

The knowledge and skills needed to perform intestinal ultrasound for inflammatory bowel diseases—an international Delphi consensus survey

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Summary

Background: Intestinal ultrasound (IUS) is a non-invasive modality for monitoring disease activity in inflammatory bowel diseases (IBD). IUS training currently lacks well-defined standards and international consensus on competency criteria.

Aim: To achieve international consensus on what competencies should be expected from a newly certified IUS practitioner.

Methods: A three-round, iterative Delphi process was conducted among 54 IUS experts from 17 countries. Round 1 was a brainstorming phase with an open-ended question to identify the knowledge and skills that experts believe a newly certified IUS practitioner should possess. The experts' suggestions were then organised into statements by a Steering Committee. In round 2, the experts commented upon and rated the statements, which were revised accordingly. In round 3, the experts rated the revised statements. Statements meeting the pre-defined consensus criterion of at least 70% agreement were included in the final list of statements.

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Results: In total, 858 items were suggested by the experts in the first round. Based on these suggestions, 55 statements were organised into three categories: knowledge, technical skills and interpretation skills. After the second round, 53 revised statements remained. After the final round, a total of 41 statements had achieved consensus.

Conclusions: We established international, expert consensus on the knowledge and skills that should be expected from newly certified IUS practitioners. These consensus statements are the first step towards mastery learning for IUS training. Educators can utilise these statements to design training programmes and evaluate the competencies of trainees before they engage in independent practice.

1 | INTRODUCTION

Inflammatory bowel diseases (IBD), including Crohn's disease (CD) and ulcerative colitis (UC), are chronic, progressive diseases of the gastrointestinal tract with a significant impact on quality of life.¹ Intestinal ultrasound (IUS) is a non-invasive modality for monitoring disease activity in both UC and CD. IUS allows frequent assessments of disease activity, and it is inexpensive, widely available, well-tolerated by patients and without ionising radiation.²⁻⁴ Several IUS studies have demonstrated high sensitivity and specificity for detecting disease activity,⁵ and high concordance between IUS and endoscopic scores.⁶⁻⁸ Despite its advantages, IUS has not been consistently incorporated into the routine care of IBD patients, and its implementation varies significantly between countries and IBD centres.⁹ A major barrier to the widespread implementation of IUS is a lack of hands-on training capacity due to the small number of high-volume centres and only limited access to formal training programmes.² However, no widely agreed upon knowledge or skills have yet been formally set out and published around which to tailor training programmes.

IUS is often regarded as operator-dependent, and while operator dependency is inherent to the performance and interpretation of any diagnostic test, potentially, this criticism is specifically targeting IUS due to the lack of standardisation in IUS training standards. Consequently, the World Federation for Ultrasound in Medicine and Biology (WFUMB) has called for common IUS training standards as a first step to ensure trainees' acquisition of the knowledge and skills needed to reduce operator dependency.¹⁰ To develop common training standards and to assess IUS skills, agreement is needed on the knowledge and skills that are to be expected from newly trained IUS practitioners. This study aimed to obtain international consensus on the knowledge and skills that a newly certified IUS practitioner should possess.

2 | MATERIALS AND METHODS

2.1 | Study design

Between February 2021 and July 2021, we conducted a three-round, iterative Delphi process to establish a consensus on the

knowledge and skills that a newly certified IUS practitioner should possess. The Delphi methodology is a multistage process with an anonymous, structured approach designed to unite individual opinions into a group consensus.¹¹ Consensus was defined as 70% or more of participants voting "agree" or "strongly agree" in the final round. We required a response rate of 60% or more among participants in order to move to the next round. Figure 1 presents an overview of the Delphi process.

2.2 | Steering committee

A Steering Committee with experience in IUS and the Delphi process was assembled to facilitate the Delphi process. The Steering Committee was composed of members from the Copenhagen Academy for Medical Education and Simulation with research experience in medical education and the Delphi methodology^{12,13} along with IUS practitioners from the Copenhagen Center for Inflammatory Bowel Disease in Children, Adolescents and Adults, which is a certified IUS training centre. This composition was chosen to assemble combined expertise on IUS and the Delphi methodology. The Steering Committee's responsibilities included identifying international collaborators, ensuring correct inclusion of Delphi panellists, developing the questionnaire, data collection and data analysis. A list of the Steering Committee members is available in Table S1.

2.3 | International collaborators

The Steering Committee invited an international group of key opinion leaders to participate in the study as international collaborators. All international collaborators had substantial involvement in IUS training as former IUS workshop leaders and documented research experience within IUS. The international collaborators were asked to invite participants meeting the inclusion criteria from their geographical region to join the Delphi panel. This ensured a Delphi panel with diverse geographical, experiential and academic backgrounds. The international collaborators also served as panellists in the Delphi rounds. A list of the international collaborators is available in Table S1.

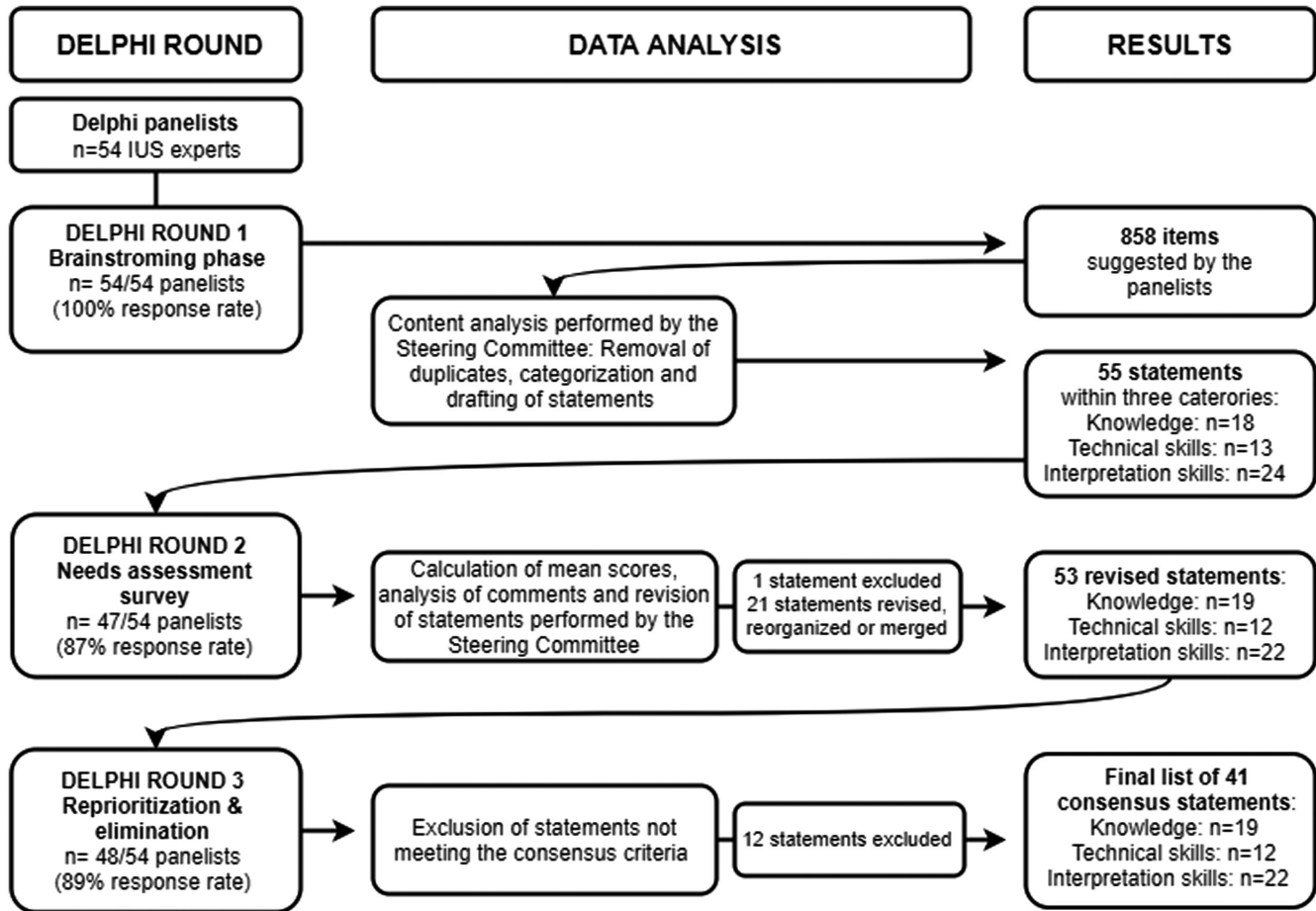


FIGURE 1 Flowchart of the Delphi process

2.4 | Inclusion of panellists

The inclusion criteria for panellists were regular use of IUS (at least monthly) and involvement in IUS training or research. To assemble a broad Delphi panel in terms of experience we included participants with any duration of experience, if they met the inclusion criteria. The specialities of the participants included Medical Gastroenterology and Hepatology, Internal Medicine, Pediatrics, and Radiology. Panellists were invited to the Delphi panel through an e-mail link to the online questionnaire. Study data were collected and managed using REDCap electronic data capture tools hosted in the Capital Region of Denmark.^{14,15} The e-mail stated that participation would result in acknowledgement in the final publication. A list of the Delphi Panel members is available in Table S2.

2.5 | Delphi round 1—Brainstorming phase

Before starting the first Delphi round, the panellists were asked to provide some general information: country in which they practice, speciality, stage of career, years of IUS experience, IUS teaching, research experience, IUS examinations performed per month, and the number of physicians performing IUS at their institution. The

first Delphi round was a brainstorming phase during which panellists were asked the open-ended question, “What are the knowledge and skills that you believe a newly certified IUS practitioner should have or should be able to perform?”

The Steering Committee used an iterative process to review responses and synthesise them into statements. This was accomplished by grouping the suggestions into three categories: knowledge, technical skills and interpretation skills. Each category was then further divided into subcategories (e.g. knowledge was subdivided into indications, limitations, anatomy, IBD, physics of ultrasonography). All responses were also sorted into subcategories, and the items within each subcategory were summarised into statements by the Steering Committee. All responses were reviewed to ensure that they were represented within the statements. Careful attention was paid to preserve the original wording used by the panellists.

A questionnaire containing the statements was distributed to all panellists for the second Delphi round.

2.6 | Delphi round 2—Needs assessment survey

In the second Delphi round, the panellists were asked to rate all statements by level of agreement, that is, “How much do you agree

or disagree that a newly certified IUS practitioner should have a specific knowledge or skill?". The Steering Committee defined a newly certified IUS practitioner as "Someone who is ready for independent practice with minimal supervision." Each statement was explored utilising a five-point Likert scale from 1, *strongly disagree* to 5, *strongly agree*. The panellists were provided the opportunity to comment and give their rationale about how they rated priorities among items. Statement exclusion in round 2 was prospectively defined as a mean score below 2.5, and the Steering Committee revised the statements according to panellists' comments.

2.7 | Delphi round 3—Reprioritizing and elimination

In the third Delphi round, the panellists re-rated the revised statements. The panellists were provided with a PDF containing the mean scores and selected comments from round two. Statements achieving at least 70% support, that is, panellists voting "agree" or "strongly agree," were included in the final consensus statements.

2.8 | Statistical analysis

Descriptive analysis was used to calculate the mean score and support for each statement and to determine consensus. R Studio was used to conduct Welch's two-sample t-test to compare differences in mean scores across groups.

3 | RESULTS

3.1 | Delphi round 1

Fifty-four IUS experts completed the first Delphi round and were included in the Delphi panel. All respondents met the inclusion criteria. The general characteristics of the Delphi panel are available in [Table 1](#).

In the brainstorming phase, the Delphi panel suggested a total of 858 items. Duplicates ($n = 93$) and items not pertaining to skills or knowledge ($n = 22$) were excluded. The remaining items ($n = 743$) were categorised as Knowledge ($n = 210$), Technical skills ($n = 311$), and Interpretation skills ($n = 222$). The items were condensed into a total of 55 statements: Knowledge ($n = 18$), Technical skills ($n = 13$), and Interpretation skills ($n = 24$).

3.2 | Delphi round 2

The second Delphi round response rate was 87% (47 of 54 panellists). The statements received an average score of 4.2, and only one statement scored less than 2.5 and was excluded. The Steering Committee revised and reorganised the remaining statements in response to the comments, including merging of two overlapping

TABLE 1 General characteristics of the Delphi panel

Country	Speciality	Years of IUS experience	Number of IUS examinations per month	Stage of career	How many doctors practice IUS at your hospital?
Australia	Medical Gastroenterology and Hepatology	>20 years	> 50	Specialist (finished specialist training)	1
New Zealand		8	15	47	8
Portugal	Paediatrics	11–20 years	41–50	Fellow in training - less than 3 years	3
France		8	3	40	2 to 5
Italy	Internal Medicine	6–10 years	31–40	Fellow in training - more than 3 years	2
United Kingdom		13	5	6	>5
Denmark	Radiology	2–5 years	21–30	1	1
Japan		24	18	PhD fellow	1
Canada	Not specified	<2 years	11–20	9	1
Belgium		1	4	1	1
The Netherlands	Spain	1	1–10	4	1
Norway	Kuwait	1			
Israel	USA	1			
Germany		2			

statements, resulting in 53 revised statements: Knowledge ($n = 19$), Technical skills ($n = 12$), and Interpretation skills ($n = 22$).

3.3 | Delphi round 3

The total response rate for the third Delphi round was 89% (48 of 54 panellists). Twelve statements did not receive consensus approval and were excluded. Thus, consensus criteria were met for 41 of the 53 (77%) statements. The statements achieving consensus are available in Table 2. The excluded statements focused on the performance and interpretation of specialised techniques, namely contrast-enhanced US ($n = 4$), perianal US ($n = 4$), elastography ($n = 2$), research ($n = 1$), and interventional procedures related to IUS ($n = 1$). The support for each statement in the final Delphi round can be found in Table S3. Panellists with 5 years or less of IUS experience did not rate the statements differently from panellists with more than 5 years of IUS experience; respective mean scores of 4.16 and 4.20, with a non-significant difference in mean score of 0.04 ($-0.18; 0.25$), $p = 0.72$. Panellists who were not yet board-certified specialists (finished speciality training) did not rate the statements differently than board-certified specialists; respective mean scores of 4.17 and 4.18, with a non-significant difference in mean score of 0.01 ($-0.31; 0.34$) $p = 0.92$.

4 | DISCUSSION

This is the first study to elicit IUS training standards using robust Delphi methodology among an international group of IUS experts. We assembled a broad panel of IUS experts from across the world, resulting in 41 consensus statements summarising the skills and knowledge a newly certified IUS practitioner should possess. The statements are categorised as pertaining to knowledge, technical skills or interpretation skills, and these categories reflect the different aspects of IUS in theory and practice. The final list of consensus statements encompasses all the competencies needed to perform an IUS examination and interpret the results.

In the final Delphi round, consensus was not reached for 12 statements and were thus excluded. These statements involved having the skills to perform and interpret specialised techniques such as elastography, contrast-enhanced US, perineal/transrectal US and interventional procedures. These statements faced criticism in the second Delphi round since they were considered too advanced or were performed in only a few centres worldwide. Interestingly, the Delphi panel still voted to include knowledge on the relevant indications for some of these specialised techniques. This is in line with previous studies emphasising the importance of having knowledge of the possibilities and limitations of specialised techniques even if the operator is not trained to perform them.¹⁶ Although the Delphi panel had suggested knowledge about elastography and the ability to perform elastography in the first round, they found very limited support in the final Delphi round. In recent studies, elastography

has shown promising results, but no standardisation or consensus exists on its implementation or clinical use.^{17,18} This is likely the reason why the Delphi panel chose not to recommend any elastography knowledge or skills. Statements regarding the ability to perform and interpret small intestine contrast-enhanced ultrasonography (SICUS) surprisingly found very limited support. SICUS is generally considered easy to perform, widely available and has been suggested as a technique for non-expert IUS sonographers to identify strictures.¹⁹ However, SICUS adds patient preparation and prolongs the procedure. The limited support for SICUS is likely explained by the small number of training centres currently performing SICUS.

Some statements only narrowly met the consensus criterion of at least 70% support. These statements included the ability to assess ulcers, luminal content and appendiceal pathology, as well as the ability to assess the rectum transabdominally. Ulcers on IUS²⁰ are suggested to be associated with disease activity and should be reported when observed²¹; however, the feature is not acknowledged by all practitioners and reproducibility may be weak.²² Luminal content assessment is qualitative, and although the bowel content's volume and consistency may enhance patients' understanding of their symptoms, it does not explicitly reflect disease activity or inflammatory load. Assessing appendix pathology is often related to acute abdominal pain unrelated to IBD and IBD units. In this point-of-care setting, these skills may be difficult to acquire if there is only limited access to the emergency department or surgical ward. Finally, assessing rectal disease using the transabdominal approach is inferior to all other bowel segments,^{23,24} which is likely why the Delphi panel only narrowly voted in favour of including this statement.

Our study represents the first step in the process of developing training standards for IUS training programmes. The competencies contained within these consensus statements represent the knowledge and skills that experts believe are needed before trainees begin to practice independently. Educators can benefit from the statements when designing training programmes to ensure these programmes allow the trainees to acquire basic competencies. Educators may also look towards the consensus statements when instructing trainees to ensure that trainees master all of these different aspects of performing IUS.

Defining the knowledge and skills needed for performing IUS allows for the introduction of mastery learning, rather than the time- and volume-based approaches currently used for certification. A mastery learning approach entails a trainee practicing so as to acquire well-defined competencies that are understood to indicate mastery instead of focusing on completing a certain number of cases or hours of training. This approach acknowledges that the number of cases or hours needed to obtain competency varies among trainees and across training environments.²⁵ The concern with time- and volume-based approaches to training is that after completing a predetermined number of cases, some trainees will still not have attained the required competencies, while others will have trained in excess of the requirements. Ensuring that all trainees possess these skills and knowledge before engaging in independent practice will

TABLE 2 Final list of consensus statements

Knowledge—A newly certified IUS practitioner should have knowledge on:

1. Relevant indications for IUS, that is, initial evaluation of IBD, evaluation of disease extent, monitoring of disease activity, assessment of therapeutic response, pre-screening before invasive procedures and detection of complications
2. Accuracy of IUS for detection of disease activity in IBD, including complications to IBD and how IUS compares to other imaging modalities
3. Limitations of US in general and specifically for IUS
4. Small and large bowel anatomy, including their typical localization and approximation to fixed organ structures (anatomical landmarks)
5. Physics of ultrasound, that is, probe frequency, depth, gain, spatial resolution, colour Doppler, artefacts and basic knowledge on contrast agents and different elastography techniques
6. Optimal conditions for scanning, that is, dark room, sufficient amount of gel, ergonomic and hygienic conditions
7. Knobology, including pros and cons of different probes
8. IBD, that is, pathogenesis, behaviour, distribution of lesions in CD and UC and their differences
9. Mural and extramural signs of IBD activity on IUS, that is, increased bowel wall thickness, loss of bowel wall stratification, increased colour Doppler signal, loss of haustration, loss of motility, inflammatory mesenteric proliferation, lymphadenopathy, free fluid and complications like abscesses, stenoses, phlegmons and fistulas
10. Differential diagnoses of IBD, for example, non-IBD findings on IUS such as diverticulitis, ischemic enteritis/colitis, bacterial enteritis, appendiceal pathology and cancers
11. Basic therapeutic options in IBD, in the context of evaluating response to treatment (not necessary for radiologists performing IUS)
12. Commonly accepted and validated scoring indices
13. The relevant indications for perineal US and transrectal US
14. (When applicable) Paediatric IUS, including differences from adult IUS, that is, the range of normality according to age
15. Relevant indications for contrast-enhanced ultrasound (CEUS)
16. Relevant indications for small intestine contrast-enhanced ultrasonography (SICUS)

Technical skills - A newly certified IUS practitioner should be able to:

17. Constantly optimise the image during the examination, that is, choosing the adequate probe, adjusting depth, gain, frequency, focus position, Doppler settings, placement of colour Doppler box, applying compression and instructing the patient in breath-holding when necessary
18. Identify relevant anatomy, that is, anatomical landmarks (psoas and iliac vessels), the other major abdominal organs, stomach, terminal ileum (or neo-terminal ileum), small bowel, cecum, ascending colon, transverse colon, descending colon, sigmoid colon and rectum
19. Identify the bowel wall layers, including the interfaces with the lumen and the serosa, and measure (in cross-sectional and longitudinal planes) the bowel wall thickness with correct calliper placement
20. Identify, adjust and grade the colour Doppler signal
21. Identify and measure/grade apparent intestinal and extra-intestinal complications to IBD
22. Identify the most common non-IBD findings, for example, diverticulosis, diverticulitis and appendicitis
23. Perform a systematic examination, that is, examine the large bowel continuously by starting at one segment and progressing logically to examine all segments, followed by terminal ileum and the remaining small bowel
24. Annotate, describe, store and report findings, including writing a report and archiving still images and cine loops

Interpretation skills - A newly certified IUS practitioner should be able to:

25. Assess the scan quality, acknowledge undetected bowel and report potential impact on the confidence level
26. Assess and differentiate mural and extramural pathology from normal bowel and assess response to treatment at follow-up
27. Assess disease location, that is, rectum, specific colonic segment, terminal ileum, ileum, jejunum or stomach, and assess the length of affected bowel segments
28. Assess for loss of bowel wall stratification
29. Assess for presence of mesenteric hypertrophy/inflammatory fat and distinguish it from normal intraabdominal fat
30. Assess for presence of lymphadenopathy
31. Assess for presence or absence of colonic haustration
32. Assess for presence of ulcers
33. Assess the amount of free fluid
34. Assess small bowel motility/peristalsis
35. Recognise IUS features that point towards chronic disease, that is, hyperechoic and relative submucosal expansion and lack of colour Doppler signal
36. Assess strictures, including luminal narrowing and prestenotic dilatation
37. Assess intraabdominal penetrating disease, that is, fistulas, inflammatory masses and abscesses
38. Assess the rectum with a transabdominal approach whenever possible
39. Assess intraluminal bowel content, that is, empty, liquid, gas or solid
40. Assess the appendix whenever visible, including diagnosing acute appendicitis and periappendicular abscess
41. Assess a post-surgical anastomosis, including assessment for disease recurrence

help reduce operator dependency and improve other physicians' confidence in IUS as a trustworthy modality.

IUS may benefit from optimising educational strategies to help trainees acquire these skills and knowledge and ensuring structured

assessment programmes to evaluate when trainees are ready to practice independently.

The present study has several strengths, including a diverse Delphi panel in terms of IUS experience and geographical origin, with

representatives from 17 countries. The study followed a strict methodology with predefined inclusion and consensus criteria, and high response rates were achieved throughout all Delphi rounds.²⁶ The panel had representation and active participation from specialities outside Medical Gastroenterology and Hepatology, including Radiology and Paediatrics, to increase applicability to these specialities.

The present study also has some inherent limitations. Our inclusion criteria allowed for a heterogeneous Delphi panel regarding the level of IUS experience and career stage. Generally, the panellists were mainly specialists with many years of experience. Our results suggest that panellists earlier in their career with less IUS experience did not rate statements differently from the rest of the panel. Ideally, panellists had a more diverse speciality background. Only one Radiologist participated, and the final list of statements reaching consensus might have changed if more had participated, given their different experience.²⁷ The vast number of items suggested in the first round made the content analysis challenging. Although all suggestions were rigorously reviewed using an iterative process, information might have been lost along the way. Another potential limitation was the Steering Committee's significant influence in handling the panellists' responses. Although careful attention was paid to the original suggested wording, the Steering Committee revised the statements based on comments from the panel, thereby directly influencing the statements' final wording.^{28,29} The panellists made the final rating and decided whether to include the statement in the list of consensus statements.

In conclusion, we achieved an international consensus by means of the Delphi methodology on the basic knowledge and skills expected in newly certified IUS practitioners. These consensus statements are the first step towards mastery learning for IUS training. Educators can use these statements when designing training programmes and when assessing IUS practitioners' knowledge and skills before they engage in independent practice.

AUTHORSHIP

Guarantor of the article: Gorm Roager Madsen.

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AUTHOR CONTRIBUTIONS

Gorm Roager Madsen: Conceptualization (equal); data curation (lead); formal analysis (lead); investigation (lead); methodology (equal); software (equal); writing – original draft (lead); writing – review and editing (equal). **Rune Wilkens:** Conceptualization (equal); data curation (supporting); methodology (equal); software (equal); supervision (supporting); writing – review and editing (equal). **Trine Boysen:** Conceptualization (equal); data curation (supporting); methodology (equal); supervision (supporting); writing – review and editing (equal). **Johan Burish:** Conceptualization (equal); data curation (supporting); methodology (equal); supervision (supporting); writing – review and editing (equal). **Robert V Bryant:** Resources (equal); writing – review and editing (equal). **Dan Carter:** Resources (equal); writing – review and editing (equal). **Krisztina Gecse:** Resources (equal); writing – review and editing (equal). **Christian Maaser:** Resources (equal); writing – review and editing (equal). **GIOVANNI MACONI:** Resources (equal); writing – review and editing (equal). **Kerri L Novak:** Resources (equal); writing – review and editing (equal). **carolina Palmela:** Resources (equal); writing – review and editing (equal). **leizl Joy Nayahangan:** Conceptualization (equal); data curation (supporting); methodology (equal); supervision (equal); writing – review and editing (equal). **Martin Groennebaek Tolsgaard:** Conceptualization (equal); data curation (supporting); methodology (equal); project administration (lead); supervision (lead); writing – review and editing (equal).

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SUPPORTING INFORMATION

Additional supporting information will be found online in the Supporting Information section.

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