Australian Critical Care 33 (2020) 219–227

Contents lists available at ScienceDirect

Australian Critical Care

journal homepage: www.elsevier.com/locate/aucc

Research paper

# Physicians' perceptions about managing enteral nutrition and the implementation of tools to assist in nutritional decision-making in a paediatric intensive care unit

Clémence Moullet, MSc [a]
Elodie Schmutz, MSc [b]
Jocelyne Laure Depeyre, BSc [a]
Marie-Hélène Perez, MD [c]
Jacques Cotting, MD [c]
Corinne Jotterand Chaparro, PhD [a, *]

[a] Department of Nutrition and Dietetics, Geneva School of Health Sciences, HES-SO University of Applied Sciences and Arts Western Switzerland, Rue des Caroubiers 25, 1227 Carouge, Geneva, Switzerland
[b] HES-SO Master, University of Applied Sciences and Arts Western Switzerland, Avenue de Provence 6, 1007 Lausanne, University of Lausanne, Switzerland
[c] Pediatric Intensive Care Unit, Lausanne University Hospital (CHUV/UNIL), Rue Du Bugnon 46, 1011 Lausanne, Switzerland

ARTICLE INFORMATION

*Article history:*
Received 11 February 2020
Received in revised form
8 March 2020
Accepted 14 March 2020

*Keywords:*
Critical care
Child
Nutrition
Protocol
Clinical decision support system

ABSTRACT

*Background:* For critically ill children hospitalised in paediatric intensive care units, adequate nutrition reduces their risk of morbidity and mortality. Barriers may impede optimal nutritional support in this population. Moreover, physicians are usually responsible for prescribing nutrition, although they are not experts. Therefore, tools may be used to assist in nutritional decision-making, such as nutrition protocols.
*Objectives:* The objective of this two-stage qualitative study was to explore the perceptions of physicians about their management of enteral nutrition in a paediatric intensive care unit and the implementation of a nutrition protocol and computerised system.
*Methods:* This study involved semistructured interviews with physicians at the Paediatric Intensive Care Unit of Lausanne University Hospital, Switzerland. Research dietitians conducted interviews before (stage one) and after (stage two) the implementation of a nutrition protocol and computerised system. During stage one, six junior physicians and five fellows were interviewed. At stage two, 12 junior physicians, 12 fellows, and five senior physicians were interviewed. Interviews were recorded, with data transcribed verbatim before a thematic analysis using a framework method.
*Results:* Three themes emerged from thematic analysis: “nutritional knowledge”, “nutritional practices”, and “resources to manage nutrition”. During stage one, physicians, especially junior physicians, reported a lack of nutritional knowledge for critically ill children and stated that nutritional issues primarily depended on senior physicians, who themselves had various practices. All physicians were in favour of a nutrition protocol and computerised system. At stage two, interviewees stated that they used both tools regularly. They reported improved nutritional knowledge, more systematic and consistent nutritional practices, and increased attention to nutrition.
*Conclusions:* The implementation of a nutrition protocol and computerised system by a multiprofessional team helped physicians in the paediatric intensive care unit to manage nutritional support and increase their attention to nutrition.


* Corresponding author. Present address: Rue des Caroubiers 25, 1227 Carouge, Switzerland. Tel.: +41 22 388 34 60.
*E-mail addresses:* clemence.moullet@hesge.ch (C. Moullet), elodie.schmutz@chuv.ch (E. Schmutz), jocelyne.depeyre@hesge.ch (J. Laure Depeyre), marie-helene.perez@chuv.ch (M.-H. Perez), jacques.cotting@chuv.ch (J. Cotting), corinne.jotterand@hesge.ch (C. Jotterand Chaparro).

https://doi.org/10.1016/j.aucc.2020.03.003

## 1. Introduction

In critically ill children hospitalised in paediatric intensive care units (PICUs), the provision of adequate nutrition decreases the risk of morbidity and mortality,[1–3] as well as the risk of long-term impaired growth and neurocognitive development.[4] However, difficulties are often encountered when managing this nutritional support. Indeed, this population is very heterogeneous in terms of age, severity of illness, nutritional status, and treatment, which makes it difficult to correctly estimate their nutritional requirements. In addition, several barriers may impede the delivery of nutritional support, such as interruptions for medical procedures, gastrointestinal disorders, or fasting for surgical procedures.[5,6]

The management of nutritional support for critically ill children requires specific knowledge and skills, especially in avoiding a cumulative energy debt associated with poor clinical outcomes.[1,7] In most PICUs, physicians must prescribe nutritional support; however, not all are experts in the field.[8] The American Society for Parenteral and Enteral Nutrition (ASPEN) recommends that a nutrition support team, including a dedicated dietitian, should be available in PICUs.[9] However, in many instances, financial resources limit this possibility. Notwithstanding this, additional support resources may be used to assist in nutritional decision-making, such as nutrition protocols, training, or computerised information systems.[10–12]

Several studies have investigated the efficacy of these tools in critical care settings and shown that an enteral nutrition (EN) protocol in a PICU setting was associated with a reduction in gastrointestinal complications and infections, as well as improved nutritional goals.[10,13,14] In a recent systematic review, computerised systems improved nutrient delivery, rates of malnutrition, weight loss, blood glucose values, clinician efficiency, and error rates in a neonatal and adult critical care setting.[11] To our knowledge, the use of a computerised nutrition system in PICUs has not been studied. In addition, the works on the effects of resources to assist in nutritional decision-making used a quantitative research design, and the needs and perceptions of physicians in PICUs to prescribe and manage nutritional support have remained unexplored. To develop and implement tools most adapted to the needs of physicians, which will favour optimal management of nutritional support in critically ill children, the physicians' views are essential and need to be studied.

Therefore, a two-stage qualitative study was designed. We aimed to explore the perceptions of PICU physicians about their management of EN and the implementation of a nutrition protocol and computerised system.

## 2. Material and methods

### 2.1. Study setting

This study was conducted at the PICU of Lausanne University Hospital, Switzerland from April 2018 to July 2019. In this PICU with 12 beds, general intensive care patients and cardiac patients are admitted. The neonatology intensive care unit (NICU) is separated from the PICU. Nutritional support was prescribed by physicians in the PICU, who may call a dietitian from the nutrition service in case of questions. No nutrition protocol was available in the PICU at the beginning of the study.

The research team, constituted by research dietitians and heads of the PICU, has conducted nutritional studies in the PICU for many years before the present study. They also provided an in-house 2-h course on nutrition for critically ill children every semester to new junior physicians and fellows.

### 2.2. Study design

This two-stage qualitative study involved semistructured interviews, underpinned by an interpretivist framework method,[15] to explore the perceptions of PICU physicians about the management of EN and the implementation of tools to assist in nutritional decision-making. Interviews were conducted over two stages, separated by the implementation of a nutrition protocol and a computerised nutrition system (MetaVision, iMD-soft®, Tel Aviv, Israel). Fig. 1 presents the timeframe of the study.

During stage one, which was conducted from April to July 2018, we aimed to explore the needs and perceptions of physicians in relation to potential tools to assist in nutritional decision-making. In August 2018, based on data from the interviews conducted during stage one, the lead physicians (MHP/JC) and the research dietitians (CJC/CM) developed and implemented in the PICU a nutrition protocol and a nutrition section on a computerised system. The nutrition protocol was based on American guidelines[9] and was revised by nurse unit managers and senior physicians of the PICU. The nutrition section of the computerised system contained energy and protein goals, goal achievements, and nutritional intake information. Nurses responsible for the computerised system input this information into a new nutrition section. At each PICU admission, junior physicians entered the energy and protein goals of the patient and were required to make any necessary adjustments during the PICU stay. During stage two, from September 2018 to July 2019, we explored the physicians' perceptions of the

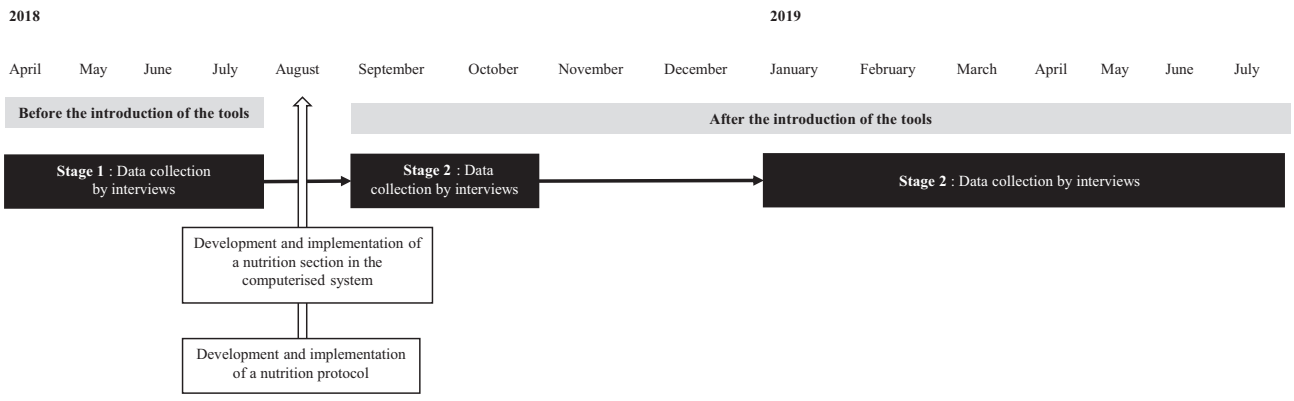


**Fig. 1.** Timeframe of the study with stage one, the introduction of the supporting tools, and stage two.

impact of the nutrition protocol and computerised system on their approach to managing EN and their opinions about the new tools.

The study was submitted to the Swiss Ethics Committee (Canton de Vaud) on research involving humans (CER-VD: no ID Req-2017-00974). The ethics committee concluded that the project was not bound by the Swiss Federal Act on research involving human beings and the ordinance on human research and that the project was exempt from their approval. Indeed, in this project, we studied the views of participants and did not collect health outcomes. Researchers still provided a written information sheet to participants and asked for their oral informed consent before interviews.

The study is reported following the Consolidated Criteria for Reporting Qualitative Research (COREQ)[16] for explicit and comprehensive reporting.

### 2.3. Participants and recruitment

Any PICU physician (i.e., junior physicians, fellows, and senior physicians) prescribing nutritional support was eligible to participate. Junior physicians, who have a master's degree in medicine, usually have no experience in the PICU and work under the supervision of fellows and senior physicians. Fellows have several months of experience in the PICU locally or in another hospital and work under the supervision of senior physicians. At the time of the study, there were five senior physicians who had worked in the PICU for several years.

Four junior and three fellow physicians were interviewed during stages one and two, to compare their perceptions about their management of EN and about the tools. We interviewed junior physicians and fellows during stages one and two to develop the tools based on their views because they are not experts in nutritional support of critically ill children. In addition, during stage two, we interviewed participants with variable experience of the tools at two different periods. We chose to interview senior physicians, who were the same during both stages, only at stage two to explore their perceptions of the implemented tools. This purposive sampling was used to recruit a mixture of participants in terms of age, years of clinical experience, and position status.[17] The heads of the PICU (JC/MHP) were excluded because they participated in study conception and tool development.

The research dietitians (CJC/CM) and the head doctors (MHP/JC) invited the potential participants by e-mail, with an information sheet attached describing the study. They were invited to ask any question about the project.

We chose the concept of saturated data to stop recruitment. This means that we conducted interviews until we no longer collected new information and the same answers were provided.[17] At stage one, data saturation was reached after nine interviews, but we decided to conduct two additional interviews to confirm that data saturation was achieved. At stage two, data saturation occurred after 23 interviews, and we included two additional interviews for each physician category.

### 2.4. Development of the semistructured interview guide

We developed a semistructured interview guide, based on our expertise in the field, nutritional guidelines,[18] our knowledge of PICU practices, and partly on the Theoretical Domains Framework (TDF) for use in behaviour change and implementation research.[19] We selected three domains of the TDF (knowledge, skills, and environment context and resources) to identify the main enablers and barriers, perceived by physicians, to managing nutritional support and using the implemented tools.[19] This choice was based on two small studies conducted by the research team in the PICU (a qualitative work using an observational method that described nutritional prescription of physicians and a quantitative work that assessed nutritional knowledge of physicians; unpublished data).

The semistructured interview design was chosen because it allows for the investigation of participants' perceptions, while orienting participants to talk about topics relevant to the research question. The researchers encourage interviewees to express themselves by asking open-ended questions. This type of interview also allows researchers to clarify and expand on topics discussed by interviewees. (CM) and (ES) conducted interviews with two junior physicians of the PICU to pilot the semistructured interview guide before data collection. This resulted in minor changes to the wording and sequences of some questions (Supplementary File 1). Relevant questions on the new tools were added during the interviews at stage two.

### 2.5. Conducting semistructured interviews

Three research dietitians conducted the interviews: Two senior research dietitians (CJC/CM) had collaborated with the PICU for many years and knew some of the interviewees, and a junior research dietitian (ES) did not know the participants. She was accompanied by a senior researcher during the first interviews.

A conversational style of interviewing was adopted with the semistructured interview guide, and physician responses provided direction for interviewers.[17] All physicians were interviewed one on one in a quiet room in the PICU. Before the interview, participants provided oral consent and brief demographics data (age, gender, position, years of experience, diploma). Interviews were audio recorded and lasted on average 24 min. Data from interviews were anonymised, and a code was assigned to each participant.

### 2.6. Data analysis

All interviews were anonymously transcribed verbatim for analysis, using oTranscribe transcription software (Elliot Bentley, MuckRock Foundation, USA). Data were displaced into NVivo, version 12, (QSR International, Melbourne, Australia) to help with data analysis management, using the framework method.[15] The interviews from stages one and two were analysed together, as the semistructured interview guide was very similar. After familiarising themselves with the transcripts, two researchers (CM/ES) highlighted important passages and then coded them to classify the data. The codes were then grouped into temporary categories. The final step was to interpret the data, develop key themes and subthemes using the TDF,[19] and explore their relationship. Any disagreements or contested themes and subthemes were discussed with the entire research team.[20,21]

In the Findings, direct quotes of participants are presented to express their views. Quotes were literally translated from French to English. Quotes were attributed to the three physician categories (i.e., junior physicians [JPs], fellows [Fs], or senior physicians [SPs]), to ensure confidentiality.

To enhance the credibility of the study, interviewer reflexivity was used to document preconceptions throughout the process, allowing them to consider their approaches to interviews and analyses.[22] Trustworthiness of data was enhanced by frequent discussions among the research team to ensure codes, themes, and subthemes were adequately described. The multiprofessional research team, comprising researchers and clinicians from dietetic and medical backgrounds, provided a range of insights into data analysis and interpretation. Finally, current PICU physicians were included, which ensured insider opinions and enhanced credibility.

## 3. Findings

### 3.1. Participants' characteristics

A total of 40 interviews were conducted with 33 physicians. During stage one, 11 physicians were interviewed (i.e., six junior physicians and five fellows). The mean age of participants was 31 ± 2 years. Seven females and four males were included. The mean duration of experience in the PICU was 4.0 mo for junior physicians and 19.5 mo for fellows.

During stage two, 29 physicians were interviewed (i.e., 12 junior physicians, 12 fellows, and five senior physicians). The mean age of participants was 35 ± 7 years. Seventeen females and twelve males were included. The mean duration of experience in the PICU ranged from 4.0 mo for junior physicians to 25.0 mo for fellows and 90 mo for senior physicians. Four junior and three fellow physicians were interviewed during stages one and two, to compare their views before and after the implementation of the tools. Participants' characteristic at stages one and two are shown in Table 1.

### 3.2. Themes and subthemes

Three themes "nutritional knowledge", "nutritional practices", and "resources to manage nutrition" were identified. Several subthemes were also identified and varied as per stage one or two (Table 2). Table 3 presents an overview of findings by themes and subthemes.

In the descriptions of findings, "the majority" corresponded to a response rate of ≥60%.

### 3.3. Nutritional knowledge

Physicians reported different levels of knowledge depending on the nutritional areas and on the stage of the study. They reported insufficient nutritional knowledge before the implementation of the tools and improved knowledge afterwards, although some areas remained unclear.

#### 3.3.1. Nutritional knowledge consistent among physicians (stages one and two)

At both stages, all participants provided similar information on fluids and electrolytes. They described that fluid requirements corresponded to 80% of maintenance requirements in intubated children and increased to 100% after extubation, as explained by one junior physician:

**Table 1**
Participants' characteristics in stages one and two ($N = 40$).

| Physician categories | Junior physicians | Fellows | Senior physicians |
|---|---|---|---|
| **Stage one** | | | |
| *N* | 6 | 5 | |
| Female n, % | 4 (67) | 3 (60) | |
| Age (years), mean ± SD | 31 ± 1 | 32 ± 2 | |
| Months of PICU experience, mean ± SD | 4.0 ± 2.0 | 20 ± 11 | |
| **Stage two** | | | |
| Physician categories | Junior physicians | Fellows | Senior physicians |
| *N* | 12 | 12 | 5 |
| Female n, % | 6 (50) | 9 (75) | 2 (40) |
| Age (years), mean ± SD | 33 ± 4.0 | 33 ± 4 | 46 ± 6 |
| Months of PICU experience, mean ± SD | 4.0 ± 1.0 | 25 ± 26 | 90 ± 27 |

PICU, paediatric intensive care unit; SD, standard deviation.

"We pediatricians have all memorised how much fluid intake we need to provide." [JP1]

#### 3.3.2. Lack of perceived nutritional knowledge (stage one)

In contrast, at stage one, physicians reported a lack of nutritional knowledge in several areas of nutritional support in critically ill children, including determination of energy and protein requirements, introduction and increase of EN, etc. The majority of junior and fellow physicians stated that they did not know what patient energy and protein requirements at PICU admission were, and they did not calculate them at PICU admission.

"I never know how many calories we are targeting according to age … it is often the supervisors who decide." [JP3]

"Nutritional goals … I can't remember by heart …" [F5]

The majority of participants mentioned that fluid balance was used to guide nutritional support instead of energy balance:

"I work in terms of volume … I don't know how much that corresponds to in terms of kcal,…we do the calculations in mL instead, therefore according to the need for fluid maintenance, not energy." [JP6]

"Finally, I don't calculate every day, I'm going to follow the fluid balance rather than the nutritional balance." [F4]

At stage one, no physicians stated that they calculated energy and protein requirements during PICU stay. A minority of the junior physicians stated that they calculated energy requirements for chronic patients. No physicians increased energy goals after extubation:

"After extubation, I know about the fluid requirements, but I don't know about the calories." [JP15]

"As long as they're lying in bed, not moving around much, I won't turn up the calories because patients are extubated …" [F5]

#### 3.3.3. Perceived nutritional knowledge was improved but remained insufficient in certain areas (stage two)

After the implementation of the tools, physicians reported improved nutritional knowledge, including the determination of energy and protein goals:

"…most numbers you learn them and after a few weeks you know them by heart. Then we put them on the order sheets and the nurses give them out." [JP13]

However, similar to stage one, physicians reported that energy requirements of extubated children were unclear. The majority of physicians stated that they did not increase energy goals after extubation and reported a lack of knowledge for these patients, which was even confirmed by two senior physicians:

"…we change the fluid requirements, but the caloric goals … I don't think we are changing them." [JP15]

"Once the patient is no longer seriously ill, the calculation must be performed differently. I think that is especially what we are not yet doing correctly." [F13]

"…I think what we're not very good at is when patients get better, it's not always easy. We don't necessarily think about increasing the needs because they are more active, it is not very clear how to do that." [SP4]

**Table 2**
Themes and subthemes.

| Themes | Subthemes |
|---|---|
| 1. Nutritional knowledge | a. Nutritional knowledge consistent among physicians (stages one and two)<br>b. Lack of perceived nutritional knowledge (stage one)<br>c. Perceived nutritional knowledge was improved but remained insufficient in certain areas (stage two) |
| 2. Nutritional practices | a. Variability of reported nutritional practices (stage one)<br>b. Reported nutritional practices were more consistent, but some areas remained inconsistent (stage two)<br>c. Increased attention to nutrition (stage two) |
| 3. Resources to manage nutrition | a. Needs for tools to clarify nutritional practices (stage one)<br>b. Opinions of physicians on the new tools (stage two) |

### *3.4. Nutritional practices*

Before the implementation of the tools, physicians reported variability in nutritional practices. They described more consistent and systematic practices at stage two.

#### *3.4.1. Variability of reported nutritional practices (stage one)*

In stage one, junior and fellow physicians reported variability of nutritional practices among the physicians, including the senior physicians, and unsystematic practices to manage EN. The five fellows reported calculating nutritional requirements at PICU admission not systematically but only in specific situations, such as in patients on parenteral nutrition, those hospitalised for long periods in the PICU, patients malnourished at admission, or premature patients.

> "Sometimes we make more advanced calculations for the neonates, but it is true that again we don't calculate systematically the nutritional needs." [F1]

> "… except in exceptional cases, a patient who stayed for a long time, who was undernourished, in this case we were interested in calories, we enriched his diet, otherwise we are not very interested in calories." [F2]

Physicians described imprecise and variable practices on the timing and quantity of EN at admission, and the increase thereafter. The majority mentioned, however, that they introduced EN within 6–48 h of PICU admission and recommended EN, with a continuous feeding, at postpyloric or gastric sites in older patients who tolerated this nutrition.

> "It depends a lot on the patient but in principle they are kept fasting at the beginning … afterwards it is very, very case dependent." [JP1]

> "I have the impression that there is no fixed rule." [JP2]

All junior physicians stated that increases in EN were dependent on the clinical situation of the patient, patient age, and the senior physician in charge of the patient. The majority of junior and fellow physicians explained that their practices were based on observations in the PICU, mostly on the practices of senior physicians, each of whom had his/her own manner of managing EN.

> "It is true that we are all very dependent on the senior physicians' practices, they do not all have the same practices … but most of what we do here will depend on the senior physicians' opinion." [F2]

#### *3.4.2. Reported nutritional practices were more consistent, but some areas remained inconsistent (stage two)*

At stage two, physicians reported more consistent and systematic nutritional practices. All junior physicians explained they could now systematically calculate patient energy and protein requirements and goals and enter values into the computerised system. Three fellows and all senior physicians explained that patient energy and protein requirements were discussed during morning medical rounds. Some physicians mentioned they were discussed daily, and others not on a daily basis.

> "What has been changed is having to enter the calorie and protein goals. Now we realise what goals we are aiming for." [JP9]

> "It is true that now the night team has to enter the data on MetaVision and during the morning medical rounds, we can see where we are in terms of total intake, if there has been a change compared to the previous day and we can adapt the new nutritional prescription." [F11]

> "Every day during the morning medical round, we read the order sheet and at some point we come to the nutrition goals, whether they have been met or not. I look at them to see if they seem to be adequate and then we discuss the nutrition strategy." [SP3].

For two fellows with limited experience in the PICU, increased EN and the reintroduction of nutrition after extubation were unclear practices. The majority of fellows and the senior physicians stated a similar increase of EN was adapted to the age of the patient and to the patient's clinical situation.

> "… it is true that there are colleagues who start again at 10, 20 ml and colleagues who start directly with what the patient already received before the extubation … it is not very clear." [F8]

> "The increase in feeding depends on the pathology of the child, its age, starting at 1 ml/h of enteral feeding, depending on the patient." [F10]

#### *3.4.3. Increased attention to nutrition (stage two)*

The majority of physicians reported that the introduction of the tools made them more attentive to nutrition:

> "Everyone is more attentive to nutrition and during the morning medical round, we look at this point." [JP7]

> "We used to have children who fasted for several days … that has not been the case anymore, I do not see it anymore and I feel like there is more attention to nutrition. Before, it was heart-lung, if it was ok, we used to look at digestion and now it is becoming something to be systematically controlled." [F9]

> "I have become more rigorous, I pay more attention to nutrition. I am even more interested in nutrition than before." [SP2]

### *3.5. Resources to manage nutrition*

During stage one, physicians were in favour of tools to clarify nutritional practices. In stage two, they cited the new tools as important resources to manage nutritional support but also

**Table 3**
Overview of findings by themes and subthemes before and after the implementation of the new tools.

| | |
|---|---|
| **1. Nutritional knowledge** | |
| 1a. Nutritional knowledge consistent among physicians (stages one and two) | - Physicians were aware of fluid and electrolyte requirements for intubated and extubated children. |
| 1b. Lack of perceived nutritional knowledge (stage one) | - Physicians reported a lack of knowledge in the following areas:<br>- How to calculate energy and protein requirements. They reported using fluid balance instead of energy balance to guide nutritional support.<br>- How to reassess energy requirements during the PICU stay.<br>- How to determine energy goals in extubated children.<br>- How much EN to prescribe during the PICU stay. |
| 1c. Perceived nutritional knowledge was improved but remained insufficient in certain areas (stage two) | - Physicians were aware of the recommendations on how to calculate energy and protein requirements.<br>- Physicians were aware of increased energy requirements during the PICU stay but did not provide precise values.<br>- Physicians knew the quantity of nutrition to prescribe when EN was introduced and the rate of increase during the PICU stay.<br>- The energy goals for extubated children remained unknown. |
| **2. Nutritional practices** | |
| 2a. Variability of reported nutritional practices (stage one) | - Physicians reported that they based their practices on observations of senior physicians with inconsistent practices.<br>- Physicians reported that energy and protein requirements were not calculated systematically, except in specific situations by fellows.<br>- The reported delay of introduction of EN varied between 6 and 48 h after PICU admission.<br>- The reported procedure to increase EN was unclear and inconsistent among physicians. |
| 2b. Reported nutritional practices were more consistent, but some areas remained inconsistent (stage two) | - Junior physicians reported that they systematically calculated energy and protein requirements and goals and entered values into the computerised system.<br>- Physicians reported that during morning medical rounds, energy and protein requirements were discussed regularly, but not systematically.<br>- Physicians reported that they did not systematically reassess energy requirements during the PICU stay.<br>- The procedure to increase EN was quite similar regarding physicians and variables as per patients' age and clinical situations.<br>- Some areas, such as the increase of EN and the reintroduction of nutrition after extubation, remained practices. |
| 2c. Increased attention to nutrition (stage two) | - The majority of physicians reported that the introduction of the tools made them more attentive to nutrition. |
| **3. Resources to manage nutrition** | |
| 3a. Needs for tools to clarify nutritional practices (stage one) | - Physicians reported using their own notes and the course on nutrition in the PICU.<br>- All physicians stated that a nutrition protocol and a nutrition section in the computerised system would be useful. They mentioned that it would help to have more consistent and systematic nutritional practices and to clarify their role in managing nutritional support.<br>- Physicians requested that the nutrition section in the computerised system include energy and protein goals, nutritional intake, and achievement of energy and protein goals. |
| **3. Resources to manage nutrition** | |
| 3b. Opinions of physicians on the new tools (stage two) | - Physicians reported that they regularly used the nutrition protocol as a reference tool. The majority explained that the nutrition protocol clarified and standardised the management of nutritional support for all medical staff.<br>- Physicians suggested clarification in the protocol of energy requirements for children recently extubated.<br>- Physicians reported that the computerised system was useful and contained important information.<br>- Physicians reported that they checked energy and protein goals and their achievements in the computerised system.<br>- Physicians reported that the main barrier to the systematic use of the new tools and managing nutritional support was a lack of time. |

reported that the lack of time was a barrier to using these tools systematically.

*3.5.1. Needs for tools to clarify nutritional practices (stage one)*

At stage one, for prescribing nutrition, all participants said they also used their own notes, and the majority cited the 2-h in-house introductory course on nutrition in critically ill children as a resource reference. They all agreed that a nutrition protocol and a nutrition section in the computerised system would be useful. They mentioned that it would help to have more consistent and systematic nutritional practices and to clarify their role in managing nutritional support:

> "Having a fairly simple document that outlines and then gives targets for different situations, is something that could help us. … What can be expected from us, what we should think about … inform us of what is desirable as good practices in the unit." [JP1]

> "… a little graph of what was supposed to be achieved and what was achieved. That would help me enormously. It would motivate me to look at it and ask myself, how can we increase nutrition?" [F1]

*3.5.2. Opinions of physicians on the new tools (stage two)*

All physicians described that they used the nutrition protocol as a main source of nutritional information. The majority explained that the nutrition protocol clarified and standardised the management of nutritional support for all medical staff:

> "I think that now we understand better what to do, how to do it and why, we know better how to calculate what we need to give in each case." [F13]

"Our care is even more homogenous because we follow a clear protocol." [SP1]

"The other thing that has changed, I think for junior physicians and fellows is that it is clear how much to give, it is not everyone deciding what they want. We all agree on the calories we give to intubated and sedated children." [SP3]

All senior physicians stated that they recommended that medical staff use the nutrition protocol.

All physicians stated that the nutrition section in the computerised system was useful and contained important information. The majority said they regularly used this section to check energy and protein goals and achievements. One fellow said:

"I find that we have a better idea of nutritional achievements … now we have benchmarks." [F11]

Some physicians stated that they used the computerised nutrition system every day during medical visits, and others stated that it was not systematically used. Two fellows said the computerised nutrition section was checked during medical visits according to the senior physicians in charge of patients. These statements were confirmed by the senior physicians, who stated they did not systematically use the nutrition section.

The majority of physicians explained that a lack of time was a barrier to using the computerised system and to management of nutritional support. The majority of junior physicians reported that they reviewed nutritional goals if they had time during the night shift. Some fellows stated that lack of time during morning medical rounds impeded recalculation of nutritional goals.

"Well, it depends on the activity of the unit, if we have time to recalculate at the morning medical round … it is possible that one or two days go by because we can't recalculate the same day." [JP15]

"… the nutrition computerised system, we don't necessarily have time … sometimes at night I look at it because we have more time. Otherwise we don't have much time during the day." [JP17]

"I look at the nutrition section of the computerised system but not systematically enough but it depends a lot on the time available … it is true that when you have a few patients in the unit, you tend to go around more." [SP1]

During stage two, the majority of physicians also cited the introductory course on nutrition for critically ill children as a reference tool.

## 4. Discussion

The objective of this two-stage qualitative study was to explore the perceptions of physicians about their management of EN in the PICU and the implementation of a nutrition protocol and computerised system. Based on 40 interviews conducted with 33 PICU physicians, we observed a need for tools to increase nutritional knowledge and consistency of practice. Two tools were developed and implemented by a multiprofessional team, including physicians, dietitians, and nurses. As a result of using the tools, physicians reported improved nutritional knowledge, more systematic nutritional practices, and increased attention to nutrition.

During stage one of the study, junior and fellow physicians reported that they felt unsure about several important areas of nutrition in critically ill children, such as the determination of energy requirements of patients, whereas they were clearly better informed on fluids and electrolytic requirements. After the implementation of the tools, physicians reported that they used the nutrition protocol as a reference and reported improved nutritional knowledge. Specific areas such as energy requirements in children recently extubated remained unclear. This was not surprising as the large majority of studies focused on critical illness during the acute phase, and there is a lack of data on nutritional requirements of PICU patients in the rehabilitation phase.[23] The lack of nutritional knowledge of physicians prescribing nutritional support in care settings has been demonstrated. In 2019, a survey of physicians including pediatricians showed that 65% of participants displayed inadequate knowledge on clinical nutrition, and only 23% felt capable of calculating daily energy requirements in postsurgical patients.[8] In adult ICUs, 44% of physicians and 26% of nurses were aware of guidelines on nutritional support.[24] In addition, 59% of participants would have liked more training on nutritional support for critically ill patients.[24]

The lack of nutritional knowledge in healthcare professionals has been well documented. One of the main causes is insufficient academic nutrition training across several jurisdictions, including the USA,[25,26] Canada,[27] Asia, and Europe,[28,29] suggesting global issues in this area. Undergraduate, masters, and continuing education levels appear insufficient in this context.[29] To counterbalance this deficit, dietitians at the Academy of Nutrition and Dietetics in the USA have adopted leadership roles in nutrition training for all health professionals and promote and encourage interprofessional practices.[25] Data from our qualitative study suggest the need for increased clinical nutrition education for physicians and improved interprofessional practices to increase nutritional knowledge.

After implementation of the nutrition tools, physicians reported more consistent and systematic practices such as determination of energy goals at PICU admission and increased attention to nutrition. Some areas remained variable among physicians and depended on the clinical situation of the patients, but this is not surprising in a clinical setting that is very heterogeneous in terms of patient age, pathologies, and illness severity. In PICU settings, several quantitative studies, including a systematic review, have demonstrated that nutrition protocols improved clinical practice, including improved introduction of EN and energy goal achievements,[30–32] decreased gastrointestinal complications, and shorter PICU stays.[13,14] American and European guidelines have recommended nutrition protocols to optimise the management of nutritional support in critically ill children.[9,33]

The impact of computerised systems has also been assessed.[34–38] In adult ICUs, the implementation of computerised systems has been effective, notably by reducing administrative workloads for caregivers and improving drug prescriptions and patient glycaemic control.[34–36] Two particular studies conducted in adult ICUs demonstrated improved practices after the introduction of a nutrition section into the computerised system, outlining nutritional intake and requirements and energy debts.[37,38] As a result, nutritional support was rapidly introduced, energy goals were more frequently attained, and energy deficits were reduced.[37,38]

In the current project, all physicians were in favour of the implementation of the nutrition protocol and the computerised system, stating that they used them on a regular basis. Despite their enthusiasm, they reported that one of the barriers to using the computerised system to manage EN, more specifically to assess the adequacy of the nutritional intakes and the nutritional goals, was a lack of time. Several works have identified a lack of time as a barrier to applying scientific recommendations in clinical practice.[39,40] The ASPEN recommends that a nutrition support team, including a

dedicated dietitian, should be available in the PICU to manage nutritional support.[9]

This study had some limitations. First, owing to limited resources, we did not study the nutritional knowledge and practices of nurses. Second, the recruitment of participants by dietitians and head doctors may have influenced the participants. Similarly, we cannot exclude the possibility that dietitian interviewers influenced favourable responses from physicians. In addition, researcher interest towards increased nutrition visibility in the PICU might have influenced data interpretation. However, the research team used several strategies to ensure methodological rigour and trustworthiness. In this study, we did not assess nutritional intake received by the patients. In the future, a comprehensive quantitative study may be performed to compare nutritional intake and achievement of nutritional goals in patients before and after the implementation of these tools, as well as to confirm the perceptions of physicians, especially of increased knowledge and consistency of nutritional practices shown by this qualitative work.

In conclusion, after the implementation of a nutrition protocol and a computerised system by a multiprofessional team, PICU physicians reported improved management of EN, including increased nutritional knowledge, more consistent and systematic practices, and increased attention to nutrition. All physicians were in favour of the implementation of the tools and reported using them on a regular basis.

## Author agreement statement

All authors declare that this manuscript is original, has not been published before, and is not currently being considered for publication elsewhere. All authors confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. They further confirm that the order of authors listed in the manuscript has been approved by all. They understand that the Corresponding Author is the sole contact for the Editorial process. He/she is responsible for communicating with the other authors about progress, submissions of revisions, and final approval of proofs.

## Conflict of interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: C.M. has received grant from the Swiss Foundation for Nutrition Research and travel fees from Nutricia and Baxter (past). C.J.C. has received grant from the Marisa Sophie Foundation and has received travel fees from Nutricia and Baxter (past).

## Funding

The study was partly funded by the Marisa Sophie Foundation and the Swiss Foundation for Nutrition Research (grant for the Master course of Clémence Moullet – grant number: 538).

## CRediT authorship contribution statement

**Clémence Moullet:** Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft. **Elodie Schmutz:** Investigation, Formal analysis, Writing - review & editing. **Jocelyne Laure Depeyre:** Methodology, Formal analysis, Writing - review & editing. **Marie-Hélène Perez:** Investigation, Software, Resources, Writing - review & editing. **Jacques Cotting:** Conceptualization, Methodology, Formal analysis, Resources, Writing - review & editing. **Corinne Jotterand Chaparro:** Conceptualization, Methodology, Investigation, Writing - original draft, Project administration, Funding acquisition, Formal analysis.

## Acknowledgements

The authors thank all physicians who agreed to participate in this study as well as the medical and nursing staff members of the PICU for their support in developing the nutritional tools. The authors also thank Alicia Marti and Elisabeth Guadagnolo of the Geneva School of Health Sciences, HES-SO, Switzerland for technical assistance with interviews transcription, and Dr. Frédéric Valla of the PICU of Lyon University Children Hospital, France, for sharing his expertise in PICU nutrition. This article integrates partial results of the Master Thesis of ES, conducted within the joint Master of Science in Health Sciences of HES-SO and University of Lausanne (UNIL), and of the Master Thesis of CM conducted at the Institute of Public Health, Epidemiology and Development, Health College of the University of Bordeaux.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.aucc.2020.03.003.

## References

[1] Larsen BMK, Beggs MR, Leong AY, Kang SH, Persad R, Garcia Guerra G. Can energy intake alter clinical and hospital outcomes in PICU? Clin Nutr ESPEN 2018;24:41–6.
[2] Mehta NM, Bechard LJ, Cahill N, Wang M, Day A, Duggan CP, et al. Nutritional practices and their relationship to clinical outcomes in critically ill children–an international multicenter cohort study. Crit Care Med 2012;40:2204–11.
[3] Mikhailov TA, Kuhn EM, Manzi J, Christensen M, Collins M, Brown AM, et al. Early enteral nutrition is associated with lower mortality in critically ill children. J Parenter Enteral Nutr 2014;38:459–66.
[4] Verstraete S, Verbruggen SC, Hordijk JA, Vanhorebeek I, Dulfer K, Guiza F, et al. Long-term developmental effects of withholding parenteral nutrition for 1 week in the paediatric intensive care unit: a 2-year follow-up of the PEPaNIC international, randomised, controlled trial. Lancet Respir Med 2019;7:141–53.
[5] Rogers EJ, Gilbertson HR, Heine RG, Henning R. Barriers to adequate nutrition in critically ill children. Nutrition 2003;19:865–8.
[6] Keehn A, O'Brien C, Mazurak V, Brunet-Wood K, Joffe A, De Caen A, et al. Epidemiology of interruptions to nutrition support in critically Ill children in the pediatric intensive care unit. J Parenter Enteral Nutr 2015;39:211–7.
[7] Carvalhal FB, Ferreira Peres WA, Fontes Lima GC, Barcellos LH, do Carmo CN, de Carvalho Padilha P. Impact of energy deficit during hospitalization and biomarkers at admission on clinical outcomes in critically ill children: a longitudinal study. Clin Nutr ESPEN 2019;32:70–5.
[8] Grammatikopoulou MG, Katsouda A, Lekka K, Tsantekidis K, Bouras E, Kasapidou E, et al. Is continuing medical education sufficient? Assessing the clinical nutrition knowledge of medical doctors. Nutrition 2019;57:69–73.
[9] Mehta NM, Skillman HE, Irving SY, Coss-Bu JA, Vermilyea S, Farrington EA, et al. Guidelines for the provision and assessment of nutrition support therapy in the pediatric critically ill patient: society of critical care medicine and American society for parenteral and enteral nutrition. JPEN - J Parenter Enter Nutr 2017;41:706–42.
[10] Wong JJM, Ong C, Han WM, Lee JH. Protocol driven enteral nutrition in critically ill children: a systematic review. Intensive Care Med 2013;39:S120–1.
[11] North JC, Jordan KC, Metos J, Hurdle JF. Nutrition informatics applications in clinical practice: a systematic review. Proceedings - Annual Symposium AMIA 2015;2015:963–72.
[12] Kim H, Chang SJ. Implementing an educational program to improve critical care nurses' enteral nutritional support. Aust Crit Care : Off J Conf Austr Crit Care Nurses 2019;32:218–22.
[13] Ziemba KJ, Kumar R, Nuss K, Estrada M, Lin A, Ayad O. Clinical decision support tools and a standardized order set enhances early enteral nutrition in critically ill children. Nutr Clin Pract 2019;34:916–21.
[14] Kaufman J, Vichayavilas P, Rannie M, Peyton C, Carpenter E, Hull D, et al. Improved nutrition delivery and nutrition status in critically ill children with heart disease. Pediatrics 2015;135:e717–25.
[15] Gale NK, Heath G, Cameron E, Rashid S, Redwood S. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. BMC Med Res Methodol 2013;13:117.
[16] Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. Int J Qual Health Care : J Int Soc Qual Health Care 2007;19:349–57.

[17] Draper A, Swift JA. Qualitative research in nutrition and dietetics: data collection issues. J Hum Nutr Diet 2011;24:3–12.
[18] Mehta NM, Skillman HE, Irving SY, Coss-Bu JA, Vermilyea S, Farrington EA, et al. Guidelines for the provision and assessment of nutrition support therapy in the pediatric critically ill patient: society of critical care medicine and American society for parenteral and enteral nutrition. Pediatr Crit Care Med : J Soc Crit Care Med World Fed Pediatr Intensive Crit Care Soc 2017;18:675–715.
[19] Cane J, O'Connor D, Michie S. Validation of the theoretical domains framework for use in behaviour change and implementation research. Implement Sci : IS 2012;7:37.
[20] Saldana J. The coding manual for qualitative researchers. 3rd ed. London: SAGE Publications Ltd; 2015.
[21] Miles M, Hubert A. Analyse des données qualitatives. 2nd ed. De Boeck; 2003.
[22] Pilnick A, Swift JA. Qualitative research in nutrition and dietetics: assessing quality. J Hum Nutr Diet 2011;24:209–14.
[23] Ridley EJ, Chapple LS, Chapman MJ. Nutrition intake in the post-ICU hospitalization period. Curr Opin Clin Nutr Metab Care 2020;23:111–5.
[24] Lane C, Wedlake LJ, Dougherty L, Shaw C. Attitudes towards and knowledge of nutrition support amongst health care professionals on London intensive care units. J Hum Nutr Diet 2014;27(Suppl 2):339–51.
[25] Hark LA, Deen D. Position of the Academy of nutrition and dietetics: interprofessional education in nutrition as an essential component of medical education. J Acad Nutr Diet 2017;117:1104–13.
[26] Adams KM, Kohlmeier M, Zeisel SH. Nutrition education in U.S. medical schools: latest update of a national survey. Academic medicine. J Assoc Am Med Coll 2010;85:1537–42.
[27] Hanninen S, Rashid M. Assessment of students' perception of the nutrition curriculum in a Canadian undergraduate medical education program. J Canad Assoc Gastroenterol 2019;2:141–7.
[28] Donini LM, Leonardi F, Rondanelli M, Banderali G, Battino M, Bertoli E, et al. The domains of human nutrition: the importance of nutrition education in academia and medical schools. Front Nutr 2017;4:2.
[29] Aggarwal M, Devries S, Freeman AM, Ostfeld R, Gaggin H, Taub P, et al. The deficit of nutrition education of physicians. Am J Med 2018;131:339–45.
[30] Wong JJM, Ong C, Han WM, Lee JH. Protocol-driven enteral nutrition in critically ill children: a systematic review. J Parenter Enteral Nutr 2014;38:29–39.
[31] Yoshimura S, Miyazu M, Yoshizawa S, So M, Kusama N, Hirate H, et al. Efficacy of an enteral feeding protocol for providing nutritional support after paediatric cardiac surgery. Anaesth Intensive Care 2015;43:587–93.
[32] Ang B, Han WM, Wong JJM, Lee AN, Chan YH, Lee JH. Impact of a nurse-led feeding protocol in a pediatric intensive care unit. Proc Singapore Healthcare 2016;25:35–42.
[33] Tume LN, Valla FV, Joosten KFM, Jotterand Chaparro C, Latten L, Marino LV, et al. Nutritional support for children during critical illness: European society of pediatric and neonatal intensive care (ESPNIC) metabolism, endocrine and nutrition section position statement and clinical recommandations. Intensive Care Medicine 2020;46:411–25.
[34] Nightingale PG, Adu D, Richards NT, Peters M. Implementation of rules based computerised bedside prescribing and administration: intervention study. BMJ (Clin Res Ed) 2000;320:750–3.
[35] Bates DW, Teich JM, Lee J, Seger D, Kuperman GJ, Ma'Luf N, et al. The impact of computerized physician order entry on medication error prevention. J Am Med Inf Assoc 1999;6:313–21.
[36] Bosman RJ, Rood E, Oudemans-van Straaten HM, Van der Spoel JI, Wester JP, Zandstra DF. Intensive care information system reduces documentation time of the nurses after cardiothoracic surgery. Intensive Care Med 2003;29:83–90.
[37] Berger MM, Revelly JP, Wasserfallen JB, Schmid A, Bouvry S, Cayeux MC, et al. Impact of a computerized information system on quality of nutritional support in the ICU. Nutrition 2006;22:221–9.
[38] van Schijndel RJ, de Groot SD, Driessen RH, Ligthart-Melis G, Girbes AR, Beishuizen A, et al. Computer-aided support improves early and adequate delivery of nutrients in the ICU. Neth J Med 2009;67:388–93.
[39] Byrnes A, Young A, Mudge A, Banks M, Bauer J. EXploring practice gaps to improve PERIoperativE Nutrition CarE (EXPERIENCE Study): a qualitative analysis of barriers to implementation of evidence-based practice guidelines. Eur J Clin Nutr 2019;73:94–101.
[40] Thomas DE, Kukuruzovic R, Martino B, Chauhan SS, Elliott EJ. Knowledge and use of evidence-based nutrition: a survey of paediatric dietitians. J Hum Nutr Diet 2003;16:315–22.