



Research article

A mixed methods exploration of intensive care unit nurses' perception of handling oxygen therapy to critically ill patients

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ABSTRACT

Objectives: Nurses handle supplementary oxygen to intensive care unit patients as part of their daily practise. To secure patients of optimal and safe care, knowledge of nurses' perception of this practise, including influencing factors for adjusting oxygenation levels is essential. This study aimed to explore intensive care nurses' perception of handling oxygenation and of factors that govern and influence this practise.

Research methodology/design: A mixed methods approach was applied comprising six focus group interviews, conducted in February/March 2017, leading to construction of a questionnaire distributed to 535 ICU nurses in September 2017. Following a process of content analysis, the findings were discussed against Gittel's framework for relational coordination.

Setting: Intensive care units in rural, urban and university hospital settings.

Main outcome: A deeper understanding of nurses' perception of handling oxygenation to patients in the intensive care unit.

Findings and results: Findings are presented through the categories *Treatment Guidance, Nursing Practise, Knowledge and Competences and Inter-professional Collaboration*.

Conclusion: Nurses' practise of handling supplementary oxygen therapy to the intensive care patient is influenced by day-by-day physician prescribed upper and lower limits for pO₂ and pCO₂, by nurses' understanding of the individual clinical patient situation and by knowledge of pros and cons in relation to oxygen therapy including observational and clinical assessment expertise. Establishing working environments in the intensive care unit setting based on mutual inter- and intra-professional respect may contribute to enhance safe and high quality patient care.

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Implications for clinical practice

- Explicit and written treatment guidelines and shared goals for oxygen treatment is needed to support correct supplementary oxygen supply and avoid day-by-day changes and risk of oxygen overload.
- Nurses' every day practise handling oxygen should rely on treatment guidelines and nurses' professional clinical assessment.
- If future research provides evidence for a more restrictive approach for oxygen supplements to the critically ill patient, it is of vital importance that nurses as well as physicians are thoroughly educated and trained, preferably together to reach high levels of shared knowledge and to serve as a basis for respectful inter-professional collaboration.

Introduction

The use of supplementary oxygen for patients in the intensive care unit (ICU) is a natural part of daily clinical practise for the ICU nurse. One of the most frequent causes of admission to the

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ICU is severe respiratory dysfunction requiring specialist treatment. Thus, the majority of intensive patients receive oxygen during their ICU stay in order to avoid critical illness related to life-threatening hypoxia.

Pioneers in the field originally believed that treatment with oxygen was always positive. This resulted in unrestricted high levels of oxygen therapy and aggressive methods of ventilation of ICU patients. In recent years an awareness have risen that high levels of supplementary oxygen therapy in mechanically ventilated patients may have unintended consequences. Existing research shows that treatment with oxygen and in particular oxygen treatment resulting in hyperoxia, can have a damaging effect. Pierson experienced that treatment with high levels of supplementary oxygen could result in injuries to the patient's lung tissue and thus to increased mortality (Pierson, 2013). Girardis et al. found that a hyperoxic oxygenation strategy increased mortality when compared to a more restrictive approach in a general ICU population (Girardis et al., 2016). In addition, hyperoxia has been associated with increased mortality in various subgroups of critically ill patients, including mechanically ventilated patients (Helmerhorst et al., 2017; Damiani et al., 2014; de Jonge et al., 2008).

Despite recent years' focus on oxygen treatment, researchers have not established the optimal level of oxygen supplement for the critically ill and mechanically ventilated patient (Damiani et al., 2014; Panwar et al., 2016; Suzuki et al., 2013). A questionnaire survey among intensivists in Canada, Australia and New Zealand showed that physicians in the ICU had different attitudes concerning the harmful effect of oxygen and therefore varied in their practise of supplementary oxygen (Eastwood et al., 2014). Consequently, the missing evidence of the optimal oxygenation level for the ICU patient leave clinicians to balance giving priority to the prevention of hypoxaemia or to the prevention of oxygen toxicity and subsequently pulmonary damage in the patients. In a Dutch qualitative study, 62 ICU physicians and 152 ICU nurses recognised the potential negative effects of long-term exposure to hyperoxia and expressed a low tolerance for high oxygen content. However, observations of their clinical practise showed that a large proportion of their ICU patients had higher arterial oxygen levels than they should have in relation to the established upper limits (Helmerhorst et al., 2014). In 2017, an international multi-centre study ([Handling <https://clinicaltrials.gov/ct2/show/NCT03174002?term=HOT-ICU&rank=1>](https://clinicaltrials.gov/ct2/show/NCT03174002?term=HOT-ICU&rank=1)) was initiated with the purpose to assess benefits and harms of lower versus higher oxygenation target in adult ICU patients with acute hypoxaemia respiratory failures (the HOT-ICU study). The nature of work in intensive care units is characterised by increasing levels of complexity, which raise the potential for confusion, errors and delays (de Bock et al., 2017). These conditions for treatment and care requires healthcare providers i.e. nurses and physicians to work interdependently to deliver quality care for the critical ill patient (de Bock et al., 2017). Research describes the nurse-physician collaboration as an important factor in improving patient outcomes and this necessitates a team approach in the treatment and care of the critical ill patient (Georgiou et al., 2017; Rose, 2011). Nurses play an important role in treatment and care of the ICU patient, which includes taking and sharing responsibility for the daily handling of oxygen supplements to the ICU patients. However, research that illuminates nurses' perspectives on the daily practise of using oxygen for the ICU patient is sparse. A questionnaire survey of 542 Australian nurses regarding the practise of oxygen therapy found a large variation in nurses' autonomy when handling oxygen to the ICU patient. The research focus included their use of oxygen during tracheal suction, their view of oxygen as a potentially damaging treatment, as well as their view of acceptable saturation levels for the ICU patient (Eastwood et al., 2012). If future research provides evidence for a more restrictive approach for oxygen

supplements to the ICU patient, it is of vital importance to build knowledge of how nurses handle the use of oxygen, including what factors nurses perceive as important for adjusting oxygenation levels in order to develop and secure optimal care and safety for the ICU patient. We therefore designed and conducted this study to gain insight into these aspects of ICU nursing, using a mixed methods approach building a quantitative data collection on data from a qualitative study (Fetters et al., 2013; Creswell and Zhang, 2009).

Aim

The aim of this study was to explore how ICU nurses perceive oxygen therapy in intensive care units. A special focus was on nurses' perception of factors that govern and influence how they handle ICU patients' oxygenation, nurses' perception of inter-professional team collaboration and of sharing responsibility.

Methods

Design

We applied an exploratory sequential design in the mixed methods approach of this study comprising focus group interviews and a questionnaire. Findings from the focus group interviews informed the development of the questionnaire and the two research approaches were thereby integrated through building to extend the exploration of the research issue (Zhang and Creswell, 2013; Fetters et al., 2013). Because different methods contribute with different perspectives, the mixed methods approach allowed us to gain a more complete picture and reach a deeper answer to the research question (O' Cathain et al., 2010).

Setting

Focus group interviews were carried out in the ICUs of three acute care hospitals, one in a capital region, one in a rural and one in an urban region. The questionnaire was distributed through a self-activating link to approximately 535 ICU nurses employed in seven acute care hospitals across five regions in one country.

The ICU in a Danish context

From June 2015 until June 2016, there were 30.326 admissions to the 43 Danish ICUs, where registered nurses care for patients. A nurse must have at least two years' experience as a general ward nurse before ICU employment. After one to two years in the ICU, the individual nurse starts formal training as an Intensive Care RN (ICRN), a combined theoretical and practical education lasting two years. During daytime hours, nursing staffing levels secures a 1:1 nurse/patient ratio, whereas nurses care for 1–2 patients in evenings and nights. The latter ratio depends on the type of ICU and the severity of the ICU patients' illnesses and overall condition. In most ICUs, a physician is present or close at hand during all hours of the day providing nurses with the possibility of receiving medical assistance, seeking advice and working inter-professionally at all times. Often ICU nurses work very independently, however, collaboration is aimed for in most ICU settings and especially when receiving patients newly admitted to the ICU and requiring immediately attention and acute interventions.

Data collection and participants

Nurses were eligible for participation in the study (focus group interviews and questionnaire), if employed in ICUs where the HOT-

Table 1

Interview guide comprising areas to discuss in focus group interviews exploring ICU nurses' perception of handling oxygen to critical ill patients in the ICU.

Opening question
“What comes to your mind, when thinking about oxygen handling in relation to patients in the ICU?”
Areas to discuss during focus group interviews
ICU nurses daily practise of handling oxygen supply to the intensive care unit patient
The patient receiving oxygen supply in intensive care units
Acute care situations
Stable situations
Responsibility in the handling of supplementary oxygen
Adjustment of oxygen supply
Oxygen

ICU study had not been implemented at the time of the data-collection. This selection was based on the assumption that the HOT-ICU study would increase focus on oxygen treatment and thus affect the nurses' clinical practise and knowledge base concerning oxygen treatment.

Focus groups

Nurses in three ICUs across three regions in one country were invited to participate in the focus group interviews by open invitations in the ICUs. During February–March 2017, six focus group interviews, lasting between 30 and 60 minutes, were conducted during daytime working hours in rooms close to the individual ICUs. A moderator guided the discussion following a semi-structured interview guide. Each interview was initiated by asking the participants: “*What comes to your mind, when thinking about oxygen handling in relation to patients in the ICU?*” A loose structured guide (Table 1) comprising certain focus areas, chosen based on the existing literature within the field, moderated the focus group discussions. All interviews were recorded digitally and transcribed verbatim.

Questionnaire

In a mixed methods study applying the approach of connexion, the latter data collection, in this case the quantitative data collection, builds upon findings from the first qualitative approach (Zhang and Creswell, 2013). Therefore, based on findings from the six focus group interviews, comprising four categories and 24 sub-categories, we developed a questionnaire. First, we structured the questionnaire according to the four categories, which were the main findings from the focus group interviews. Then we picked out 35 statements, all formulated word by word by ICU nurses during focus group interviews, to comprise the main content of the questionnaire. Nurses were to agree or disagree to the statements on a five point Likert scale with the answering possibilities; strongly disagree, disagree, indifferent, agree, strongly agree. In the questionnaire, the 35 statements were supplemented with eight demographic questions and four clinical questions. The questionnaire was pilot tested by three ICU nurses and revised due to their comments before it was distributed to a larger group of ICU nurses.

We contacted and included ICUs from seven acute care hospitals, representing a broad variety of hospital sizes, teaching/university status, and being either regional, urban, or rural. The seven ICUs comprised the three ICUs were focus group interviews had taken place, supplemented by another four ICUs. All ICU nurses in these seven hospitals received an e-mail from their nurse ward managers, on behalf of the research team, inviting them to participate in the survey by activating a link to a SurveyXact questionnaire.

Ethical approval

According to The Northern Nurses' Federation, no ethical permission is required (snn-norden.dk). Ethical considerations applied

to universal human values and professional opinion of what constitutes proper behaviour and attitudes in relation to employees. All participants received written and verbal information about study aims and methods and they received a guarantee of confidentiality of any delivered information before giving written informed consent to participate. All data were anonymous and nurses were informed that declining from participation in the study would not influence their relationship with ward or hospital managers. Participation in the survey was optional and completion of the questionnaire was regarded as informed consent.

Data analysis

The two datasets were analysed separately. Transcribed focus group interviews were analysed using content analysis inspired by Graneheim and Lundman (2004). The first step in the process of analysis comprised that both authors, constituting the research team, individually read the text several times and coded it as a line-by-line coding. According to the study's inductive approach, the text determined what was relevant to code. In the second step, following the coding, both authors independently grouped the identified codes under headings thereby constructing sub-categories. In step three of the analysis process, categories were formulated. All steps in this process were inspired by the description presented by Graneheim and Lundman. Both sub-categories and categories were discussed between the two authors until reaching consensus.

Statistics

Descriptive analyses of demographic data included percentages, mean, and range. Answers to the 35 statements in the questionnaire were dichotomised combining the two disagree answering possibilities into one, and the two agree answering possibilities into one. Descriptive analyses of these data included percentages. All analyses were performed using SurveyXact.

Findings and results

Focus group interviews – participant characteristic

In the six focus group interviews, comprising of seven, two, six, four, three and four participants respectively, 26 female nurses participated. Their experience as RN ranged from three years to 36 years (mean 17.9 years) and their ICU experience ranged from 2 months to 28 years (mean 9.8 years).

Focus group interviews – findings

Having applied a process of content analysis to the transcribed text material resulted in the following categories emerging; **Treatment guidance, Nursing Practise, Knowledge and Competences,**

and Inter-professional Collaboration. The categories express the manifest content of the interview text and answer the “what?” component embedded in the research question (Graneheim and Lundman, 2004). Table 2 presents the final steps in the analysis process. The findings are presented in more detail as part of the mixed methods results including further descriptions of the four categories and illustrative quotations.

Questionnaire – participant characteristics

In total, 206 (38%) ICU nurses completed the questionnaire of whom 203 (99%) were female and 170 (83%) were employed at general ICUs. Further demographic details are presented in Table 3. Results from the questionnaire are presented in percentages in the Table 4 and in the presentation of the mixed methods results.

Mixed methods results

In the Mixed Methods results section results from the focus group interviews and the questionnaire respectively are integrated through narrative by a weaving approach (Fetters et al., 2013), aiming to reach a deeper understanding of the research question by relating the questionnaire results to nurses' quotations thereby illuminating if ICU nurses generally supported or rejected nurses' (focus group) perceptions.

Treatment guidance

Nurses described that most patients receive oxygen in some way or the other during their stay in the ICU, a statement agreed to by 97% questionnaire respondents. Additionally, nurses described that they act without a formal written instruction on upper or lower limits for oxygen therapy. In the questionnaire 68% agreed to this statement. However, nurses expressed being used to working and adjusting oxygen supplement according to a standard prescription. A standard prescription is not a written guideline but still guidance known by everyone to follow in clinical practise. A standard prescription frames practise together with reflections about the patient's diagnosis and possible chronic illness.

"What matters to me is the standard prescription framing my practise, because then I have something to act within. ... Maybe I will act based on my experience, but that is not enough. The standard prescription framing my practise can be narrow and it can be wide, but having it is a necessity, because then I can act without having to involve the doctor all the time". (Focus group 1)

Table 2

Findings including the final steps (categories and sub-categories) in the analysis of focus group interviews as part of a mixed methods study exploring nurses' perspective of handling oxygen to the intensive care unit patient.

Categories	Treatment guidance	Nursing Practise	Knowledge and Competences	Inter-professional Collaboration
Sub-categories	Treatment goals Parameters and limits Patient categories Reason for ICU admittance Mechanical ventilator vs. non-mechanical ventilator Medical prescription Acute/emergency vs. non-emergency Standardized treatment	Handling/using oxygen Autonomy Responsibility Clinical observations Decision-making process Feeling safe	Bedside teaching Experience Education Toxicity Knowledge about oxygen	Culture Collegial sparring Collegial support Lack of acknowledgement Mutual trust Physicians' interest and belief Disagreement
Codes (examples)	Individual treatment goals for upper and lower limits guide practise (Focus group 3). Nurses handle oxygenation generously (Focus group 2).	Patients are seldom below the pO2 limit Oxygen is given based on nurses' assessment (Focus group 2).	Knowledge about oxygen and toxicity through education and bedside training (Focus group 5).	Close cooperation with the physician Dialogue and close at hand. (Focus group 1).

Table 3

Demographic details of Intensive care nurses participating in a questionnaire exploring nurses' perspective of handling oxygen to the intensive care patient.

Characteristic	Number (%)
<i>Gender</i>	
Female	204 (99%)
<i>Age</i>	
21–30 years	20 (10%)
31–40 years	48 (23%)
41–50 years	62 (30%)
51–60 years	64 (31%)
61–70 years	12 (6%)
<i>Experience as a registered nurse (years)</i>	18.4 (½–42) Mean (range)
<i>Experience working in the ICU (years)</i>	12.2 (0–36) Mean (range)
<i>Type of Intensive Care Unit</i>	
General	170 (83%)
Cardiology	27 (13%)
Other	9 (4%)
<i>Type of hospital</i>	
University	115 (56%)
Regional	92 (45%)
<i>Post graduate formal education</i>	
Intensive Care Nursing	165 (80%)
Other	6 (3%)
None	37 (18%)

In the questionnaire, 81% expressed that the patient's medical chronic condition was always taken into consideration when deciding on an appropriate oxygenation level for the individual patient, and an important distinction was made between patients diagnosed with Chronic Obstructive Lung Disease (COLD), a common patient category in the ICUs, and patients without COLD. The standard prescription frame for oxygen saturation level to aim for was described as the most basic “common knowledge” in the ICU known by everyone after just a short time of employment. However, it was underpinned during focus group interviews that adjusting oxygen supplement for the intubated and mechanically ventilated patient could not be assessed and discussed separated from evaluating and discussing the adjustment of other settings on the mechanical ventilator, agreed to by 96% of the questionnaire respondents. Furthermore, oxygen therapy was described to be targeted according to the individual patient situation. Nurses described using both the saturation and the results of arterial blood analysis (pO₂ and pCO₂) to assess the patient and target treatment goals. Nurses would always start oxygen therapy by providing high levels of oxygen supplement to the newly arrived

Table 4
ICU nurses' responses to 35 statements in a mixed methods study of ICU nurses' perception of handling oxygen to the Intensive Care Unit patients.

Statements	n 206		
	Dichotomised agree (%)	Neither (%)	Dichotomised do not agree (%)
Assessing the patient's oxygenation needs is a natural part of ICU nursing practise	96		4
I adjust the amount of oxygen for the individual patient based on a standard prescription	69	18	13
I adjust the amount of oxygen for the individual patient based on a physician's prescription	72	23	5
I adjust the amount of oxygen for the individual patient based on an individual (no standard prescription) nursing assessment	68	13	19
I assess the patient's need for oxygenation adjustments at the beginning of my working shift	74	14	12
I change autonomously the settings of the mechanical ventilator and receive approval from the physician afterwards.	59	23	18
I always consult the physician about the settings of the mechanical ventilator before I make any changes	25	31	44
I never make adjustment in the settings of the mechanical ventilator as it is a physician's responsibility	3	15	82
In my ICU, we have a guideline for weaning patients from the mechanical ventilator	51	28	1
In my ICU, we normally prevent de-saturation by supplying patients with extra oxygen before suction procedures or before repositioning or mobilisation	79	14	7
Patients' medical chronic condition impacts how much oxygen I'll give the patient	81	9	10
I have received thorough bed-side training how to handle oxygen for the intensive care patient	78	14	8
It is my impression, that in my ICU, knowledge about oxygen's toxicity impacts nursing practise	54	31	15
It is my impression, that in my ICU, knowledge about oxygen's toxicity impacts physicians' practise	62	30	8
The way I handle oxygen for the ICU patient has changed as I have gained more knowledge and more experience	87	11	2
In the ICU where I work, we all attend inter-professional discussions about clinical issues	71	13	16
I know about oxygen's toxicity	99		1
I know about the possible serious side-effects of oxygen overdose	85	10	5
My knowledge about oxygen has enhanced during my theoretical and practical training as an ICU nurse	67	27	6
In my ICU, adjusting oxygen supply relies on an inter-professional decision	44	32	24
In my ICU, nurses consult each other about adjusting oxygen supply	85	10	5
In my ICU, we discuss problems/Issues related to oxygen's possible toxicity	52	21	27
In my ICU, oxygen supply is always addressed during rounds	64	19	17
In my ICU, the oxygen prescription can change from one day to another depending on the physician seeing the patient	65	17	18
Oxygen is an important part of the treatment of the ICU patient	93	3	4
In my ICU, oxygen is used/regarded as a medication	57	22	21
In my time as an ICU nurse, I have noticed remarkable reductions in oxygen delivery	36	37	27
Most patients in my ICU, receive oxygen	97	1	2
The amount of oxygen supplied for the individual patient must be prescribed by a physician	39	34	27
Physicians trust nurses to act responsible when supplying oxygen	94	5	1
The level of oxygen supply should always be assessed together with other settings on the mechanical ventilator	96	2	2
In my ICU, physicians' personal attitudes about oxygen control their prescriptions	41	34	25
Oxygen may reduce anxiety or dyspnoea in the ICU patient	43	34	23
Acute hypoxia is much more dangerous than having a high pCO ₂	81	13	6
In emergency situations we provide as much oxygen as possible	76	17	6
I mainly handle oxygen based on the:			
• Saturation by the pulsoxymeter	55%		
• Arterial blood analysis	77%		
• Clinical assessment (watch-feel-listen)	39%		
In my ICU, we have written clinical guidelines about upper and lower limits regarding:			
• Saturation	49%		
• pO ₂	49%		
• pCO ₂	46%		
• FiO ₂	36%		
• I do not know	46%		
In my ICU, the following collaborators expect nurses to take responsibility for adjusting oxygen supply:			
• Nurse colleagues	82%		
• Physician colleagues	92%		
• Unit managers	39%		
• Department managers	22%		
In my ICU, training in handling patient oxygenation has primarily been:			
• Bedside training	85%		
• Theoretical training	56%		

patient and adjust the level of oxygen according to the pO₂. Some expressed being part of a culture where giving a little extra oxygen was considered a benefit to patients e.g. before tracheal suction the nurses would give the patient 100% oxygen for 1 min to prevent de-saturation. This was regarded a standard procedure and agreed to by 79% in the questionnaire.

Nursing practise

Nurses perceived handling oxygen supplement to ICU patients as an everyday natural part of nursing practise. This perception

was confirmed by 96% of nurses responding to the questionnaire. Furthermore, nurses perceived having a personal and professional responsibility to adjust patients' oxygen levels based on their clinical observations and the physicians' instructions. Nurses emphasised that using their professional clinical assessment of the patient guided their actions.

"But sometimes I have to adjust it (oxygen supply) myself because there is a patient diagnosed with COLD, but it is in the patient record, and you can tell that the saturation should not be that high!"

Interviewer: "What do you do then?"

"Well, I believe, we discuss it during patient rounds, but we also reduce it (oxygen supply) ourselves. We accept that the saturation is lower than prescribed originally."

"And you take a look at the pH-value to see if it is . . . appropriate. . . . Actually, I think that we are quite good at. . . ."

"I think, this is one of the things one mentions during patient rounds. . . . upper and lower limits? . . . which level and what are we aiming for?" (Focus group 5)

However, in order to do so, nurses found bedside training to be a necessity, but only 78% agreed to having received thorough training. Nurses described giving both high and low priority to assessing a patient's oxygenation and adjusting oxygen supply. On a daily basis nurses aim at balancing being precautious and acting responsible and independently. The questionnaire revealed that 69% and 68% respectively of responding nurses agreed to taking into consideration both physicians' general prescription for upper oxygen and saturation limits as well as their own clinical assessment when adjusting oxygen supply. During focus group interviews, nurses described being aware of the risk of oxygen overdose during their everyday clinical work. In the questionnaire, this statement was supported by 54%. However, nurses also expressed paying less attention to oxygen toxicity but giving priority to reducing risk of hypoxia. In the questionnaire, the majority, 81%, found hypoxia to be more dangerous than high pCO₂ levels. During critical deterioration 76% of the nurses agreed on no limits for oxygen delivery. Handling oxygen supply to reduce patients' feelings of fear of dyspnoea was during focus group interviews described to be an important part of nursing practise, a statement agreed to by 43%.

Knowledge and competences

Besides bedside training, nurses evaluated formal ICU education to be of high significance when learning how to handle ICU patients' oxygen therapy. In the questionnaire, 67% agreed that formal ICU education improved their knowledge and skills. During focus group interviews, nurses emphasised that formal education and bedside experience teach nurses the importance of paying attention to balancing patients' oxygen needs and the risk of oxygen toxicity.

"I attended a class a year ago and my attention was drawn towards whether oxygen should be used as a medication. It should be, because there are so many side effects. When I talk to my colleagues, I can tell, that is not the approach. . . .e.g. . . .in relation to atelectasis and. . . .there are several things, you should pay attention to. However, one does not think about it on a daily basis. When you adjust the oxygen supply, you look at the figures and numbers or other circumstances. And one should pay more attention to these things. . . .the side effects and complications related to oxygen supply". (Focus group 6)

Some nurses perceived oxygen as a medication requiring prescription from a physician when adjusted, agreed to by 57% of the respondents in the questionnaire, whereas others believed oxygen delivery to be less restricted than a medication. Nurses described being familiar with the issue of oxygen toxicity, confirmed by 99% in the questionnaire. However, 15% of the responding nurses expressed not having knowledge of specific side effects of hyperoxia.

Inter-professional collaboration

During focus group interviews, nurses expressed that they value a working culture securing inter-professional collaboration, and supporting professional reflections based on their clinical observations. Some nurses described that they act on their own when

adjusting oxygen supplements and inform the physician afterwards, a working culture agreed to by 59% of the questionnaire respondents. Nurses perceived that in general physicians appreciate and accept nurses' autonomy.

"Well, I think that, somehow, they (doctors) are listening to what we have to say".

"Actually, I think that when I talk to the doctor, and I always tell what I have done, then I always get very positive feedback, and several of the doctors have said that I'm doing a great job". (Focus group 6)

However, some nurses warned against this procedure due to risks of committing failure causing fatal consequences to both the patient and the nurse, and they described being more comfortable with asking for the physician's confirmation before adjusting oxygen supply or otherwise changing the settings of the mechanical ventilator. However, this statement was confirmed by 25% of questionnaire respondents. Nurses described how autonomy in decision-making, and the ability to trust one's own observations and clinical assessment was based on nursing experience and especially ICU experience. Nurses expressed that on one hand both physicians and managers expect them to call for assistance whenever needed, but on the other hand, they also expect them to act independently. Such ambiguous expectation would complicate everyday practise.

"I believe we are privileged. That is, we get to develop our skills and to use them. However, in doing so lies a great responsibility and great mutual expectations, because you need to trust one another inter-professionallybut also to trust other nurses. . . . We expect nurses to ask for advice, if they feel unsure or cannot cope with the situation. You must ask for help then!" (Focus group 3)

In the questionnaire 94% agreed to a statement expressing that physicians trust nurses to act responsible when supplying oxygen. Nurses experienced a working environment of mutual trust and acknowledgement; however only 44% agreed to a statement expressing that in their ward, adjusting oxygen supply was an interdisciplinary decision. Some mentioned that disagreements between nurses and physicians or between different physicians about treatment-goals influenced clinical practise and the working environment, which was agreed to by 65% of the questionnaire respondents. In the focus group interviews nurses expressed that some physicians lacked knowledge and acceptance of nurses' competences and they showed little interest in oxygen therapy regarding ICU patients who were not intubated.

Discussion

The purpose of this mixed method study was to explore how ICU nurses perceive oxygen therapy in Danish intensive care units, focusing on factors that govern and influence nurses' practise of handling oxygenation, of inter-professional team collaboration, and of sharing responsibility. We identified the categories *Treatment Guidance, Nursing Practise, Knowledge and Competences, and Inter-professional Collaboration*. These categories entail and describe nurses' perceptions and comprise the above-mentioned factors. Altogether, questionnaire results confirm nurses' perceptions of handling oxygen as expressed directly in focus group quotations or emerging in sub-categories and categories. In order to enhance reflections about nurses' perceptions of handling oxygen to patients in the ICU, we discuss the identified four categories, representing the study' mixed methods results, against Gittel's framework for Relational Coordination, especially against the framework's three sub-dimensions: *common goals, shared knowledge and mutual respect* (Gittel et al., 2013; Gittel, 2009), but also

against additional research. The core elements of Relational Coordination are the relationships among different healthcare providers and the communication between them, described in detail in the seven sub-dimensions: common goals, shared knowledge, mutual respect, frequent, timely and accurate communication as well as problem solving (Gittell et al., 2013; Gittell, 2009). In the everyday clinical setting, the complexity of a variety of clinical situations requests that several clinicians of different health care professions and medical specialities work together, which makes these complex situations especially demanding. Breakdowns in communication or unmet challenges to collaboration may compromise patient safety. When applied to working situations, Gittell's framework has been found to assist health professionals to coordinate care in a better way and to support the understanding of the nurse – physician relationship in complex clinical situations, including their communication process (Gittell et al., 2013, Gittell, 2009).

Most patients in the ICU receive supplementary oxygen. However, in this study we found that written guidelines and instructions about this important everyday procedure do not govern practise, as they are non-existing. Instead common treatment goals, known by everyone, but not at hand in the format of a written guideline or instruction guide nurses' practise on how to supply oxygen to different patient categories, e.g. patients diagnosed with COLD. Furthermore, so-called "standard prescriptions" govern nurses' practise of handling oxygen to ICU patients. The term covers physicians' prescriptions regarding upper and lower limits for oxygen treatment for individual patient categories. A standard prescription provides a free space for nurses to act within. Nurses appreciate this kind of guidance as it enables them to act independently, to tailor care based on their assessment of the patient, and interpret treatment goals guided by the patient's vital parameter values and arterial blood analysis. However, structuring care and treatment based on loosely described treatment goals may put patients' safety at risk, as nursing actions will depend extensively on the individual nurse's beliefs and competences and not on evidence-based knowledge. Furthermore, adverse events, due to misunderstandings or breakdowns in communication, is a risk to take into consideration when nurses' actions are structured by loosely described treatment goals. Gittell describes that if nurses and physicians share explicit common goals for the treatment and care they deliver to patients, it may secure delivering the best possible treatment and patient care during hospital admission and a successful patient pathway (Gittell, 2009). Gittell reports that explicit and negotiated common goals may help nurses and physicians align their actions with each other. In our study, nurses described feeling frustrated when physicians changed treatment goals on a day-by-day basis without any explanation as to why. Some nurses view such actions to represent a lack of respect towards nurses' practise and knowledge. When physicians change treatment goals without sharing their reflections about the impact on quality of care or patient safety, nurses feel that their professional knowledge of the individual patient is ignored. Without a solid argumentation for changing treatment goals, nurses might continue to practise handling oxygen the way they believe will suit the patient best. In addition, Gittell reports that mutual respect encourages nurses and physicians to value the contributions of others, to consider the impact of their actions on others, and to hear what others have said (Gittell et al., 2013; Gittell, 2009). Moreover, our study showed that sharing treatment goals is important as supported by Helmerhorst, who found that shared treatment goals are crucial when treating patients with oxygen for their respiratory dysfunction to avoid life-threatening hypoxia (Helmerhorst et al., 2017, 2015). Furthermore, a shared goal is a necessity to avoid damages to the patient's lung tissue and thus

to an increased mortality caused by hyperoxia (Girardis et al., 2016; Pierson, 2013).

The category *Nursing Practise* entails nurses' perceptions of handling oxygen in the ICU as being an everyday nursing activity, which nurses take responsibility in performing well for all patients. For the ones who have just been admitted to the ICU, handling oxygen is a lifesaving activity, and for those who are about to be discharged handling oxygen may be a reminiscence of the high monitoring acute care environment, which the patient has been exposed to for days or even weeks. This study's findings underline how handling oxygen was often fitted in between other essential clinical tasks, such as preparing and administrating medications, providing enteral nutrition for the patient, and adjusting a patient's positioning, or mobilising the patient. Giving priority to adjusting oxygen supply is thereby challenged by other tasks. Nursing practise, adjusting oxygen to ICU patients, is a balancing act influenced by the individual nurse's clinical observations, her knowledge about risk of hypoxia and risk of oxygen intoxication and by the sparse guidance from physicians to reach the best possible solution for the patient. The existence of shared knowledge between nursing colleagues and between nurses and physicians is valued to be the ground on which to decide how to handle oxygen treatment. However, shared evidence-based knowledge was not found to influence ICU nursing practise, as nurses rely on their knowledge about the patient coming from the continuing clinical measuring of the patient's vital signs, blood test results, and their own clinical observations and assessments.

The category *Knowledge and Competences* reflects that oxygen toxicity is common knowledge among ICU nurses, and training through formal ICU education is of significant importance to nurses when learning how to perform the balancing act of handling oxygen to ICU patients. However, not all nurses are familiar with knowledge of specific side effects of hyperoxia, which is crucial for securing patient safety. Besides, theoretical knowledge may not influence daily nursing practise. Nurses pay less attention to theoretical knowledge about serious side effects of oxygen, when acting bedside. The transfer of theoretical knowledge learned in a classroom context to the clinical setting and become integrated into clinical practise is a well-known challenge in health care. This aspect of handling oxygen to the ICU patient was also reported by Helmerhorst, who found that physicians' knowledge of serious side-effects was found to be of a theoretical kind and not solid enough to guide their practise (Helmerhorst et al., 2014). The aspects of knowledge and competences were also identified in Rowley-Conwy's study in relation to perceived barriers to the assessment of delirium in the ICU. Lack of knowledge was found to be the most common barrier leading to difficulty in assessing intubated patients (Rowley-Conwy, 2017).

The category *Inter-professional collaboration* entails nurses' descriptions of working side by side with other nurses and with physicians making each piece of clinical patient information cumulate into a shared base of knowledge that guide their course of actions. The majority of nurses found that they share important knowledge both intra- and inter-professionally, and shared knowledge is established in close collaboration between nurses and physicians working together to help patients through their stay in the ICU. In our study, nurses' ability to align their actions with the physicians' actions was found to depend on the individual nurse's belief in her own clinical assessment of the patient, her knowledge base and experience. Gittell emphasises that *shared knowledge* enables nurses and physicians to understand how their tasks fit together by contributing with their own mono-professional knowledge base (Gittell, 2009). Our findings reveal that some autonomous nurses might adjust supplementary oxygen for the patient and ask for permission or a prescription from the

physician afterwards whereas others prefer to collaborate with the physician beforehand. In fact, the latter group of nurses emphasise that they independently decide on the best care for the patient, but ask for the physician's accept before putting it into practise. Weston identified how nurses' professional clinical autonomy directly affects patient care. In the Weston study, autonomy was understood as the ability to make independent decisions related to patient care (Weston, 2009). Autonomy is an important part of nursing professionalism, however to ensure high quality patient care, discussions and consultations with inter-professional colleagues may even be of greater importance.

We found that nurses perceived the working culture in the ICU to influence their practise of handling oxygen to ICU patients positively or negatively. If the working culture facilitates that nurses are being listened to, respected, trusted to deliver safe care and to know when to act independently and autonomously and when to ask for collegial assistance, then nurses take great responsibility in providing safe oxygen treatment. However, on the other hand, when the working culture is characterised by inter-professional disrespect and unfamiliarity among physicians about nurses' skills and competences it may influence the individual nurse's practise of handling oxygen negatively and compromise her/his autonomy. According to Gittell, mutual respect encourages nurses and physicians to value the contributions of others, to consider the impact of their actions on others, and to hear what others have said (Gittell et al., 2013; Gittell, 2009). Gittell elaborates this by describing that in her research, when nurses and physicians worked inter-professionally, respecting each other's professionalism, they came to understand the valuable contribution that each of them brought to the situation. Furthermore, mutual respect has been shown to improve the quality and fluency of the teamwork, which is described to positively affect the patients' course (Lauvås and Lauvås, 2006).

As described by Zeitler and Lauvås and Lauvås, a constant developing process, comprising sharing knowledge, learning, and building consensus, constitutes an ideal situation of inter-professional collaboration (Zeitler et al., 2010; Lauvås and Lauvås, 2006). However, the predominant organisation of inter-professional clinical work in the hospital setting is a hierarchical structure where physicians prescribe and other professionals, often nurses, perform physicians' prescriptions. This fosters a discussion about the importance of teamwork and a search for ways to push forward and give priority to inter-professional collaboration. Inter-professional teamwork is considered a key element for improving patient outcomes (Coleman et al., 2008; Zwarenstein and Reeves, 2006). The nurse-physician collaboration is an important factor in improving patient outcomes and necessitates a team approach in the treatment and care of patients (Georgiou et al., 2017; Rose, 2011), therefore handling oxygen to ICU patients requires inter-professional teamwork in acute situations and every day collaboration.

Methodological limitations

This was a multi-centre and mixed methods study in which a questionnaire was constructed based on nurses' descriptions of their perceptions of handling oxygen to ICU patients. We believe that the mixed methods approach enhanced study findings by providing rich data illuminating both agreement and diversity in ICU nurses' perception of oxygen therapy practise and factors that influence this practise. Trustworthiness in study findings was aimed for by several measures. First, credibility was enhanced by including a broad variety of ICUs across one single country and by including a broad variety of nurses, from each ICU, in both focus group interviews and questionnaire. Using researcher triangula-

tion, involving two researchers, one having ICU experience and one without, in the research process from the beginning to the writing of this paper reduced researcher bias and enhanced credibility. Furthermore, conducting all six focus group interviews, transcribing, and analysing them within a short timespan supported dependability. To validate the questionnaire it was pilot tested before put into use in a large scale, however only 38% of nurses, receiving the questionnaire, responded to it, which may reduce reliability of the questionnaire results. A response rate of 38% is low. However, the snapshot we present is still based on more than 200 responding nurses. Our aim was not to produce one truth, but to present nurses' perspectives on factors that govern and influence how they handle oxygen to ICU patients.

Conclusion

This mixed methods study illuminates that nurses perceive handling oxygen to the ICU patient as governed and influenced by a conglomerate of **Treatment Guidance**, of how they approach their own **Nursing Practise**, of their own and their colleagues' **Knowledge and Competences**, and of the settings' culture for **Inter-professional Collaboration**. This means, nurses perceive their practise to be influenced by the day-by-day physician prescribed upper and lower limits for pO₂ and pCO₂, by their own understanding of the individual clinical patient situation, and by nurses and physicians' knowledge of pros and cons in relation to oxygen therapy including their observational and clinical assessment expertise. Furthermore, nurses believe that everyday practise of handling supplementary oxygen therapy demands close inter-professional collaboration between physicians and nurses and an understanding of the responsibility they share for this practise.

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Conflict of interest

None.

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