



The current status of simulation training and certification for thoracic surgery in Europe: a scoping review

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Background: The past two decades have seen increasingly rapid advances in new surgical techniques and procedures in thoracic surgery. One of the greatest challenges is to educate and train thoracic surgeons in a safe and patient-free environment. The content of surgical training and education differs significantly among European countries. A common European training and certification structure might provide better opportunities to educate competent thoracic surgeons in the future. The objective of this article is to summarize the current state of educational programs and certification within thoracic surgery in Europe.

Methods: A comprehensive search of the literature was performed, using PubMed Database, Medline, Cochrane and Google Scholar from May 2000 until June 2023, focusing on thoracic surgery education and training, thoracic surgery education and certification in Europe, certification, and training of general thoracic surgeons in Europe, and Canadian and American training and certification in thoracic surgery.

Results: A total of 560 articles were retrieved from PubMed/Medline, Google Scholar, and Cochrane. After removing the duplicates, 365 articles were scanned based on their title and abstract. Three hundred and twelve articles did not meet the inclusion criteria for this study. Fifty-three full text articles were assessed for eligibility and a total of 25 articles were selected for this study. In addition, we must accept the adopt advances in thoracic surgery and evolve the modern training program in thoracic surgery. There is a need for revision and refining of thoracic surgeon's curricula across Europe. By harmonizing the training programs and certification in Thoracic Surgery across Europe, we provide competent thoracic surgeons with an equalized and better patient outcome.

Conclusions: There is a need for a structured and evidence-based surgical curriculum, which includes simulation training to provide competent surgeons in Europe. Certification and examination boards with hands-on courses may ensure the quality of knowledge and help trainees gain basic and advanced surgical skills.

Keywords: Thoracic surgery; thoracic surgical education; simulation; certification

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Introduction

Surgical education faces the shift of acquisition from the current apprenticeship model, where surgeons learn surgery from their mentors to an evidence-based surgical proficiency training and education program (1). Thoracic surgery has advanced in recent years with the development of minimally invasive surgery, robotic surgery, laser therapy or endoscopic cryotherapy (2,3). The increase of more complex procedures and advances in surgical techniques, demands that thoracic surgeons are well-trained and competent to deliver the most optimal care for the patients (4-6). To overcome these obstacles, and educate future thoracic surgeons, a structured training curriculum and a formal evaluation and certification must be established.

There is a considerable variation in the content of education, training, and certification among European countries (7). According to the current European guidelines on training and educating thoracic surgeons (8), the curriculum and specific content of training depends on the individual national regulations in collaboration with specific specialty societies (9,10). E.g., the thoracic residency program in Denmark is based on the Danish regulations for all specialties (11). The framework consists

of 1 year introduction followed by 5 years of specialization and involves an apprenticeship with seven roles such as leadership, collaborator, medical expert, communicator, scholar, health advocate, and professional, which is similar to Canadian cardiothoracic curriculum, CanMed 2005 and the Royal College of Physicians (12).

The European Union of Medical Specialists (UEMS) board improves the implementation of each individual country national requirements for cardiothoracic surgery curriculum and the idea is supported by the European Society of Thoracic Surgery (ESTS) and European Association for Cardio-Thoracic Surgery (EACTS) (8,9). The UEMS Section of Thoracic Surgery and the European Board of Thoracic Surgery (EBTS) established a certificate to fellow of the EBTS. The Board exams are organized by the two Scientific Societies ESTS and EACTS. The UEMS created the European Council for Accreditation of Medical Specialist Qualification (ECAMSQ) to promote quality of education and is in charge of the duration and content of training and evaluation of competence (13).

To date, a common curriculum has not yet been developed and the specific content and organization of the curriculum in each country depend on the individual national regulations. This causes imbalance in the qualification and competency of thoracic surgeons, which can affect the quality of care offered to the patients. A common European curriculum, based on the consensus of key thoracic leaders to include theoretical and hands-on courses, where simulation is a part of training to reach competency outside the operation theatre is needed. This article reviews the data for the current training and education systems in thoracic surgery. This review provides an up-to-date information on challenges within training thoracic surgeons and discuss the existing knowledge within educational systems. We present this article in accordance with the PRISMA-ScR reporting checklist (available at <https://asj.amegroups.com/article/view/10.21037/asj-22-33/rc>).

Methods

We performed a comprehensive search of the literature, using PubMed, Medline, and Google Scholar, focusing on thoracic surgery education and training, thoracic surgery education and certification in Europe, certification, and training of general thoracic surgeons in Europe, and Canadian and American training and certification in thoracic surgery.

Highlight box

Key findings

- An up-to-date information on challenges within training and certification of thoracic surgeons and discuss the existing knowledge within educational systems.

What is known and what is new?

- Educational programs and certification of thoracic surgeons differs among European countries. There is a need for a common European certification and training program. Harmonizing training programs across European countries may increase the qualification and competency of thoracic surgeons with better patient outcome.
- An update overview of current training programs and challenges in training future thoracic surgeons.

What is the implication, and what should change now?

- There is a need for an evidence-based curriculum on how to train future thoracic surgeons across Europe. The thoracic surgical societies must take initiatives to re-structure the training program, include simulation training to prepare trainees outside operation theatre and allow trainees perform more procedure under supervision by experienced surgeons. We believe that a European based certification and examination would improve the theoretical and surgical knowledge of future surgeons.

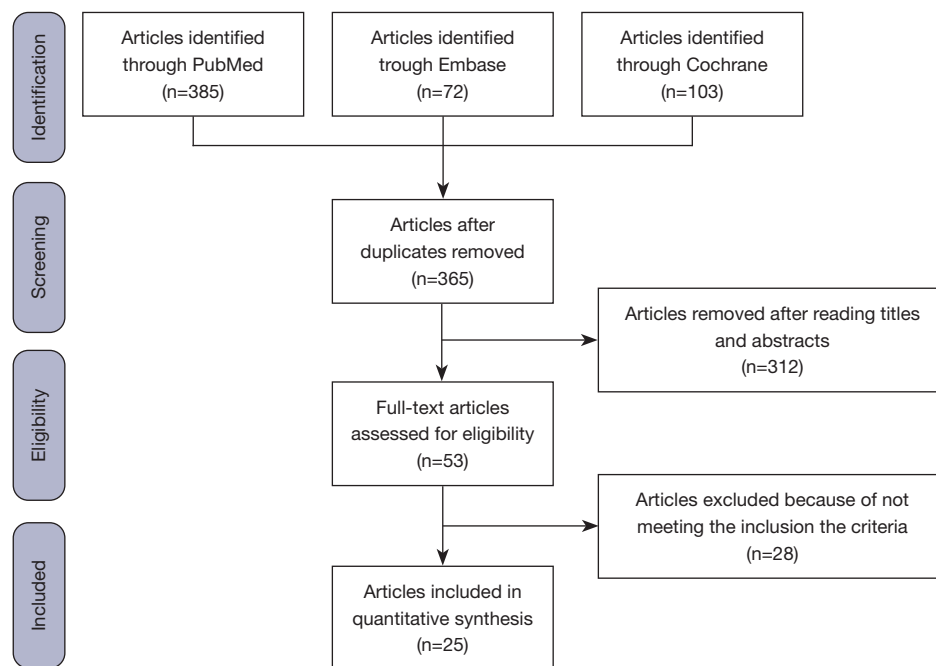


Figure 1 Flowchart showing the inclusion and exclusion of the articles.

We first conducted a search of the PubMed and OVID/Medline databases using the keywords ‘thoracic surgery education’, ‘training thoracic surgeon in Europe’, ‘certification in thoracic surgery’—we also included more general terminology such as certification and training, but excluded articles clearly conference presentation and editorial letters, including full-text accessible articles in English. We then performed an analysis that included all these studies from May 2000 to June 2023. After reviewing the articles, all potentially relevant studies were elevated. Please see the [Table S1](#).

The reference list of articles was reviewed for further identification of potentially relevant studies. All publications were limited to the English language. Inclusion criteria included studies that reported on thoracic surgery training, education, certification, and educational platform in European countries, as well as Canadian and American guidelines. Conference presentations and editorial letters were excluded.

Results

The search algorithm yielded 560 articles from PubMed/Medline, Google Scholar, and Cochrane. After the removal of duplicates, 365 articles were scanned, based on their

title and abstract, whereas 312 articles did not meet all the inclusion criteria for this study. Fifty-three full text articles were assessed for eligibility and a total of 25 articles were selected for this study as they describe the utility of education, training, and certification in cardio/thoracic surgery (*Figure 1*). The 28 articles which were not included in the study: articles that involved the impact of coronavirus disease 2019 (COVID-19) on thoracic surgery training and education, consensus on guidelines for thoracic surgeons in the American associations, single-institution experience in training cardiothoracic surgeons, and articles describing cardiothoracic surgery in single institutions. However, we did include articles comparing the European and American educational systems in cardiothoracic surgery. Five of 25 (20%) included articles involved training, simulator training, and assessment of surgical residents in thoracic surgery. These articles define the importance of surgical education and the simulators’ role in training and certification outside the operation theatre. These studies also evaluated the effectiveness of simulation training and suggested that simulation training must be embedded in surgical training curriculum. Two articles (8%) describe the advances in surgical techniques and technology and suggest trainees must be well educated to perform competently. Three articles (12%) were used to compare major differences in

education thoracic surgeons in American, Canadian, and some European countries. Four articles (16%) worked on a large consensus-based syllabus and curriculum for a harmonized European thoracic surgical education and certification. Three articles (12%) discuss future perspectives from a trainee's perspective and the effect of harmonizing the training in the future and how to structure training programs and what crucial steps must be taken. Seven other articles (28%) discuss the current guidelines on structure, qualification, and criteria regarding definition and scope of general thoracic surgery. One article (4%) describes the development of a European examination and their success in the process with better patient outcome.

Characteristic of the studies and their key findings are included in *Table 1*.

Discussion

Thoracic surgery is an evolving specialty which includes minimal invasive surgery, robotic surgery, and other advanced procedures. This complexity and high stakes of thoracic surgery affect the training and certification of future surgeons.

The training programs, theoretical content of training and length of training depend on each national regulation, and list skills and knowledge needed to diagnose and treat patients, however, there is limited evidence behind these training programs (14,15). The European thoracic surgery society and organizations are working toward a common, evidence-based European educational training program (8,9).

European guidelines on training

European guidelines on structure and qualification of general thoracic surgery suggest different approaches for training and certifying thoracic surgeons (8). There is a consensus among key leaders in thoracic surgery that a minimum of 100 minor thoracic surgical procedures per trainee must be performed in first year as a part of training future surgeons. The expert panel also suggests that training in minimal invasive surgery, board discussions, journal clubs, and discussion of pre-operative cases must be a part of educating surgeons, but these suggestions are not compulsory among institutions. Implementation as such needs more dedication from different thoracic institutions. Trainees in many institutions start with minor procedures such as pleural chest tube insertion, video-assisted thoracoscopic surgery (VATS) cyst resection,

VATS wedge resection and then they move on to more complex and advanced procedures, such as VATS lobectomy and segmentectomy. A structured and evidence-based curriculum is not available on how to train and certify trainees.

We believe there is a need for a structured approach to identify which procedures must be taught outside the operation theatre in simulation-based training and in real live surgery for newly qualified thoracic surgeons. A systematic approach for curriculum development and implementation was described by Kern (28). Kern's six steps approach to curriculum development is widely used in health care systems. The first step is to identify problem and needs. Expert consensus must be gathered in a Delphi process on how to train surgical residents. Once the procedures are identified, the Kern's six steps approach can continue to guide development and implementation of evidence-based training program and curriculum. However, there are other programs to train thoracic surgeons (12).

Working hours and academic enrichment

Working hours, clinical and non-clinical academic enrichment differ a lot from one thoracic surgical institution to another. The European guidelines suggest that working hours needs to fit with the European Working Hours Directive, but this can be very difficult (16). According to Danish law, a doctor must work 37 hours per week, however, the working hours are different in many European countries.

The academic program does not include an allocated time for research and many surgeons must perform research along with their clinical training. Academical research as a requirement in the education of thoracic surgeons would help improve trainees' knowledge and provide new information to the specialty.

Structure of training and certification

The pathway to become a board-certified thoracic surgeon differs among European countries. E.g., in Denmark, cardiothoracic residency is 5 years, after a year of internship and introduction. No other prior specialization such as general surgery is demanded (11). While in some other European countries and in the United States, it can require 5 years of residency in general surgery followed by 2 years subspecializing in thoracic surgery (10,17). Both methods have benefits and disadvantages. Training for 5 years will

Table 1 Key findings and summary of the papers included in the scoping review

Author, year	Key findings	Summary
Konge <i>et al.</i> 2018 (1)	Simulation-based training must be embedded in training curriculum	Four-step simulation training programs
Hennon <i>et al.</i> 2012 (2)	Advances in surgical techniques and technology are expanding the options for surgical diagnosis, staging, and treatment of treatment of all stages of lung cancer. These techniques have improved the risk-benefit ratio of surgery	Improvement in surgical techniques benefits patients
Hennon <i>et al.</i> 2011 (3)	Thoracoscopic lobectomy for advanced-stage NSCLC can be performed safely, with results equivalent to open techniques	We must accept the adopt advances in thoracic surgery
Bonrath <i>et al.</i> 2015 (4)	Comprehensive surgical coaching surgery is superior to conventional training for trainees learning minimal invasive surgery	Surgical training programs are effective in minimal invasive surgery
Nashaat <i>et al.</i> 2019 (5)	Simulator training provide trainees invaluable practice in the current environment where exposure to operating rooms is being decreased	There is a lack of well-designed trails validating simulators for training
Hussein <i>et al.</i> 2022 (6)	Surgical simulation is effective in the development of technical skills in cardiothoracic surgery. Simulation training is not incorporated into surgical curriculum. Implementing such training programs, need commitment from trainees and surgical associations	It is time to evolve how we train our future trainees by simulation
Massard <i>et al.</i> 2020 (7)	The European Society of Thoracic Surgeons formed a task force and developed a consensual curriculum in general thoracic surgery to promote training throughout Europe	We need a task force and experts' consensus to build a common training program
Brunelli <i>et al.</i> 2014 (8)	The task force developed criteria regarding definition, scope, structure, and qualification of general thoracic surgery unit, including training and education and recommendations for subjects of particular interest It is meant to tackle the challenge of cultural and language barriers and harmonizing European education in thoracic surgery	Need for revision of modern thoracic surgeon's curricula
Massard <i>et al.</i> 2018 (9)	Training thoracic surgeons varies in terms of training, content of training in Europe. Task forces of European Respiratory Society and the ESTS working on a large consensus-based syllabus and building curriculum	The goal of this process is to define a road map for training program for learners and teachers
Grondin <i>et al.</i> 2017 (12)	Thoracic surgery residency program includes the completion and certification in general or cardiac surgery in Canada. The duration of thoracic surgery residency is 2 years followed by a written and oral examination at the completion of training	Even though the Royal College has accredited certification in general surgery, there is a need for refining the scope of practice
Massard <i>et al.</i> 2014 (13)	Strives to present the harmonization of training and certification all over the European space	GTS and ESTS prioritize education. The educational platform aims to prepare trainees to certification and continuous medical education
Frick <i>et al.</i> 2017 (14)	Harmonization of thoracic surgery training across Europe is essential to ascertain even quality of patient care, facilitate mobility of specialists, and improve an international exchange of expertise	By harmonizing, we exchange knowledge, learn from each other and improve
Ilonen <i>et al.</i> 2015 (15)	In an ESTS survey 62% of trainee expressed an interest in working abroad. Harmonization of training would increase the opportunity of research and education	The European board of examination for thoracic surgery is a key to achieve harmonization
Tchantchaleishvili <i>et al.</i> 2010 (16)	Different cardiothoracic surgery training programs has specific strengths and weaknesses	Despite differences in training programs, we can always learn from each other

Table 1 (continued)

Table 1 (continued)

Author, year	Key findings	Summary
Moffatt-Bruce <i>et al.</i> 2014 (17)	Developed strategies to improve and promote innovation in the methods of training	Time to develop strategies to improve in the methods of training
Sherif <i>et al.</i> 2016 (18)	It's crucial for the organizations of education to adopt mechanisms for certification and provide credentialed surgeons	Certification is recognition of well-educated and skilled surgeon
Chitwood <i>et al.</i> 2008 (19)	Reforms regarding simulation training, specialty cross-training, new technology must be done. Working together thoracic surgery will be guided into right direction and provide our patient's innovative therapy	There is a need for a reform in thoracic surgery education
Depypere <i>et al.</i> 2016 (20)	Thoracic surgery training has become more structured in several European countries. More initiatives will further improve, harmonize thoracic surgery training in future	Several initiatives are taken toward harmonization of training programs, further steps are needed
Haidari <i>et al.</i> 2022 (21)	Validity evidence for a simulator-based test of VATS lobectomy competence including multiple lobes of the lungs was provided. The test can be used to ensure basic competence for thoracic surgery trainees	Different valid simulators exist, and simulation training is effective in learning surgical skills
Petersen <i>et al.</i> 2018 (22)	The VATS lobectomy assessment tool helps training and certification of thoracic surgeons	Assessment tools helps to assess trainees' performance in valid way
Jensen <i>et al.</i> 2019 (23)	The VATS lobectomy assessment tool aids supervisors with the decision of when the trainees are ready for unsupervised performance	Assessment tools in VATS surgery is valuable tool for assessing trainees
Moon <i>et al.</i> 2014 (24)	Simulation is required by the Board of American Surgeon. Simulation tools make it possible to define surgical technical skills objectively	Simulation training plays a major role to avoid major complications in the operating theatre
Lerut <i>et al.</i> 2021 (25)	The UEMS section of Thoracic Surgery contributed to the improvement of the identity of Thoracic Surgery as a specialty throughout Europe. Its main activities are focusing on harmonization of training and organization in Thoracic Surgery	The UEMS played a major role in training program across Europe
Klepetko <i>et al.</i> 2001 (26)	Important steps are taken by the European scientific societies to establish the documents needed to perform GTS under established and controlled conditions	Describing the structure of general thoracic surgery in steps
Parigi <i>et al.</i> 2021 (27)	The UEMS Section and Board of Pediatric Surgery succeeded on the development of a high-quality European examination harmonization of pediatric surgery. They are planning a standard pediatric surgery training throughout Europe	Once the necessary step is taken, the process will be successful. The key leaders in different specialties, can affect the process

NSCLC, non-small cell lung cancer; ESTS, European Society of Thoracic Surgery; GTS, general thoracic surgery; VATS, video-assisted thoracoscopic surgery; UEMS, European Union of Medical Specialties.

give the opportunity to operate more, do more research and gain experience, however at the same time, you will only be specialized in thoracic surgery and have limited experience in general surgery. This approach might be the most optimal method. In Denmark, there is no board certification exam. Trainees in thoracic surgery follow the steps in logbooks. In this process, trainees must achieve surgical and theoretical knowledge and must participate in compulsory surgical courses. Whereas in the USA the board certification requires an exam consisting of computer-based

multiple-choice questions with an oral exam (17-19).

This could be a great opportunity for residents to refresh their knowledge and study more. The European educational committee, directed by the ESTS director of education, together with UEMS coordinates teaching tracks and e-learning platforms (8,13,20). The ECAMSQ has described the content and duration of training and evaluation of competence and EBTS offers a yearly examination and certification process (13,20). The examination consists of interviews, case discussions, and oral examinations, but

these programs and exams are not compulsory and not accepted by all the different European countries.

Training opportunities

Training and certification of thoracic surgeons in a harmonized Europe are being discussed, but unfortunately with less focus on training opportunities (9,22). Training opportunities such as simulation or virtual reality simulation play a crucial role in training future surgeons in a risk-free environment outside the operating theatre (2). A virtual reality simulator with five different lung lobes is developed by Surgical Science in cooperation with the Copenhagen thoracic surgeons. The validity evidence for the simulator test has been provided (21). This simulator can be used to improve basic and advanced surgical techniques. Competency in thoracic surgery can be assessed in a reliable way and these methods can be used to implement a standardized mastery learning training program for trainees in VATS (22-24,29). Konge *et al.* suggest simulation training must be a part of thoracic surgical curriculum (1). Massard *et al.* (9) and Lerut *et al.* (25) provided consensus about the procedures and content of training curriculum for a harmonized European-based thoracic education and certification program in a Delphi study.

Future perspectives on education and training

The ESTS school offers hands-on courses, which is a great opportunity to meet other surgeons around the world and learn from the experts and share ideas. In developing collaborative links, the education and training will improve (26,30). International collaborations open the doors for broad teamwork and the pooling of resources. A fellowship within the European country would provide a new understanding of patient management and observe and see experts performing advanced surgical procedures (26). Parigi *et al.* describe that the UEMS Section and Board of Pediatric Surgery developed high quality examinations and standards in pediatric surgery training across Europe and this has led to standardization and harmonization of in pediatric surgery throughout Europe (27). In the future, simulation-based training must play a major role in training procedures outside the operation theatre. Consensus of key leaders in thoracic surgery must be gathered, the need and problem must be identified, and Kern's model used to develop a common surgical curriculum in thoracic surgery. With reducing working hours and more complex

procedures being performed, it is crucial to prepare trainees with simulation training and supervision by experienced surgeons.

This is an up-to-date scoping review of the current status of simulation training and certification for thoracic surgery in Europe, providing the latest knowledge in this topic.

However, the manuscript is limited because we only focus on training of thoracic surgeons in Europe. Including Asia, US and Africa could have made the manuscript more generalizable, but this was beyond the scope. We could also have included other specialties, such as abdominal surgery, invasive cardiology, orthopedic surgery to see how they train and educate future surgeons.

Conclusions

Thoracic surgical education faces multiple challenges. There is a need for changing the structure of training and certification in thoracic surgery. We believe that simulation should be a part of the thoracic training curriculum and certification, and content of training should be harmonized across all European countries.

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Table S1 The strategies of article searched

Search number	Query	Search details	Results
10	Training of general thoracic surgeons in Europe[Title/Abstract]	((("education"[MeSH Subheading] OR "education"[All Fields] OR "training"[All Fields] OR "education"[MeSH Terms] OR "train"[All Fields] OR "train s"[All Fields] OR "trained"[All Fields] OR "training s"[All Fields] OR "trainings"[All Fields] OR "trains"[All Fields]) AND ("drugs, generic"[MeSH Terms] OR "drugs"[All Fields] AND "generic"[All Fields]) OR "generic drugs"[All Fields] OR "generic"[All Fields] OR "family characteristics"[MeSH Terms] OR ("family"[All Fields] AND "characteristics"[All Fields]) OR "family characteristics"[All Fields] OR "generation"[All Fields] OR "generations"[All Fields] OR "general"[All Fields] OR "general s"[All Fields] OR "generalisability"[All Fields] OR "generalisable"[All Fields] OR "generalisation"[All Fields] OR "generalization, psychological"[MeSH Terms] OR ("generalization"[All Fields] AND "psychological"[All Fields]) OR "psychological generalization"[All Fields] OR "generalization"[All Fields] OR "generalisations"[All Fields] OR "generalise"[All Fields] OR "generalised"[All Fields] OR "generalises"[All Fields] OR "generalisibility"[All Fields] OR "generalising"[All Fields] OR "generalities"[All Fields] OR "generality"[All Fields] OR "generalizability"[All Fields] OR "generalizable"[All Fields] OR "generalizations"[All Fields] OR "generalize"[All Fields] OR "generalized"[All Fields] OR "generalizes"[All Fields] OR "generalizing"[All Fields] OR "generally"[All Fields] OR "generals"[All Fields] OR "generate"[All Fields] OR "generated"[All Fields] OR "generates"[All Fields] OR "generating"[All Fields] OR "generation s"[All Fields] OR "generational"[All Fields] OR "generative"[All Fields] OR "generatively"[All Fields] OR "generativity"[All Fields] OR "generator"[All Fields] OR "generator s"[All Fields] OR "generators"[All Fields] OR "generically"[All Fields] OR "genericity"[All Fields] OR "generics"[All Fields]) AND ("thoracal"[All Fields] OR "thoracical"[All Fields] OR "thorax"[MeSH Terms] OR "thorax"[All Fields] OR "thoracic"[All Fields] OR "thoracics"[All Fields]) AND ("surgeon s"[All Fields] OR "surgeons"[MeSH Terms] OR "surgeons"[All Fields] OR "surgeon"[All Fields])) AND "in europe"[Title/Abstract]) AND ((ffrft[Filter]) AND (fha[Filter]))	7
8	Certification[Title/Abstract] AND training program[Title/Abstract]	("certification"[Title/Abstract] AND "training program"[Title/Abstract]) AND ((ffrft[Filter]) AND (fha[Filter]))	116
4	Certification in thoracic surgery[Title/Abstract]	("certificate"[All Fields] OR "certificate s"[All Fields] OR "certificated"[All Fields] OR "certificates"[All Fields] OR "certification"[MeSH Terms] OR "certification"[All Fields] OR "certifications"[All Fields]) AND "in thoracic surgery"[Title/Abstract]	18
3	Training thoracic surgeon in Europe[Title/Abstract]	((("education"[MeSH Subheading] OR "education"[All Fields] OR "training"[All Fields] OR "education"[MeSH Terms] OR "train"[All Fields] OR "train s"[All Fields] OR "trained"[All Fields] OR "training s"[All Fields] OR "trainings"[All Fields] OR "trains"[All Fields]) AND ("thoracal"[All Fields] OR "thoracical"[All Fields] OR "thorax"[MeSH Terms] OR "thorax"[All Fields] OR "thoracic"[All Fields] OR "thoracics"[All Fields]) AND ("surgeon s"[All Fields] OR "surgeons"[MeSH Terms] OR "surgeons"[All Fields] OR "surgeon"[All Fields])) AND "in europe"[Title/Abstract]	21
2	Thoracic surgical education[Title/Abstract]	"thoracic surgical education"[Title/Abstract]	14