated advanced practice such as prescription of intraoperative medications is needed.

4.3. Training duration

Five studies (Duncan et al., 2017; Hui et al., 2015; Shum et al., 2010; Goodfellow et al., 2003; White et al., 1987) recommended that nurse-surgeon trainings should be at least one year. This represents the majority and median of the included studies. This is relatively short compared to the three to seven years of surgical residency training for United States physicians before qualifying as surgeons (American College of Surgeons, 2021). However, the nurse-surgeons in the included studies were only trained to perform specific surgeries thereby effectively offsetting the difference.

4.4. Theory teaching

Most of the studies concluded that the theoretical component of nurse-surgeon training and education should be delivered in the training hospital. This coincides with the recommendation for residency trainings of physicians in which theory is also taught in the hospital setting (Rashid, 2017). Additionally, Rashid (2017) advocated for a more structured delivery of theoretical concepts using adult learning frameworks and simulation to improve the overall learning outcomes. Four studies (Gallagher, 2017; Redwood et al., 2009; Spiegel, 1995; DiSario and Sanowski, 1993) in this review also recognised the advantage of simulation and was incorporated in their programmes. It was unclear from the studies the level of the educator delivering the theory (nurse or physician).

4.5. Practicum and clinical supervision

Direct Observation of Procedural Skills is the method of choice in clinical training whereby a learner performs a procedure and is evaluated contemporaneously by a clinical supervisor following a set number of procedural observations (Erfani and Ebadi, 2018). It was interesting that in 83% of the studies, the clinical supervision and assessment of competence were undertaken by a surgeon. Clinical supervisors can function as preceptors, proctors, mentors, and coaches during practicum and are therefore vital in any surgical education and training models (Sachdeva, 2021). However, there is still an ongoing debate in terms of the number of procedures required during practicum to ensure the validity and reliability of the Direct Observation of Procedural Skills model (Mayne et al., 2020; Erfani and Ebadi, 2018). Our findings suggest that this is still the case as the included studies gave differing views on the number of procedures a nurse-surgeon trainee should observe and perform during practicum. The sample median in this review is 35 observations and 35 supervised procedures (Goodfellow et al., 2003; Duthie et al., 1998; Maule, 1994).

4.6. Surgical competency assessment

Our findings indicate that surgical competency assessment was present in 83% of the nurse-surgeon trainings in the included studies, regardless of surgical speciality. There is however a great diversity and ambiguity in the number of surgical procedures required to be performed by the nurse-surgeon trainees in the included studies. This coincides with the surgical residency programmes for physicians where surgical competency assessment is heavily dependant on the subspecialty of Surgery that they would like to specialise in (Meakins, 2001). Therefore, we do not recommend a specific number of procedures that a nurse-surgeon trainee must perform to attain surgical competence. Our study suggests that at a minimum, nurse surgical trainings should include a surgical competency assessment.

Nine studies (Duncan et al., 2017; Hickey et al., 2009; Wright, 2000; Goodfellow et al., 2003; Cash et al., 1999; Duthie et al., 1998; Spiegel, 1995; Maule, 1994; DiSario and Sanowski, 1993) utilised a formative approach to surgical competency assessment using the Direct Observation of Procedural Skills model, hence surgical competence upon completion of the training. Although this is the most widely accepted teaching and evaluation method in surgical training, Erfani and Ebadi (2018) argue that subjective factors such as assessor bias and dissimilarity could cloud the objectivity of this model. Nevertheless, Mayne et al. (2020) and Erfani and Ebadi (2018) agree that the Direct Observation of Procedural Skills model is an effective assessment tool during surgical training.

4.7. Limitations

Despite critical appraisal being undertaken, we acknowledge that the included studies did not score high for methodological rigour and quality using the Mixed Methods Appraisal Tool (Hong et al., 2018). We also acknowledge the limited number of studies included in this review, which is expected in emerging nursing practices and therefore proves that nurse-surgeon training and education is under reported. Furthermore, due to the eligibility criteria developed for this review, eight studies (Abraham, 2020; Beck, 2013; Bodle et al., 2008; Doughty and Watkins, 2018; Dryer, 2006; Fletcher and Russell, 2019; Godsell, 2005; Gruber, 1996; Hough et al., 2012) were excluded that could have further confirmed the existence, and diversified the countries, of nurse-surgeon practice. These excluded articles were conducted in Ireland (Hough et al., 2012) and New Zealand (Doughty and Watkins, 2018) that studied nurse-surgeon practice in the following specialties: dermatology (Godsell, 2005); gynaecology (Bodle et al., 2008); interventional radiology (Dryer, 2006); and urology (Fletcher and Russell, 2019).

4.8. Grading of recommendations, assessment, development and evaluations

Due to the low and very low certainty of evidence in this review and the limited number of available studies around nurse-surgeon training and education, our Grading of Recommendations, Assessment, Development and Evaluations recommendation is discretionary (Schünemann et al., 2013; Atkins et al., 2004). More high-quality studies are necessary to reach a strong recommendation for the appropriate method of nurse-surgeon training and education.

4.9. Implications for practice, policy, and future research

Although the body of evidence in this review is rated low in quality and certainty, indications from the included studies can be translated in the context of policy, practice, workforce, and future research around nurse-surgeon training and education internationally.

4.10. Policy

Our review provides the first known evidence that nurse-surgeon training and education can be streamlined by combining theory teaching, physician-supervised practicum, and surgical competency assessment. Our findings can be used by national decision makers in recommending and developing a streamlined nursing pathway to surgical residency training in many subspecialties of Surgery where surgeons are scarce, or where a surgical workforce is desperately needed to avoid the millions of deaths from many surgically treatable conditions and deliver surgical care to the billions of people needing these essential health services.

Our review is also well timed particularly in the development of policies to aptly utilise the perioperative nursing workforce in the pandemic era where optimisation of surgical capacity in many countries was further exacerbated by the coronavirus disease. Considering its restrictive impact on the face-to-face training and education of surgical interns and medical students (Al-Jabir et al., 2020), internal upskilling of nurses who are already employed within a given organisation can be an alternative in maintaining or improving the delivery and efficiency of surgical care, without the need to wait unpredictably for the coronavirus restrictions to be lifted so the surgical residency internships or clinical placements of medical students could proceed. Additionally, with the impact of coronavirus on critical care, re-deployment of surgeons and anaesthetists meant some of the surgeries might be cancelled or deprioritised (Al-Jabir et al., 2020). Again, this could be an opportune time for an internal theatre nurse to be trained to perform minor surgeries while the surgeon is re-deployed to treat a more complicated case.

4.11. Practice

Our review recommends standardisation of nurse-surgeon training and education by incorporating theory teaching, practicum, and surgical competency assessment in the programme. This standardisation will lead to consistency, uniformity, and ultimately accreditation of nurse-surgeon practice (Kriznik et al., 2019). The outcomes will be comparable and therefore could be regulated, replicated, measured, and subjected to quality improvement (Kriznik et al., 2019) to ensure that a high standard of care is provided to patients undergoing surgery. Additionally, a standard model of training and education is more likely to be adapted in practice than a novel approach without any scientific basis (Castillo, 2013).

Many inconsistencies and ambiguities in the nursing titles were also found across the included studies affecting clarity and generalisability of the studies. We recommend using a more consistent language on this topic to avoid fragmentation and isolation of research data. The authors believe that “nurse-surgeon” is the most suitable umbrella term to encapsulate this emerging perioperative nursing practice. This coincides with the terminology “surgeon” referring to physicians trained to perform surgery, regardless of surgical speciality.

4.12. Future research

Taking into account the low quality and certainty of evidence available in this review, a more rigorous research methodology should be utilised to enhance the quality and certainty of evidence around nurse-surgeon training and education. One issue that we found is the possibility of publication bias in many of the included studies (see Table 2). This could have been avoided through the use

of comprehensive reporting guidelines specific to the design of the study being conducted. Some of the included studies also used a limited number of trainees (see Table 3) affecting the generalisability of findings. A larger study might be required to improve this issue.

As our eligibility criteria excluded grey literature and non-research papers, it is highly likely that our review has not fully identified and captured the breadth of nurse-surgeon training and education worldwide. A scoping review that will include published and unpublished, research and non-research papers would be suitable in achieving this goal. Our search was also limited to English language studies which may have missed relevant studies in non-English speaking countries. Lastly, the lack of a specific medical subject heading for nurse-surgeons may have limited the ability of this review to identify all relevant studies. We therefore recommend that the keyword "nurse-surgeon" be included in the medical subject heading thesaurus.

4.13. Nursing workforce

The nursing workforce is ageing, and many early career nurses are leaving the profession (International Council of Nurses, 2021; World Health Organisation, 2020). We cannot control ageing, however, the International Council of Nurses (2021) and World Health Organisation (2020) argue that an attractive career advancement structure could be key to retaining our nurses and attracting the younger generation to enter the nursing workforce. Millennials are the most educated nurses in history, and they feel engaged through increased responsibility and maximisation of their potential; they will leave if these expectations are unmet (Keith et al., 2021). Therefore, supplying them with an attractive nursing career pathway and eliminating the notion that nurses will never equate to physicians in clinical practice might be advantageous. The World Health Organisation (2020) believe that investing in nurses will ameliorate health outcomes, sustain global health, and boost an inclusive economic climate. Nurse-led surgery is one example of an attractive career advancement pathway that has been proven to improve surgical health outcomes worldwide. Here is an innovative nursing practice that with a structured residency training, may engage nurses to stay in the profession and attract more people to enter the nursing workforce (Institute of Medicine, 2011). By empowering our perioperative nurses to reach the top of their scope of practice, we are challenging the status quo and instigating a transformational leadership within nursing that will redefine and ultimately futureproof our profession in the perioperative field (Institute of Medicine, 2011).

Conclusions

Nurse-led surgery models of care emerged from the need of many health systems worldwide to meet the growing surgical demands. Nurse-surgeon training and education were found to be at least one year in duration. The entrants would benefit from having a nursing background and experience in the relevant surgical speciality. Three components of nurse-surgeon training and education surfaced during the review. These are: andragogical theory teaching that is delivered in the teaching hospital with simulation; a practicum involving a minimum of 35 observations and performance of 35 procedures that are supervised by a surgeon; and the formative Direct Observation of Procedural Skills assessment model that deems the learner competent upon successful completion of training. An implication for policy is a recommendation for national decision makers to develop a streamlined nursing pathway to surgical residency and utilisation of internal perioperative nurses to optimise surgical capacity amidst the coronavirus restrictions on face-to-face surgical training and education of medical interns and students. For future research, a rigorous research methodology is required to improve the quality and certainty of evidence. The use of consistent language around nurse-surgeon training, education and practice may prevent fragmentation and isolation of valuable data. A scoping review might be a more suitable method in capturing the full breadth of nurse-led surgery. Standardisation of nurse-surgeon training and education will produce a consistent clinical practice that can be regulated, accredited, and adapted. A structured nurse-surgeon career pathway is an emerging nursing practice innovation that might be a key to retaining young nurses and futureproofing the profession in the perioperative setting through attractive retention strategies that are calibrated specifically for millennial nurses and the younger generation.

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Registration

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Protocol

A protocol was prepared by the authors but not submitted for registration. No amendments were made immediately after the search had commenced.

Availability of data, code, and other materials

See supplementary material 4

Declaration Competing Interest

None

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijnsa.2021.100048.

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