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Consensus-based indicators for evaluating and improving the quality of regional collaborative networks of intensive care units: Results of a nationwide Delphi study

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ABSTRACT

Purpose: To select a consensus-based set of relevant and feasible indicators for monitoring and improving the quality of regional ICU network collaboratives.
Methods: A three-round Delphi study was conducted in the Netherlands between April and July 2022. A multidisciplinary expert panel prioritized potentially relevant and feasible indicators in two questionnaire rounds with two consensus meetings between both rounds. The RAND/UCLA appropriateness method was used to categorize indicators and synthesize results. A core set of highest ranked indicators with consensus-based levels of relevance and feasibility were finally tested in two ICU networks to assess their measurability.
Results: Twenty-four indicators were deemed as relevant and feasible. Seven indicators were selected for the core set measuring the standardized mortality rate in the region ($n = 1$) and evaluating the presence, content and/or follow-up of a formal plan describing network structures and policy agreements ($n = 3$), a long-term network vision statement ($n = 1$), and network meetings to reflect on and learn from outcome data ($n = 2$). The practice tests led to minor reformulations.
Conclusions: This study generated relevant and feasible indicators for monitoring and improving the quality of ICU network collaboratives based on the collective opinion of various experts. The indicators may help to effectively govern such networks.

1. Background

Like many other healthcare settings, Intensive Care Units (ICUs) struggle daily with the consequences of staff shortages, rising costs and the ever-increasing demand for care [1-3]. Regionalization, which emphasizes the regional organization of patient flow and health services resources into a system "to deliver the right resources to the right patient in the right place at the right time" [4], has been encouraged for decades as a strategy to optimize healthcare efficiency and improve clinical outcomes [5-7].

There has been a long tradition of regional collaboration between ICUs in specific clinical and scientific areas in the Netherlands. However, regionalization gained further momentum and a formal character with the adoption of the National Quality Standard 'Organization of Intensive Care' in 2016, which stated, "A nationwide network system should be set up to maximize the efficiency and (joint) outcomes of intensive care" [8,9]. The Quality Standard contains recommendations for and commitments to regional collaboration and the formation of ICU network organizations. This ultimately led to a nationwide system of 12 networks in which ICUs work together within a specific geographical area to ensure that patients are treated in the right ICU with the right resources and expertise tailored to their critical care needs. More recently, the COVID-19 pandemic boosted the collaboration between ICUs within and outside the ICU networks [10].

While societal developments and quality standards have impelled ICUs both in the Netherlands and abroad to intensify and professionalize

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their regional collaboration, widespread consensus is lacking among stakeholders as to what indicators are appropriate for evaluating the quality of regional collaboration. Nevertheless, such indicators are an important part of network governance and can help ICU clinicians and policy-makers monitor and improve their collaborative network's functioning. In addition, mutual sharing and reflection on indicator outcomes between the networks can stimulate individual networks to improve their own functioning by learning from others. Therefore, the aim of this study was to determine a consensus-based set of indicators that are relevant and feasible for monitoring and improving the quality of regional ICU network collaboratives.

2. Methods

2.1. Design, setting and panel

A three-round Delphi study was conducted in the Netherlands between April and July 2022 (Fig. 1). The Delphi technique is an iterative multistage process designed to transform expert opinions into group consensus [11]. The study was executed according to the principles of the RAND/UCLA Appropriateness Method (RAM), which was initially developed to detect collective agreement on the appropriateness of delivered care [12] but also fits studies aiming to determine appropriate quality indicators in healthcare based on the collective opinion of experts [13,14]. In accordance with the RAM, the following steps were conducted: recruitment of experts, multiple rounds of data collection (online questionnaires and expert panel meetings), and data analysis after each round. To enhance the robustness of this study, the guidance on Conducting and REporting DElphi Studies (CREDES) was followed [15].

2.2. Identification and development of potential indicators

To determine a consensus-based core set of indicators, we started by listing all possible relevant indicators. Potential indicators were identified via several resources: 1) a title and abstract scan of 4.411 hits (i.e., reviews, original studies and opinion articles) from PubMed, Embase and Web of Science using specific inclusion criteria and a specific search string (Supplement 1); 2) a review of grey literature (e.g., reports, vision and policy documents and websites) with information relating to the governance of regional collaborations in healthcare (Supplement 2); and 3) checking the reference list of papers to identify additional relevant information sources (snowballing approach). One author (GH) extracted concrete indicators from the literature and used relevant text to develop and further operationalize potential indicators. Subsequently, an advisory board consisting of ten persons with specific expertise (i.e., governance of ICU care, quality indicators) and/or representing important stakeholders (i.e., intensivists, ICU nurses, patients) were asked to review the list and provide suggestions for additional indicators, reformulations or removal of duplicates or those considered irrelevant. Two authors (GH and MZ) then synthesised findings from all sources into a final list of indicators. The indicators that measured the same concept were grouped and categorized based on the professional insights of the authors and feedback from the advisory board. This resulted in a list of 85 indicators divided across 14 categories (Supplement 2), which formed the starting point of the Delphi study.

2.3. Recruitment of Delphi panel members

For the Delphi, GH and MZ recruited a panel of experts based on their involvement in and affinity with regional ICU collaboration. Panel

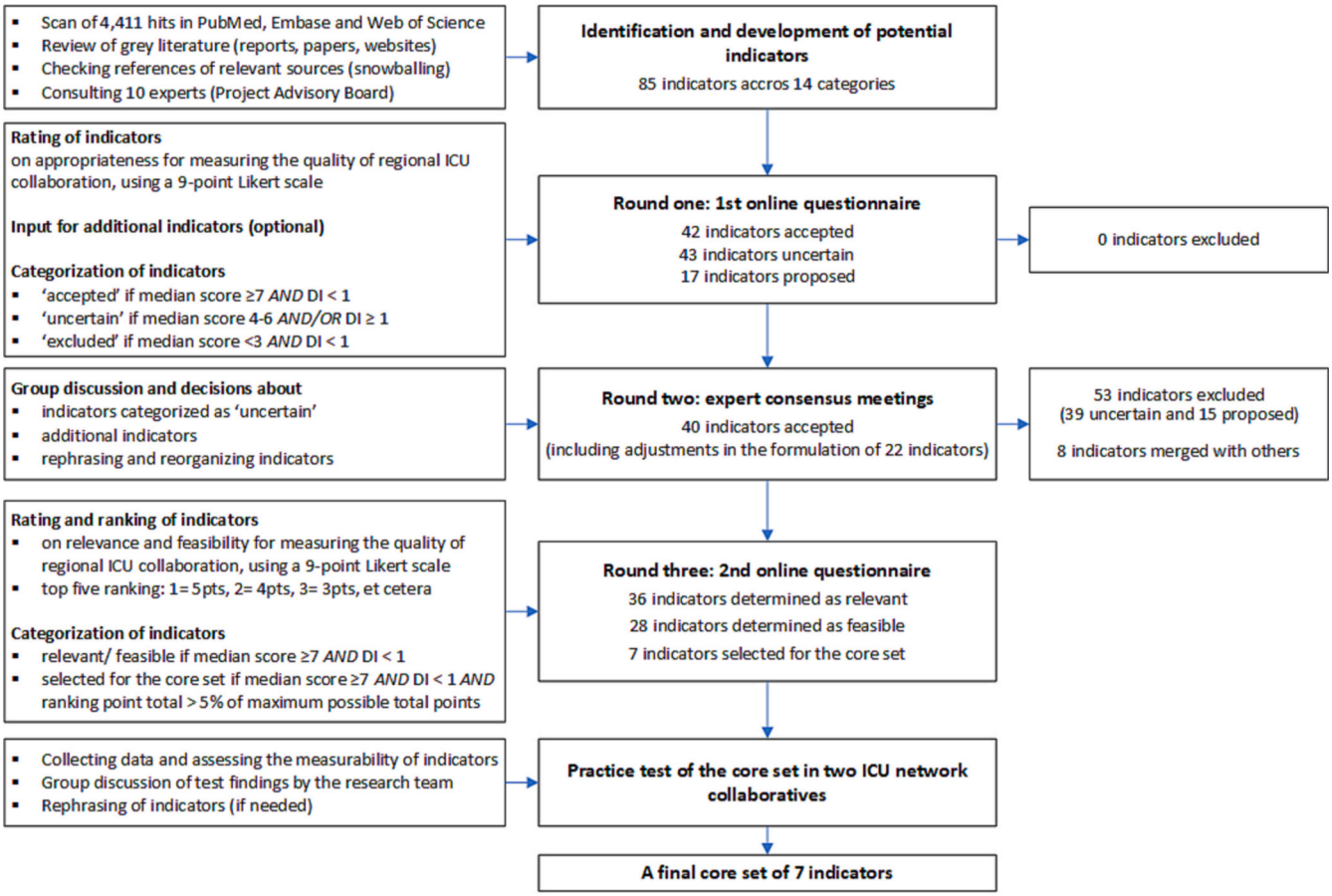

Fig. 1. Flow chart of the study.

members were purposively sampled to compose a well-balanced panel including different types of ICU professionals (i.e., intensivists, ICU nurses, managers, executives and quality officers) from different hospitals (academic versus regional and large versus small) across different geographical regions. The panel was completed with representatives of organizations for former ICU patients and relatives, external experts in healthcare governance, quality measurement or regionalization, and officers of the Dutch health inspectorate.

A total of 62 persons were approached via the networks of the authors, the advisory board and the Dutch ICU Nurses' Association. They were informed about the study and invited to participate by email. In each Delphi round, panel members received an email invitation describing the purpose of that round and the estimated time investment for panel members. Non-responders were reminded once after two weeks.

2.4. Round one: first online questionnaire

In the first round, panel members were asked to rate the appropriateness of each of the 85 indicators using an online questionnaire. Panel members were specifically instructed to rate each indicator on a nine-point Likert scale ranging from 1 (not at all appropriate) to 9 (very appropriate) with the question: "Please rate to what extent you consider this indicator appropriate for evaluating and improving the collaboration between ICUs in the region". Panel members were thereby asked to take several aspects into consideration. First, whether they found the indicator relevant (i.e., does it measure the quality of regional collaboration?). Second, whether they found the indicator feasible (i.e., is it possible and affordable to collect, measure and report the required data?). Third, whether they found the indicator actionable (i.e., do outcomes provide sufficient reason and opportunities for improvement). The indicators were organized per category. For each category, panel members were asked to provide suggestions for additional indicators if felt needed.

Data were processed and analysed using a standardized tool in Microsoft Excel 2016 (Microsoft, USA). Median scores were calculated for each indicator to determine the degree of appropriateness. The disagreement index (DI) was calculated for each indicator to determine panel agreement on each indicator. As described in the RAM, the DI is the ratio between the interpercentile range (IPR) and the IPR adjusted for symmetry (IPRAS), which can be calculated following the equation described in Supplement 3 [12]. A DI <1 indicates agreement, with a score closer to zero indicating stronger agreement. Indicators were then categorized based on the median score ranking the importance of the indicator combined with the DI. We defined three groups of indicators as follows: (1) accepted: those considered as appropriate (median ≥ 7) and with agreement within the panel; (2) uncertain: those considered as somewhat appropriate (median 4–6) and with agreement, or those without agreement in the panel; and, (3) excluded: those considered inappropriate (median ≤ 3) with agreement in the panel [12]. The comments were qualitatively analysed by GH, who read all narratives, clustered those with the same meaning and summarized them into a list of proposed indicators. Indicators categorized as 'uncertain', as well as the list of proposed indicators, were further discussed in the consensus meetings with members of the Delphi panel (second round).

2.5. Round two: consensus meetings

Upon completing the first questionnaire, all panel members were invited to participate in a consensus meeting. We decided to organize two meetings instead of one to increase the chance that all members could participate. Moreover, a smaller number of participants would facilitate a practical group discussion and input from all participants. Panel members could participate in person or remotely via a video connection. Before and during the meeting, members were informed about the group ratings (median and DI scores) and judgment ('accepted', 'uncertain' or 'excluded') for each indicator and informed about the proposed indicators. The goals of the meeting were to discuss the findings and concerns regarding the measurability and actionability, and to collectively decide whether or not to accept for the following round: 1) the indicators categorized as 'uncertain', and 2) the list of proposed indicators. Moreover, the formulation and operationalization of each indicator were reviewed, and suggestions for rephrasing texts were discussed.

Both meetings lasted 90 min and were supervised by GH. MZ took notes of the conversations and decisions. Based on the notes, a draft of the results was developed by GH and MZ and shared with the participating panel members to check the credibility of the results.

2.6. Round three: second questionnaire

The indicators accepted in round one and those added and revised after the consensus meetings in the second round were included in a second questionnaire. First, the relevance and feasibility of each indicator were separately scored on a nine-point Likert scale. Second, the panel was asked to prioritize the indicators by selecting an overall 'top 5' of the most relevant and feasible indicators. For each number-one ranking by a panel member, we granted an indicator five points; for each number-two ranking, we granted four points and so on.

Again, a group median score was calculated for each indicator to determine its relevance and feasibility, and the DI was calculated to determine the level of agreement. Indicators with a median ≥ 7 and a DI < 1 were considered relevant or feasible. In addition, the ranking point total for each indicator was calculated. Finally, indicators were selected for the core set if they had group medians ≥ 7 and DIs < 1 for both relevance *and* feasibility and received >5 % of the maximum possible ranking points. The indicators were classified according to Donabedian's model (structure, process or outcome measure) [16].

2.7. Practice test to assess the measurability of the core set indicators

The core set indicators were finally tested on their measurability in two ICU network collaboratives in the Netherlands. These networks were mainly chosen for pragmatic reasons. The members of the research team are affiliated with these networks and had therefore quick access to the people and resources to conduct the test. Within each network, multiple persons (i.e., the head of an ICU, a region manager/quality officer and one intensivist with network tasks) were asked to collect data and assess the measurability of each indicator. These persons were chosen and approached based on their formal tasks and role within the network and access to relevant indicator data. If data could be collected so that the indicator could be analysed and described with words or expressed as a quantity, this was indicated as 'measurable'. Relevant indicator data was then provided in a preformatted Excel sheet. Participants were also asked to provide reasons and suggestions for reformulating the indicator in the Excel sheet, particularly if an indicator was assessed as 'not measurable' or 'difficult to measure'. Once the Excel sheets were filled in for both networks, the authors met and used these data to discuss the possible need for revisions. At the end of the meeting, a definitive core set of indicators was determined.

2.8. Ethical considerations

The panel members were informed that participation was voluntary and that all data would be processed anonymously and used only for research and quality improvement purposes. The members' consent was assumed upon returning the completed questionnaires and participation in the consensus meeting. Because participants in this study were not subjected to physical and/or psychological procedures, no approval was needed according to the Dutch Medical Research Act (WMO). This study was conducted in accordance with the principles of the Declaration of Helsinki, and data were handled according to the General Data

Protection Regulation.

3. Results

3.1. Demographics of Delphi panel members

In total, 51 of the 62 persons contacted (82%) agreed to participate in the Delphi, of whom 47 (92%) completed the first questionnaire in round one (Table 1). Of the panel members who completed this questionnaire, 28 (57%) were able to participate in the consensus meetings. Forty-three panel members (83%) completed the second questionnaire. In all three rounds, most of the panel members were around 50 years of age and experienced professionals from both academic and regional hospitals, with mean years of work experience varying between 8 and 11. In both questionnaire rounds, the views of ICU professionals working in 10 of the 12 Dutch ICU-networks were covered. In each round, relevant ICU professions (i.e., intensivists, nurses, managers) and the patient/relative perspective were represented by more than one expert. Reasons for non-participation were time constraints and not working anymore in the ICU.

3.2. Delphi round one

The experts assessed the initial list of 85 indicators in round one. The group median scores and DIs for the appropriateness of each indicator are provided in Supplement 2. Based on these scores, 42 indicators were considered appropriate with panel agreement (49%). There was uncertainty for the remaining 43 indicators, with none lacking panel agreement. Experts proposed 17 additional indicators (Supplement 4).

3.3. Delphi round two

After the consensus meetings in round two, 18 of the 42 (43%) indicators accepted after the first round required formulation adjustments to proceed to the final round. One of the 43 'uncertain' indicators (2%) and two of the 17 proposed indicators (12%) also proceeded to the following round after reformulation. Eight indicators (five in the 'accepted' category and three in the 'uncertain' category) were merged with other indicators and did not proceed to the following round. All other indicators were excluded (Supplement 5). Thus, 40 indicators were accepted for assessment in the third round.

Table 1
Characteristics of panel experts.

	1st questionnaire (round one)	Two consensus meetings (round two)	2nd questionnaire (round three)
Total invited, n	51	28	52*
Participants, n (%)	47 (92)	16 (57)	43 (83)
Gender, male (%)	25 (53)	6 (38)	24 (55)
Median age, years (IQR)	50 (45–58)	50 (45–56)	51 (45–58)
Stakeholder type, n (%)			
Intensivist†	20 (43)	5 (31)	20 (47)
ICU nurse	9 (19)	4 (25)	7 (16)
ICU manager	4 (9)	1 (6)	3 (7)
ICU network coordinator	2 (4)	1 (6)	1 (2)
ICU quality officer	3 (6)	2 (13)	3 (7)
Patient/relative/ representative	4 (9)	2 (13)	4 (9)
External expert§	3 (6)	–	3 (7)
Health care inspector	2 (4)	1 (6)	2 (5)
Mean work experience, years (IQR)	10 (4–17)	8 (5–13)	11 (4–15)
Working in an academic hospital (%)	60	77	45

ICU: Intensive Care Unit; IQR: Inter Quartile Range.
* One person was added to the panel based on his expertise after round two.
† Including medical heads of ICUs.
§ Experts in healthcare governance, quality measurement and regionalization.

3.4. Delphi round three

The remaining 40 indicators were assessed by the experts in round three. Table 2 gives an overview of the indicators with group median and DI scores for relevance and feasibility, and are listed in order of highest to lowest ranking (i.e., percentage of maximum possible ranking points). Based on the median ≥ 7 and DI < 1, the experts assessed 36 indicators as relevant and 28 as feasible. A subset of 24 indicators was assessed as relevant and feasible, which were mainly distributed among the categories: 'quality of regional ICU care' (4/4), 'contact and consultation' (4/4), 'exchange of knowledge and expertise' (2/2), 'governance and policy' (6/8) and 'well-being of ICU staff' (2/3) (Table 2). A total of seven indicators were selected for the core set (Table 2).

3.5. Practice test of the core set

All core set indicators were considered measurable in both ICU networks. However, providing evidence or data for several indicators would require additional documentation of activities and outcomes, such as describing the improvements implemented after regional quality discussion meetings (Table 3). Participants advocated for a designated person within the network who is responsible for this documentation. Participants also suggested using data (e.g., notes, action lists and PowerPoint slides) from network meetings as evidence for making the core set indicators measurable. Several minor revisions were made to improve the measurability and actionability of the indicators, which led to a definitive indicator core set shown in Table 3.

4. Discussion

To our knowledge, this study is the first to identify appropriate indicators for evaluating and improving the quality of regional ICU collaboratives. The results were based on the collective opinion of a multidisciplinary group of experts who represented different viewpoints and interests regarding ICU network collaboration and governance. This systematic, stepwise method generated a set of 24 indicators with satisfactory consensus-based levels of relevance and feasibility. In addition, a core set of seven indicators (three structure, three process and one outcome) were deemed most relevant and feasible, and proved measurable in practice. These indicators measure the Standardized Mortality Rate in the region ($n = 1$) and the presence, content and/or follow-up of a formal plan describing network structures and policy agreements ($n = 3$), a long-term network vision statement ($n = 1$), and network meetings to reflect on and learn from ICU outcome data ($n = 2$).

The 'structure' indicators in the core set address two of the four features of network collaboration as described in the framework by D'Amour et al. [17], namely: shared goals and vision and formalization (i.e., the documentation and use of procedures that communicate desired outputs and behaviours by network members). Two other important features of the framework, internalization (i.e., the awareness of network members of their interdependencies, sense of belonging and mutual trust) and governance (i.e., the leadership functions that support effective collaboration), are not measured by the indicators in the core set. Indicators addressing these features were assessed in the study but were considered less appropriate by the expert panel because of the lack of reliable and valid instruments for measuring these features. Furthermore, the two 'process' indicators in the core set align with previous papers addressing the importance of shared reflection, learning

Table 2
Assessment scores for the indicators after the second questionnaire (Delphi round 3) ($N = 43$).

Indicator			*Relevance*		*Feasibility*		*Ranking*
#	*Type*	*Formulation*	*Median*	*DI*	*Median*	*DI*	*% maximum points*
C5	Structure	A regional ICU cooperation plan is integrated in the policy plan of each ICU in which the tasks, responsibilities and competences of each hospital/ICU within the network are clearly described (yes/no).*	8	0.3	8	0.3	10.1
D14	Process	ICU indicator data from NICE† is regionally discussed with a focus on learning and improving (yes/no).*	8	0.2	8	0.2	8.1
C6	Process	The regional ICU cooperation plan is demonstrably annually evaluated and actualized within the network (yes/no).*	8	0.2	8	0.2	7.9
C8	Structure	Presence of an annual (quality) report of the ICU network describing the network governance structure, actions and outcomes (yes/no).*	8	0.2	8	0.2	6.4
D16	Process	The number and a description of the nature/types of improvements implemented after regional quality discussion meetings.*	7	0.2	7	0.2	5.4
A1	Outcome	SMR within the ICU network, expressed as the ratio of the observed and predicted mortality.*	7	0.1	8	0.1	5.3
B4	Process	Demonstrable follow-up of experiences and recommendations of ICU patients (and their relatives) who were transferred to another ICU in the region, expressed in scores/narratives.	7	0.5	6	0.5	5.3
C7	Structure	A long-term vision is formulated in which the role of each ICU within the network is clearly defined (yes/no).*	8	0.4	7	0.4	5.0
C9	Structure	Regional governance structure has been set up and formalized (yes/no).	7	0.2	8	0.2	3.7
B3	Process	Experiences and recommendations of ICU patients (and their relatives) who were transferred to another ICU in the region, expressed in scores/narratives.	7	0.5	6	0.5	3.4
E19	Structure	Availability of real-time/current information on bed capacity and occupation within the ICU network (yes/no).	8	0.3	6	0.3	3.4
C10	Process	Attention to possible threats to the network collaboration expressed by actions and/or the use of measures to identify, control and reduce risks to regional cooperation, as described in actions/documents.	7	0.5	6	0.5	3.1
G31	Structure	Presence of multidisciplinary working groups within the ICU network aimed at improving quality and safety of regional ICU care(yes/no).	8	0.3	7	0.3	2.9
A2	Outcome	ICU readmission rate within the ICU network, expressed as the percentage of the total number of admitted ICU patients who return to the ICU during the same hospitalization stay.	6	0.2	8	0.2	2.8
E22	Structure	Regional agreements concerning indications for ICU transfer (and return) are respected (yes/no).	7	0.3	6	0.3	2.8
F27	Structure	Presence of an agreement that states for which ICU patients physicians consult a peer within the ICU network (e.g. using the SOFA score) (yes/no).	7	0.2	7	0.2	2.6
F28	Structure	Presence of adequate technical infrastructure for remote consultation and discussion in each ICU within the network (yes/no).	8	0.4	7	0.4	2.5
D15	Process	Number of research collaborations (ongoing and completed over the past five years) within the ICU network.	7	0.4	7	0.4	2.2
D13	Outcome	The number and a description of the nature/types of incidents with transferred ICU patients within the network.	7	0.3	7	0.3	2.0
E20	Process	Information is exchanged within the ICU network on bed capacity and occupation (yes/no).	8	0.4	7	0.4	1.6
F30	Structure	Adequate technical infrastructure to facilitate information exchange within the ICU network (yes/no).	8	0.3	7	0.3	1.6
J39	Outcome	Extent to which ICU staff are intrinsically motivated to work together within the region, measured by a validated instrument and/or interviews.	7	0.5	6	0.5	1.6
E26	Process	Number of times per year that the ICU bed occupancy of 80% is exceeded and/or additional emergency ICU beds are needed within the ICU network.	7	0.4	7	0.4	1.4
H34	Outcome	Job satisfaction level of ICU staff within the ICU network, measured by a validated instrument.	7	0.3	7	0.3	1.4
J40	Outcome	Extent to which ICU staff have confidence in network cooperation, measured by a validated instrument and/or interviews.	7	0.5	6	0.5	1.1
E18	Structure	Presence of a central point (location and equipped with staff) responsible for monitoring and informing ICUs on available ICU beds in the region (yes/no).	7	0.4	7	0.4	0.8
E23	Structure	Mobile ICU is available within the ICU network for 24 h per day (yes/no).	7	0.7	6	0.7	0.8
F29	Structure	Presence of adequate technical infrastructure for monitoring bed capacity and staffing in the ICU network (yes/no).	7	0.5	7	0.5	0.8
G32	Structure	Number and type of other regional activities aimed to exchange knowledge and experiences (e.g., symposia).	7	0.2	7	0.2	0.6
H35	Outcome	Turnover ratio of ICU nurses and physicians within the ICU network.	7	0.4	7	0.4	0.6
J38	Outcome	Extent to which ICUs and staff identify themselves with/ feel part of their ICU network, measured by a validated and/or interviews.	7	0.5	6	0.5	0.6
E21	Process	Information is exchanged within the ICU network on staff capacity and staffing (yes/no).	7	0.2	6	0.2	0.3
I37	Structure	Available budget within the ICU network for educating ICU nurses.	7	0.3	6	0.3	0.3
E17	Process	Number of patient transfers within the network linked to ICU capacity problems.	7	0.2	7	0.2	0.2
H33	Outcome	Experienced workload by ICU staff within the ICU network, measured by a validated instrument.	7	0.5	6	0.5	0.2
C11	Structure	Strong leadership (decisive, stimulating) in the network, expressed by scores/narratives.	6	0.9	6	0.9	0
C12	Structure	Annually available time and budget for ICU staff within the ICU network to devote to tasks regarding regionalization of ICU care.	7	0.4	7	0.4	0
E24	Structure	Presence of regional agreements concerning ICU refusal of patients (yes/no).	6	0.5	7	0.5	0
E25	Process	Annual percentage of patients refused within the ICU network.	6	0.7	7	0.7	0
I36	Structure	Available budget within the ICU network for (advanced/ continuing) training of staff.	7	0.3	7	0.3	0

DI: Disagreement Index (0–1 = consensus); ICU: Intensive Care Unit; SMR: Standardized Mortality Ratio; NICE: National Intensive Care Evaluation Registry; SOFA: Sequential Organ Failure Assessment.
Categories: A. Regional health outcomes; B. Experiences of ICU patients and relatives; C. Governance and policy; D. Quality of regional ICU care; E. Capacity sharing, patient transfers and bed occupation; F. Contact and consultation; G. Exchange of knowledge and expertise; H. Well-being of ICU staff; I. Education and training; J. Network culture and identity.

* Indicators selected for the coreset on the basis of: a median > 7 and DI score < 1 for both relevance and feasibility, and receiving $\geq$5% of the maximum possible ranking points.

† NICE collects data on intensive care patients (demographics, comorbidities, reason for ICU admission, acute physiological disturbance) and their outcomes to monitor and improve the quality of care. This registry receives monthly batches of data from ICUs extracted from local electronic hospital registries (https://www.stichting-nice.nl/).

Table 3
Revised core set indicators after the practice test.

#	*Type*	*Formulation*
1	Structure	A regional ICU cooperation plan is integrated in the policy plan of each ICU in which the tasks, responsibilities and competences of each hospital/ICU within the network are clearly described (yes**, including a description of the content**/no).
2	Process	ICU indicator data from NICE is regionally discussed with a focus on learning and improving (yes/no).
3	Process	The regional ICU cooperation plan is demonstrably annually evaluated and actualized within the network (yes**, including a description of the evaluation and actualization**/no).
4	Structure	Presence of an annual (quality) report of the ICU network describing the network governance structure, actions and outcomes (yes**, including a description of the content** /no).
5	Process	The number and a description of the nature/types of improvements implemented after regional quality discussion meetings.
6	Outcome	SMR **(including 95% Confidence Interval)** within the ICU network, expressed as the ratio of the observed and predicted mortality.
7	Structure	A long-term vision **of the ICU network** is formulated in which the role of each ICU within the network is clearly defined (yes/no).

ICU: Intensive Care Unit; SMR: Standardized Mortality Ratio; NICE: National Intensive Care Evaluation Registry.
Revisions are indicated with bold font.

and improvement of care rather than only assessing clinical outcomes and figs [18,19]. The SMR is the only 'outcome' indicator in the core set, which is a valid outcome indicator expressing the ratio between the expected and actual number of deceased ICU patients. However, different patient populations can lead to considerable variation unless this ratio is corrected for case-mix. Therefore, comparing SMRs between hospitals in the region should be done cautiously and always combined with information about the patient population served by hospitals and other context information [20,21]. Nevertheless, comparing and discussing mortality statistics can be a valuable starting point for reflection and improvement within networks.

Our findings contribute to the current ICU quality improvement literature, as they inform clinicians, policy-makers, and managers for the first time on a set of indicators that may help to effectively govern ICU networks, thereby increasing the chance of networks' success [22]. The indicators that are considered most relevant and feasible cover a broad range of ICU network quality aspects such as continuous learning and improvement, clinical performance, communication, exchange of knowledge and expertise, governance, ICU staff and bed capacity, and well-being and education of ICU staff. The set includes both quantitative indicators (e.g. SMR, turnover rate) to benchmark performance over time or between ICUs, as well as qualitative indicators (e.g. description of actions following regional quality improvement meetings) to provide more nuanced information or help interpret the quantitative data [19]. The relatively short and pilot-tested core set can be used directly to govern or develop regional ICU network collaboratives. It should serve as a starting set for further fine-tuning under the guidance of professional associations in critical care. It might be possible to develop and add reliable and valid indicators for measuring other important network quality aspects currently missing from the core set, such as those related to internalization and leadership that are currently missed in the core set. Furthermore, the core set should be dynamic and regularly updated to include new quality problems, challenges and developments in ICU care. In addition, executives of the networks and professional associations should pay attention to the context in which the indicators are implemented [23]. For example, a lack of shared interest and mutual trust within and between networks, and poor communication about the purpose of using these indicators, may hamper data sharing and transparency of reliable data. It is vital that networks see and use the indicators as a tool to promote discussion and learn from differences within and between networks and to seek opportunities to improve the current network collaboration, rather than seeing the indicators as check marks or summative judgments for quality that serve external accountability [24]. Moreover, a lack of resources (e.g., a dedicated quality officer) may interfere with collecting and analysing indicator data. If the indicators are to be successfully implemented in practice, it is therefore vital to identify potential barriers and select appropriate strategies to overcome them [25]. The development of web-based applications or software programs with specific formats would facilitate the necessary documentation of activities and outcomes at the individual ICU and network levels. Moreover, integrating indicator data in existing registries (e.g., NICE) could facilitate data access and sharing within and between ICU networks [26].

4.1. Limitations

Our findings should be seen in the light of several limitations. First, the indicators assessed in this Delphi study have not been scientifically evaluated on reliability, validity and discriminability. The extensive literature search prior to the Delphi did not lead to the identification of potentially relevant indicators that had been tested for these characteristics in previous studies. Consequently, indicators were selected based on their perceived added value for monitoring and improving the regional collaboration of ICUs. In hindsight, validated appraisal instruments could have improved the systematic assessment of indicators on relevance, scientific soundness and feasibility [27]. Second, although some structure indicators were deemed relevant and feasible, they may not be actionable after fulfilment (e.g., the presence of a long-term vision statement). Many Dutch ICU networks already have a certain organizational structure in place [9]. This situation calls for further adjustment and fine-tuning of the set tailored to the local context. Third, the indicators were selected by an expert panel whose scores for relevance and feasibility may have been influenced by the country and region-specific contexts. Findings may correspond with the perspectives of similar experts internationally but are not necessarily generalizable to the organization of regional ICU collaboratives in other countries. Although the indicators were assessed and selected for the Dutch setting by a Dutch expert panel, they are fairly generic and therefore most likely also applicable in other countries where regional ICU care is organized in a similar way. However, they are less useful in countries where (regional) ICU care is organized differently. For example, in countries where critical care resources are allocated and concentrated in high-volume hospitals, and less attention is paid to regionalization. Or in countries where preconditions are missing for gaining insight into the selected indicators, such as the lack of agreements on measuring outcomes (e.g., SMR) or the absence of a national intensive care registry like NICE in the Netherlands or the Intensive Care National Audit and Research Centre (ICNARC) databases in the United Kingdom [28,29]. Finally, former ICU patients and relatives were less well represented compared to ICU professionals, which may have introduced bias in the scoring and selection of the indicators.

5. Conclusion

In a three-round Delphi study, a multidisciplinary expert panel reached a consensus on a set of indicators with satisfactory levels of relevance and feasibility to monitor and improve the quality of regional ICU network collaboratives in the Netherlands. This set may help Dutch ICU clinicians and policy-makers govern regional ICU networks and provide clues for governing regional ICU collaboratives abroad.

Although a core set of indicators proved to be measurable in practice, effective and long-term use of the indicators will require further refinement of the set and analysis of implementation barriers and facilitators.

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Authors' contributions

GH, MZ and HH conceived the study. GH, MZ and RV were responsible for the recruitment of participants and the collection of data. GH analysed and interpreted the data under the supervision of MZ. All other authors contributed substantially to the interpretation of data. GH drafted the manuscript, which was critically revised for important intellectual content by all other authors. All authors read and approved the final manuscript.

CRediT authorship contribution statement

Gijs Hesselink: Conceptualization, Methodology, Investigation, Resources, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Rutger Verhage:** Investigation, Resources, Writing – review & editing. **Iwan C.C. van der Horst:** Resources, Writing – review & editing. **Hans van der Hoeven:** Conceptualization, Resources, Writing – review & editing, Funding acquisition. **Marieke Zegers:** Conceptualization, Methodology, Investigation, Resources, Formal analysis, Project administration, Supervision, Writing – review & editing, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no competing interests.

Data availability

The datasets of the current study are available from the corresponding author upon reasonable request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcrc.2023.154440.

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