Research Article

Technical Skills Curriculum in Neonatology: A Modified European Delphi Study

Emma Therese Bay[1,2], Niklas Breindahl[1,2,3], Mathilde M Nielsen[1], Charles C Roehr[4,5,6,7,8], Tomasz Szczapa[7,8,9], Luigi Gagliardi[10], Maximo Vento[7,8,11], Douwe H Visser[12], Ragnhild Stoen[13,14], Daniel Klotz[15], Alexander Rakow[16], Morten Breindahl[1], Martin G Tolsgaard[3,17,18], and Lise Aunsholt[1,18,19]

[1] Department of Neonatal and Pediatric Intensive Care, Copenhagen University Hospital, Denmark
[2] Faculty of Health and Medical Sciences, University of Copenhagen, Denmark
[3] Copenhagen Academy for Medical Education and Simulation (CAMES), Copenhagen University Hospital, Denmark
[4] National Perinatal Epidemiology Unit, Nuffield Department of Population Health Medical Sciences Division, University of Oxford, Oxford, United Kingdom
[5] Faculty of Health Sciences, University of Bristol, Bristol, United Kingdom
[6] Newborn Services, Southmead Hospital, North Bristol NHS Trust Bristol, Bristol, United Kingdom
[7] European Society for Paediatric Research, Satigny, Switzerland
[8] European Board of Neonatology, Satigny, Switzerland
[9] 2nd Department of Neonatology, Neonatal Biophysical Monitoring and Cardiopulmonary Therapies Research Unit, Poznan University of Medical Sciences, Poznan, Poland
[10] Division of Neonatology and Pediatrics, Ospedale Versilia, Viareggio, Azienda USL Toscana Nord Ovest, Pisa, Italy
[11] Division of Neonatology, University and Polytechnic Hospital La Fe (HULAFE) and Health Research Institute (IISLAFE), Valencia, Spain
[12] Department of Neonatology, Emma Children's Hospital, Amsterdam University Medical Centers, Academic Medical Center, 1105 AZ Amsterdam, The Netherlands
[13] Department of Neonatology, St. Olavs Hospital, Trondheim University Hospital, Trondheim, Norway
[15] Department of Clinical and Molecular Medicine, Norwegian University of Science and Technology, Trondheim, Norway
[15] Center for Pediatrics, Division of Neonatology and Pediatric Intensive Care Medicine, Medical Center - University of Freiburg, Faculty of Medicine, University of Freiburg, Freiburg, Germany
[16] Department of Women´s and Children´s Health, Karolinska Institutet, Stockholm, Sweden
[17] Department of Obstetrics, Copenhagen University Hospital, Rigshospitalet, Denmark
[18] Department of Clinical Medicine, Faculty of Health and Medical Sciences, University of Copenhagen, Denmark
[19] Department of Comparative Pediatrics and Nutrition, Faculty of Health and Medical Sciences, University of Copenhagen, Denmark

Short Title: Technical Skills Curriculum in Neonatology

Corresponding Author:

Full name: Emma Therese Bay

Department: Department of Neonatal and Pediatric Intensive Care

Institute/University/Hospital: Copenhagen University Hospital

Street Name & Number: Juliane Maries Vej 6

City, State, Postal code, Country: Copenhagen, DK - 2100, Denmark

Tel: (+45) 53781878

E-mail: emma.therese.bay@regionh.dk

Number of Tables: 5

Number of Figures: 1

Word count: 2732 (abstract: 246, main body of text: 2486)

Keywords: Neonatology, Simulation-based training, Technical skills, Delphi method, Curriculum

Abstract

Introduction

Simulation-based training (SBT) aids healthcare providers in acquiring the technical skills necessary to improve patient outcomes and safety. However, since SBT may require significant resources, training all skills to a comparable extent is impractical. Hence, a strategic prioritization of technical skills is necessary. While the European Training Requirements in Neonatology provide guidance on necessary skills, they lack prioritization. We aimed to identify and prioritize technical skills for a SBT curriculum in neonatology.

Methods

A three-round modified Delphi process of expert neonatologists and neonatal trainees was performed. In round one, the participants listed all the technical skills newly trained neonatologists should master. The content analysis excluded duplicates and non-technical skills. In round two, the Copenhagen Academy for Medical Education and Simulation Needs Assessment Formula (CAMES-NAF) was used to preliminary prioritize the technical skills according to frequency, importance of competency, SBT impact on patient safety, and feasibility of SBT. In round three, the participants further refined and reprioritized the technical skills. Items achieving consensus (agreement of ≥75%) were included.

Results

We included 168 participants from 10 European countries. The response rates in rounds two and three were 80% (135/168) and 87% (117/135), respectively. In round one, the participants suggested 1964 different items. Content analysis revealed 81 unique technical skills prioritized in round two. In round three, 39 technical skills achieved consensus and were included.

Conclusion

We reached a European consensus on a prioritized list of 39 technical skills to be included in a SBT curriculum in neonatology.

Introduction

Increasing patient numbers of premature infants admitted to neonatal intensive care units (NICUs) are matched with improved survival rates, and improved neonatal outcomes are associated with increasing technical proficiency of healthcare providers [1–4].

Medical simulation-based training (SBT) can be applied to different disciplines and aims, including team training to teach skills and procedures, such as low-frequency, high-risk procedures, promising to result in improved patient safety outcomes [5,6]. In this study, we refer to SBT exclusively in the context of technical skills training in neonatology. However, given that SBT requires significant resources, it is impractical to train all skills to a comparable extent [6], underscoring the necessity for strategic prioritization of technical skills.

A recent prioritization exercise by Thim et al. explored technical skills needed by pediatric practitioners [7]. Acknowledging the significantly different skill-set requirements to practice present-day neonatology and also appreciating the existing challenges arising from different training pathways for neonatologists throughout Europe, the European Society of Pediatric Research devised the 3rd edition of the European Training Requirements in Neonatology (ETR) [8–10]. The ETR Neonatology, consented by the Pediatric Section of the Union of European Medical Specialists (UEMS) in 2021, defines the Syllabus for training in Neonatology in Europe [9,10]. The Syllabus, however, does not include a prioritized list of technical skills required to practice neonatology at the expert level, nor does it specify training content deliverable by SBT. This gap supports the need for a European, consensus-based, prioritized list of technical skills for a SBT curriculum in neonatology.

We aimed to identify and prioritize technical skills necessary to practice neonatal medicine and guide curriculum developers, clinical supervisors, and aspiring neonatologists in tailoring their educational portfolios and programs.

Materials and Methods

Study Design

This study used a modified three-round iterative Delphi process [11] to establish European consensus on the technical skills to be included in a SBT curriculum in neonatology (shown in Fig. 1).

Steering Committee

A steering committee was assigned to manage all steps of the process. Members were selected based on their role as key opinion leaders in neonatology and neonatal education. The committee's tasks included identifying participants, piloting survey questionnaires, and performing content analysis following the first Delphi round. The members were excluded from participating in the surveys to minimize their influence.

Participants

Each steering committee member identified a minimum of 10 experts from their respective country based on the following inclusion criteria: 1) Head of a neonatal department; 2) Head of clinical education at a neonatal department; 3) Professor or postgraduate clinical associate professor of neonatology. In line with similar Delphi studies [12,13], all experts were required to nominate up to three physicians training to become neonatologists (trainees) to ensure physician training requirements were considered. Their participation remained anonymous to the experts who nominated them. Participants who failed to answer Delphi rounds two or three were excluded from the study. Participation was individual, anonymous, and voluntary.

Data Collection

Data was collected through online structured and semi-structured questionnaires using the secure Research Electronic Data Capture (REDCap) platform [14]. The first author, ETB, developed the survey questionnaires, communicated with the participants during all three Delphi rounds, and was the only steering committee member with access to deanonymized data.

Delphi Round 1: Brainstorming Phase

The first Delphi round was a brainstorming phase where the participants answered the following question: “List all the technical skills that should be learned during the neonatal subspecialist training." In this study, we used "technical skills" to refer to clinical procedures with a clear, practical, hands-on element excluding physical examinations. All technical skills were eligible.

Content analysis was performed by the steering committee and excluded duplicates, non-technical skills, and knowledge, which refers to understanding or information about a subject. The steering committee was allowed to congregate and change the wording of the suggested technical skills with identical content due to variations in phraseology. All decisions were based on a unanimous agreement. The included technical skills were returned to the participants in the second Delphi round. Baseline participant characteristics were collected in the first round.

Delphi Round 2: Exploration of Training Needs

The second Delphi round explored the need for training of each technical skill. A modified version of the Copenhagen Academy for Medical Education and Simulation Needs Assessment Formula (CAMES-NAF) [11,13] explored and prioritized the skills.

The modified CAMES-NAF contained four factors for each technical skill: 1) Frequency in clinical practice; 2) Importance of being competent; 3) Risk or discomfort for patients when performed by an inexperienced physician; 4) Feasibility for SBT. All factors were answered on a five-point Likert scale [15].

Factors 1 to 3 were answered by the participants and were presented in the survey questionnaire as follows:

1) “How often is the technical skill/group of skills performed by newly trained neonatologists in your department?”

2) “How important is it for you that a newly trained neonatologist can perform one of the following technical skills/group of skills?”

3) “Do you think simulation-based training in the following technical skills/group of skills increases patient safety when performed by a physician in training to become a neonatologist?”

Supplementary Material 2 and 3 show a complete overview of the questions and response anchors. As we expected steering committee members to be policymakers, the fourth factor of CAMES-NAF (feasibility) was only answered by the committee members. Feasibility scoring explored three elements for each technical skill: 1) Suitability for SBT; 2) Available equipment for SBT; 3) Cost of SBT. The score was calculated as the mean scores of the three. The final CAMES-NAF score was calculated as the mean score of the four equally weighted factors for each technical skill. The final CAMES-NAF score determined the preliminary prioritization of the technical skills in descending order. The preliminary prioritized list was returned to the participants in the third Delphi round.

Delphi Round 3: Elimination and Prioritization

In the third Delphi round, the participants were asked to review the preliminary prioritized list from the second Delphi round. They were asked whether the items should be included or excluded from a prioritized list of technical skills. The participants were explicitly asked to exclude any technical skills other healthcare professionals primarily perform. Subsequently, the participants had the opportunity to change the prioritization of the technical skills. The steering committee defined consensus as an agreement of ≥75% in the third round [16].

Statistical Analysis

Categorical data from the first Delphi round was presented as frequencies (percentages and counts). Continuous variables were presented as medians with interquartile range (IQR) due to non-normal distribution (analyzed using histograms) and range as appropriate. We used Spearman's rank correlation to compare the preliminary ranking from the second Delphi round (based on the CAMES-NAF scores) with the final reprioritized list after the third Delphi round. Statistical analyses were conducted using RStudio (version 2022.07.01) for quantitative analysis and Microsoft® Excel 2021 for qualitative analysis.

Results

Delphi Round 1

Data collection was performed from October 2022 through March 2023. We invited 327 participants (197 experts and 130 trainees), and of these, 51% (168) accepted to participate (91 experts and 77 trainees) in the first Delphi round. Of the 91 experts, 66 were heads of department, 24 were heads of clinical education, and 19 were professors/clinical associate professors of neonatology (Table 1). Some fulfilled more than one of the listed roles. In the first Delphi round, 1964 items were suggested. During content analysis, 1883 items were excluded (69 non-technical skills, 1814 duplicates). The remaining 81 technical skills were returned to the participants for the second Delphi round.

Delphi Round 2

The response rate in the second Delphi round was 80% (135/168, 78 experts and 57 trainees). The CAMES-NAF scores generated the preliminary prioritization of technical skills. The top five technical skills were: 1) Neonatal resuscitation and stabilization in the delivery room: Comprehensive group of skills according to guidelines [17]; 2) Manual non-invasive ventilation, one person technique; 3) Neonatal resuscitation and stabilization in the NICU: Comprehensive group of skills according to guidelines [17]; 4) External maneuvers to open the airway (e.g., jaw thrust, head positioning); and 5) Perform chest compressions. Chest compressions were kept as a separate skill, as it is rarely performed. The complete list of technical skills, including CAMES-NAF scores, is shown in Table 2, and the feasibility assessment is shown in Table 3.

Delphi Round 3

The response rate in the third Delphi round was 87% (117/135, 70 experts and 47 trainees). The participants excluded 43 technical skills, providing a final list of 39 skills required by newly trained neonatologists (shown in Table 4). The top ten skills in this study were all part of the Airway, Breathing, Circulation, Disability, and Exposure (ABCDE) approach to the initial assessment of a critically ill infant [18]. The preliminary ranking of the 39 technical skills was maintained after the third Delphi round (Spearman's rank of 1, $p<0.001$). The experts and trainees diverged on nine technical skills (shown in Table 5). Additionally, they diverged on the prioritization of 10 technical skills, of which six were included in the final curriculum. The three-round process is shown in Fig. 1.

Discussion/Conclusion

This study presents a European consensus on a prioritized list of 39 technical skills to be included in a SBT curriculum in neonatology. The current European Training Requirements in Neonatology (ETR) recommends 24 technical skills [9,10]. Our study identified all 24 skills and 15 additional, provided a prioritization, and added details related to the skills. This consensus will help the interpretation and implementation of the recommended technical skills.

The technical skills in the ETR are not prioritized, carrying a risk of a discrepancy between the accessible resources and the needs of neonatologists. Compared to the ETR [9,10], the 15 added technical skills include ultrasound procedures, intraosseous access, surfactant administration techniques, and equipment set-up. The skills may not have been included in the ETR, as they were either considered too advanced for newly trained neonatologists (e.g., surfactant administration by Less Invasive Surfactant Administration (LISA)) or were perceived as skills mainly performed by nurses (e.g., set-up of CPAP/BIPAP).

However, among the top three skills identified in this study, two were 'Comprehensive group of skills according to guidelines'. For example, the ability to resuscitate and stabilize an infant is of paramount importance when working in a NICU, and it was strongly emphasized by the participants in the first Delphi round. After extensive discussions in the steering committee, we decided to maintain it as a combined group of skills rather than dividing it into individual components. This comprehensive group of skills encompasses a multitude of complex abilities, which should be trained together according to the algorithm provided in the Neonatal Resuscitation Council Guidelines 2021 [17].

In this study, we included both neonatal experts and trainees. A downside to expertise is that skills have become intuitive, and the steps needed to become an expert may be challenging to recall [19]. Experts remain uncertain about the extent of forgotten content, risking extensive knowledge gaps that could affect their participation in our study [19,20]. Conversely, the trainees may not have the necessary experience and knowledge to suggest all the required skills. This study evenly proportioned the number of experts and trainees, improving our results' applicability in a modern neonatal SBT curriculum. Experts and trainers' opinions diverged on the inclusion of nine items. For example, training Point-of-care ultrasound (POCUS) was deemed advantageous by predominantly trainees, arguing it would enhance the safety and efficiency of specific procedures [21]; however, possibly underestimating the training needed to become competent. The counter-argument was that the equipment needed for POCUS represents a considerable investment, and POCUS integration has

been slow in neonatology [21]. Therefore, some experts may have considered POCUS as too advanced for newly trained neonatologists, thus excluding POCUS.

We defined consensus as an agreement of ≥75% in the final round [16]. One limitation related to a pre-defined consensus cut-off is that items of importance for some may fall below the threshold and consequently be excluded [16]. In our study, this implies that eight technical skills could have been included if a lower cut-off (>70%) was chosen. Therefore, we encourage curriculum developers to review all the suggested technical skills identified in this study and the prioritization and consensus rates (Supplementary Material 4).

This study has certain limitations. A non-response bias may have been introduced, as only 51% of invited participants responded in Round 1. The results are influenced by a sample selection bias, as steering committee members selected the participants to increase the response rate. Therefore, the results reflect the current need for technical skills in neonatology across high-income European countries. While certain SBT scenarios require costly sophisticated simulators, such as ultrasound machines, most SBT can be conducted using minimal resources. For example, skills training of manual non-invasive ventilation and vascular access methods can be executed with limited resources, hence a viable training option for most NICUs. This study found a strong correlation between the CAMES-NAF prioritization and the final re-prioritization by the participants, which may represent an acquiescence bias. However, previous studies have found the same strong correlation [7,22]. The results may not represent the needs of all countries, and the curriculum may, therefore, necessitate adaptations to fit the requirements and equipment availability in NICUs worldwide. This study only identified technical skills to be included in a SBT curriculum. However, excellent use of non-technical skills has been shown to improve clinical performance [23], and it is essential to include such skills when designing SBT courses. Whereas this study aimed to identify technical skills that should be included in a simulation-based curriculum in neonatology, most training occurs in the clinical setting. SBT should not replace real-life clinical education, as the performance in a simulated environment may not accurately reflect clinical performances [24].

Furthermore, some of the included technical skills may be challenging to train, e.g., ultrasound procedures. The feasibility assessment, shown in Table 3, systematically evaluates each skill's potential for SBT implementation. The results of this study should thereby not stand alone but act as directions for what future trainees should be offered within the simulated context before entering clinical training.

The endorsement of our curriculum by 117 neonatal experts and trainees from 10 European countries testifies to the relevance of our curriculum. Furthermore, the high response rates in rounds two and three decrease the introduced risk of non-response bias. Trainees accounted for 46% of the participants and were equally divided throughout their training (shown in Table 1), which ensured different perspectives on the training. The participants completed the surveys individually, and the answers were anonymized, eliminating the potential bias of dominant participants getting excessive influence. Finally, the steering committee did not influence the selection or final prioritization of technical skills.

In conclusion, this study presents a prioritized list of 39 technical skills to be included in a SBT curriculum for neonatology. This list should be incorporated into the next edition of the ETR in neonatology to ensure an evidence-based approach to a uniform SBT program for neonatal trainees throughout Europe.

Statements

Acknowledgment

The authors would like to acknowledge the time and effort of all 168 participants in this study for completing one or more Delphi rounds. A list of participants who wish to be acknowledged by name, title, and affiliation is shown in Supplementary Material 1.

Statement of Ethics

The participants were informed about the purpose of the study and the importance of participation before being included. In this case, they were guided to an informed consent form and confidentiality declaration before accessing the survey. Participation was anonymous, and confidentiality was maintained throughout all rounds.

The Committee on Health Research Ethics in the Capital Region of Denmark waived the need for ethical approval as this was a questionnaire study (Journal number: 22023968). Data management and processing were approved (ID-number: P-2022-463).

Conflict of Interest Statement

The authors have no conflicts of interest to declare

Funding Sources

ETB received funding from the Department of Neonatal and Pediatric Intensive Care research fund, Copenhagen University Hospital, Denmark, to conduct this study. The department did not influence the study design, data collection and analysis, interpretation, publication decision, or manuscript preparation.

Author Contributions

Emma Therese Bay, Niklas Breindahl, Mathilde M Nielsen, Martin G Tolsgaard, and Lise Aunsholt wrote the first draft of the study protocol. All co-authors, Emma Therese Bay, Niklas Breindahl, Mathilde M Nielsen, Charles C Roehr, Tomasz Szczapa, Luigi Gagliardi, Maximo Vento, Douwe H Visser, Ragnhild Stoen, Daniel Klotz, Alexander Rakow, Morten Breindahl, Martin G Tolsgaard, and Lise Aunsholt, contributed to the study's conceptualization, design, and methodology. All co-authors contributed to data collection, analysis, and interpretation. Emma Therese Bay wrote the article draft. All co-authors reviewed the manuscript. The final manuscript was read and approved by all co-authors.

Data Availability Statement

The datasets that support the findings of this study are not publicly available due to privacy reasons but are available from the corresponding author upon reasonable request.

Abbreviations

ABCDE: Airway, Breathing, Circulation, Disability, and Exposure

CAMES-NAF: Copenhagen Academy for Medical Education and Simulation Needs Assessment Formula

CMV: Conventional Mechanical Ventilation

ETR: European Training Requirements in Neonatology

GA: Gestational age

iNO: Inhaled Nitric Oxide

INSURE: INtubation SURfactant Extubation

IQR: Interquartile range

LISA: Less Invasive Surfactant Administration

MD: Medical doctor

MIST: Minimally Invasive Surfactant Therapy

NICU: Neonatal intensive care unit

PhD: Doctor of Philosophy

RDS: Respiratory distress syndrome

SBT: Simulation-based training

UEMS: Union of European Medical Societies

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Figure Legends

Fig. 1. The modified Delphi process. Abbreviations: CAMES-NAF = Copenhagen Academy for Medical Education and Simulation Needs Assessment Formula; SBT = Simulation-based training.