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Barriers to delivery of enteral nutrition in pediatric intensive care: a world survey

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ABSTRACT

Objective: To explore the perceived barriers by pediatric intensive care healthcare professionals (nurses, dietitians and physicians) in delivering enteral nutrition (EN) to critically ill children across the world.

Design: Cross-sectional international online survey adapted for use in pediatric settings.

Setting and subjects: Pediatric Intensive Care physicians, nurses and dietitians across the world

Interventions: The 20-item adult intensive care 'Barriers to delivery of enteral nutrition' survey was modified for pediatric settings, tested and translated into ten languages. The survey was distributed online to pediatric intensive care nurses, physicians and dietitians via professional networks in March – June 2019. Professionals were asked to rate each item indicating the degree to which they perceived it hinders the provision of EN in their pediatric intensive care unit (PICUs) with a 7-point Likert scale from 0 "not at all a barrier" to 6 "an extreme amount".

Measurement and Main Results: 920 pediatric intensive care professionals responded from 57 countries; 477/920 (52%) nurses, 407/920 (44%) physicians and 36/920 (4%) dietitians. Sixty-two percent had more than five years PICU experience and 49% worked in general PICUs, with 35% working in combined cardiac and general PICUs. The top three perceived barriers across all professional groups were: (1) enteral feeds being withheld in advance of procedures or operating department visits, (2) none or not enough dietitian coverage on weekends or evenings, (3) not enough time dedicated to education and training on how to optimally feed patients.

Conclusions: This is the largest survey that has explored perceived barriers to the delivery of enteral nutrition across the world by physicians, nurses and dietitians. There were some similarities with adult intensive care barriers. In all professional groups, the perception of barriers reduced with years PICU experience. This survey highlights implications for PICU practice around more focussed nutrition education for all PICU professional groups.

Keywords: child; infant; critical care; enteral nutrition; feeding; practices

Article tweet:

PICUs should identify barriers to delivering enteral nutrition in their PICU using a newly adapted quality improvement tool for pediatrics

<https://espnice-online.org/Education/Professional-Resources>

INTRODUCTION

Successfully achieving delivery of enteral nutrition (EN) to critically ill children is associated with improved clinical outcomes (1,2). Yet, multiple barriers remain to achieving adequate nutrition enterally in the critically ill child. Some of these are common to all pediatric intensive care units (PICUs), but for some, the barrier is organisation and unit specific (3,4). Recently, a survey instrument was developed and validated for adult intensive care units (AICUs) (5-7) to assess EN barriers in an ICU. This tool allowed clinicians to directly assess and address the perceived barriers in their ICU, with an aim to optimise enteral nutrition delivery. In the adult survey, 20 known barriers to delivering EN identified in the literature are rated on a Likert scale relating to the perception of the item being a barrier. The aim of our study was to explore the barriers in providing optimal nutrition to children in PICU settings worldwide as viewed by nurses, doctors and dieticians using this survey tool, modified for the pediatric setting.

MATERIALS AND METHODS

A cross-sectional electronic survey design was used. The 20-item adult survey instrument (5-7) was examined and modifications were made based on previously identified pediatric barriers from the literature. The modified survey was then pilot tested in a single UK PICU with 62 PICU staff (physicians, nurses and dieticians). All items from the adult survey were considered relevant and therefore no items were deleted; however, the wording of some items was revised for clarification. Four additional barrier items specific for PICU population were identified and added to the survey. Afterwards, pilot testing with nine professionals in a second PICU (in France) using the same method yielded one additional barrier item, resulting in a new 25-item barrier of enteral nutrition in PICU survey (Supplemental Figure 1). Added items were: 1) Severe fluid restriction; 2) conservative PICU feeding protocol; 3) Feeding tube or pump delivery problems; 4) Enteral feeds withheld for bedside procedures; and 5) Lack of staff knowledge and support around breastfeeding mothers.

In addition to the 25 barriers, basic demographic data was collected; PICU experience, PICU type and country, with one open ended question asking if there were any other barriers not listed. The survey was translated from English by bi-lingual clinicians into ten languages (French, Italian, Dutch, German, Latvian, Chinese, Spanish, Arabic, Polish and Portuguese) using a recognised cultural adaptation process (8) and tested by local clinicians for face validity. SurveyMonkey™ was used for distribution. Given the nature of distribution of this survey, there was no anticipated survey response. However, we aimed for an equal spread across continents and near equal amongst professional groups (acknowledging that the dietician numbers would be lower based on the number of dietitians compared to physicians and nurses). The inclusion criteria were: nurses, assistant nurses, dieticians

and doctors who are working in a PICU and make decisions around feeding in critically ill children. The exclusion criteria were: non-clinical nurses or staff who worked permanently outside clinical PICU setting. Neonatal and adult intensive care staff were excluded. If PICUs were mixed (neonates or adults), the introduction letter made it clear that the questions were to be answered regarding feeding in children aged 0 (term infants) to 17 years.

Data collection

The e-survey was sent out via established professional networks to PICU nurses, doctors and dieticians via country leads and via organisational newsletters (The European Society of Pediatric and Neonatal Intensive Care (ESPNIC), the UK Pediatric Intensive Care Society (PICS) and the World Federation of Pediatric Intensive Care Societies (WFPICS) in March -June 2019. Reminders were sent to country leads with low responses to improve response rates. No identifiable staff, patient or PICU data was collected, and consent was implied by completing the survey. Country leads were responsible for ensuring ethical requirements were obtained according to their country regulation. In the UK, (where data were gathered and analysed) this study was approved by the Pediatric Intensive Care Society (PICS) Study group and was approved as an audit by University Hospitals Bristol. Ethical approval was provided in the Netherlands by the Institutional Review Board of the Erasmus Medical Centre [MEC-2019-0065].

Data analysis

The datasets (one for each language version) from SurveyMonkey were downloaded, checked and combined into one dataset and imported into IBM SPSS version 25 (IBM Corp., Armonk, NY, USA) for analysis. All data were categorical data or ordinal data (Likert scale) and were first analysed descriptively and then inferential analysis undertaken to test relationships between categorical variables including continents/geographical regions, professional groups, PICU type regarding perceived barriers using chi square tests. The Likert scale ranged from 0 (not at all) to 6 (an extreme amount). Median [IQR] refers to the full Likers scale. However, barriers were further categorised as not a barrier (respondents who scored 0), moderate barrier (respondents who scored 1-3) and important barrier (respondents who scored score 4-6) consistent with the adult survey analysis (5,6). For subgroup analysis, the Europe countries were classified into three European regions as in the ETHICUS study (9); northern (Ireland, Latvia, Lithuania, the Netherlands, Sweden, and United Kingdom), central (Austria, Belgium, Germany, France, Luxembourg, Poland, and Switzerland), and southern (Bulgaria, Italy, Portugal, Spain). When a statically significant level was obtained using Chi square, differences between the variable were further compared using a z-test with Bonferroni correction. A p-value of <0.05 was considered significant and two tailed tests were used.

RESULTS

There were 920 survey responses from 57 countries (Figure 1). Most respondents were nurses (52%), and physicians (44%) followed by dietitians (4%). Sixty-two percent of respondents had more than five years PICU experience, and half (49%) worked in a general PICU with 32% in a mixed cardiac and general PICU (Table 1).

Top Barriers

The top five perceived barriers were: 1. Enteral feeds being withheld in advance of procedures or operating department visits (43%), 2. No dietitian coverage on weekends, evenings or holidays (38%), 3. Not enough time dedicated to education and training on optimal feeding of patients (34%), 4. In stable resuscitated patients, other aspects of care taking priority over nutrition (33%) and 5. Delays in obtaining small bowel access in patients intolerant of nutrition (31%). Table 2 presents the perceived importance of all barriers. However, these perceived barriers differed by professional group (Table 3 and Table 4). Importantly, dietitians perceived severe fluid restriction as the most significant barrier (69%), whereas for physicians it was withholding feeds before procedures (46%) and for nurses it was insufficient dietitian coverage on weekends, evenings and holidays (44%).

Comparing different PICU types: general PICUs compared to units which admitted cardiac surgical children and combined PICU-NICUs showed little differences in perceived barriers (Table 5) with severe fluid restriction being rated highly as a barrier across all PICU types (General 27% vs General & Cardiac 31% vs PICU and NICU 26% $p=0.354$). The two highest perceived barriers were consistent among the PICU types: Not enough (or no) dietitian coverage during weekends, evenings and holidays ($p=0.664$) and not enough time dedicated to education and training on how to optimally feed patients ($p=0.701$). When we examined perceived barriers by years of PICU experience, in all groups we found a reduction in perceived barriers as PICU experience increased (Supplementary file 2). This was statistically significant for seven barriers.

Within Europe (with the largest number of respondents; $n=517$), there were several significant differences in perceived barriers between northern, central and southern Europe (Table 6). Four barriers were perceived as a significantly greater barrier in northern Europe compared to southern or central Europe, these were: nutrition therapy not discussed on ward rounds ($p<0.001$), waiting for the dietitian to assess the patient ($p=0.004$), not enough dedicated time for training and education on how to optimally feed patients ($p<0.001$), and lack of familiarity with current guidelines for nutrition in the PICU ($p=0.001$).

There were also significant differences in 14 perceived barriers when comparing continents (Supplement file 3). Across all continents the biggest perceived barrier was enteral feeds being withheld for procedures and operating department visits, and this was the highest perceived barrier

in Southern America. A lack of knowledge around breastfeeding mothers was also significantly different between continents with the barrier perceived almost three times more in Northern America (48%) compared to Australasia (17%) ($p=0.001$). Most strikingly, was the perceived lack of dietician support and coverage in PICUs, which varied across countries, but even in units with a dietician (many had no dietitian input at all).

DISCUSSION

This is the largest survey undertaken to identify perceived barriers to the delivery of enteral nutrition in PICU settings across the world. It is also only the second survey to include all three professional groups responsible for the delivery of EN in the ICU (nurses, physicians and dieticians). With permission, we adapted and tested a new pediatric version of the survey tool validated for adult intensive care (5-7), providing a new pediatric version of this quality improvement tool.

We identified the main perceived barriers of enteral nutrition in PICU that were related to fasting for procedures, dietician coverage, inadequate education, care priorities and delays in gained small bowel access. However, there was variability in perceived barriers between the professional groups. In PICU, the first observational study to describe barriers to EN (10) found severe fluid restriction in children with congenital heart disease (CHD) the main barrier, followed by the interruption of feeds for procedures. In our study, only the dieticians perceived this as the most important barrier, and overall it ranked sixth. Interestingly, we did not find any significant difference between PICUs that admitted cardiac surgical children and those that did not, even though the fluid restriction for post-operative cardiac children is greater.

Cahill et al., (5) used the adult barriers survey to explore the views of 138 critical care nurses across five adult intensive care units in the USA and Canada. Three of these are consistent with our top five PICU perceived barriers but ranked differently. However, another adult ICU survey (11), found different barriers: with the main barrier being insufficient nursing staff to deliver EN (60%) followed by a fear of adverse events by feeding aggressively (56%).

The problem of feed interruption is well recognised (3,4,12). Mehta et al., (12) in a prospective observational study of 117 children, found interruptions occurred in 30% of PICU patients, and 58% of these interruptions were classed as avoidable. A Canadian survey of physicians and dieticians (3) also found fasting for procedures a major barrier. Fasting for procedures, both in the PICU (such as for extubation) or outside the PICU (for radiological procedures) and to the operating department, are considerable problems for most intensive care patients. No evidence exists regarding 'safe' fasting times for critically ill children and specifically which procedures require fasting for. The fear driving the fasting, is potentially having a 'full stomach' and the risk of pulmonary aspiration associated with

emergency reintubation (if the endotracheal tube became dislodged). Despite recent ERAS recommendations for 'well' children being fasted preoperatively, which have considerably reduced fasting times (13), there is no evidence for fasting times in critically ill children, being fed, often minimally and already intubated. New techniques, such as gastric antral ultrasound (14,15), need to be examined in the PICU population, to determine a more accurate way to individualise fasting times to critically ill children, with a view to avoiding the blanket 6 hour fasting rule.

In a UK-wide survey of PICU physicians, nurses and dieticians (4), the top five barriers were: severe fluid restriction (60%), the child being 'too ill' to feed (17%), surgical post-operative orders (17%), nursing staff being slow in starting feeds (7%) and hemodynamic instability (7%). However, despite the paucity of randomized trial evidence to support enteral feeding during critical illness states, a substantial body of observational study evidence exists (16,17,18,19,20) indicating early EN is both feasible and improves clinical outcomes.

More recently, a retrospective study of 444 children in 6 PICUs in the USA (21), identified the biggest risk factors for delayed EN were non-invasive ventilation (NIV), followed by invasive ventilation, increasing severity of illness, impending procedures and gastrointestinal disturbances within the first 48 hours. Interestingly, non-invasive ventilation was not listed as barrier in our survey (nor is it in the adult survey), and only two people mentioned being on NIV as a barrier in free text responses. Children requiring non-invasive respiratory support are at risk of requiring escalation of care to intubation. Many early guidelines recommended avoiding or limiting enteral nutrition in respiratory distress (American Bronchiolitis Guidelines), however NIV is no longer a barrier to enteral feeding, in accordance with recent updated guidelines (22).

Only 4% of the respondents were dieticians, and, the perceived inadequacy of dietician coverage in PICUs was identified by dieticians and physicians. Specialist dieticians and their educational level vary significantly across countries. Additionally, there are relatively few of these individuals compared to other healthcare professionals, with many European units reporting having no dietician at all (23). Nutritional support teams (including a dietitian) have been shown to be beneficial in optimising nutrition in PICUs (24). This has been shown in a Latin American and Spanish survey on nutrition in paediatric intensive care where 68% of the participant PICUs had a nutritional support team (NST) and the availability of a NST was associated with better nutritional practices (24). A perceived lack of education around nutrition (and the optimal feeding of critically ill patients) is concerning. In the UK, 'nutrition' is a required component of both specialist PICU nursing education and PICU medical trainees, however, how it is taught is variable. In some countries, specialist PICU training programs for doctors or nurses do not exist, and individuals train in adult critical care or anaesthesia, further contributing to their lack of knowledge around pediatric nutrition. In this context, the European

Society of Pediatric and Neonatal Intensive Care (ESPNIC) and its nutrition section, has a major role to play in providing education for all professionals.

The lack of prioritisation of nutrition over other aspects of care, has been identified as a problem in a recent Australian adult ICU nursing survey (25). In this study, nurses identified their main perceived role related to EN was the care, maintenance and management of EN and being an advocate for EN. When asked to rank their care priorities however, nutrition support and management ranked sixth after physiological monitoring of other systems, but before hygiene and psychological support. They concluded that education (as well as reducing other barriers) could improve nurses' understanding of the importance of nutrition and thus improve the prioritisation of nutrition within the competing demands of their workload. Additionally, a survey investigating barriers in an Israeli hospital found the time it takes to prescribe nutritional therapy, lack of protocols, and awareness of the staff of the nutritional therapy as the main barriers and highlighted the importance of collaboration between the clinical specialities (26). The role of a nutrition support nurse could also be a valuable aspect in a nutritional support team, especially in PICUs without a dietician. This nurse can act as an important player for patients and the healthcare organisation by having enough knowledge, attitudes and competences to fulfil the role of a clinical nutrition expert (27).

We found delays in obtaining small bowel access, was also reported as a barrier. Although the pediatric evidence does not show superiority in post-pyloric feeding as the primary feeding method, some units do utilise this method successfully in all patients (28-30). However, most units reserve this method for children intolerant of gastric feeding (23). In the only RCT of EN via gastric versus post-pyloric feeding (30) there was significant crossover and drop out reported in the post-pyloric arm because of inability to place the pyloric tube. Newer devices (31) may assist in ease of correct placement of these tubes in larger children, but others have simply implemented intensive nurse-training to achieve high placement success.

One of the most common reasons for failure to deliver enteral nutrition in PICUs is that of feed intolerance (3,12), yet this was not a survey item, and its definition remains problematic (32,33). In our pilot work this item was not suggested to be added, however several free text responses in this worldwide survey did suggest this as an item. Therefore, in future versions of this tool we will consider adding this item.

The Canadian Critical Care Nutrition network (<https://www.criticalcarenutrition.com/resources/strategies-for-improving>) who developed the barriers survey as part of a larger nutrition improvement program which focusses around: auditing your own practice, standardising care, identifying barriers, improving nutrition knowledge and having nutrition champions. They argue that this quality improvement survey sought to identify modifiable

ICU organisational and healthcare team barriers to the delivery of enteral nutrition, rather than patient-related and subjective factors such as feed intolerance.

The differences in perceived barriers by professional groups is interesting and has not been examined before. All three groups perceived fasting prior to procedures and operating department visits as a significant problem. The lack of dietician input was identified by both physicians and dietitians (in the top three barriers), but not nurses. This shows some consistency amongst the three professional groups but reflects their specific professional role around nutrition. Future education and interventions to improve enteral nutrition in PICUs must involve all three of these professional groups. This freely available survey (available in eleven languages on the ESPNIC website <https://espnice.org/Education/Professional-Resources>) can now be used by PICUs to firstly identify barriers in their unit, and then target these barriers to improve the delivery of enteral nutrition, as part of a unit-based quality improvement program. This survey tool was adapted to a paediatric ICU population and deliberately excluded neonatal wards, as the organizational, behavioural, clinical and pathophysiological aspect could be different. It would be interesting to evaluate these aspects in future research.

There are some limitations of our study that warrant highlighting. Firstly, due to our distribution method via professional networks and organisational websites and newsletters we are unable to know a denominator and thus calculate a response rate or rule out possible selection bias. Secondly, because of this we were also unable to control for the variation in response rates from different countries, thus we had significantly more European responses. As we adapted the adult survey for pediatric use, we did not add questions to the survey regarding nutritional protocols or nutritional teams available in the PICU, nor did we ask whether the respondents felt the perceived barriers to actually causing inadequate feeding. However, the strengths of our study are our extensive responses (920 across 57 countries) and in our inclusion of all three professional groups involved in the delivery of enteral nutrition. Unfortunately, the responses from dietitians were lower, which prevented us making firm conclusions regarding this group. Furthermore, our translation into multiple languages ensured the survey did not just reach an English-speaking group, a bias in many other surveys.

CONCLUSIONS

This study has demonstrated that many perceived barriers to enteral feeding remain in pediatric intensive care units internationally. These are similar, but not the same as those in adult ICUs. These barriers relate to organisational and staff factors as well as patient factors relating to their clinical status. Whether the barrier is real or not, if clinicians believe these, then this still inhibits the delivery of enteral nutrition. Generating evidence to support or refute these perceived barriers is ongoing, but further education to improve awareness of the existing evidence and facilitate the implementation of

best evidence into local unit guidelines is required. The use of local feeding guidelines with or without nutrition support teams, have been shown to be effective in promoting enteral nutrition and as such should be encouraged. Physicians, nurses and dieticians must all be involved in this process and in actively addressing barriers in their PICU.

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Drafting of the manuscript: Lyvonne Tume

Critical revision of the manuscript for important intellectual content: Frederic Valla, Sascha Verbruggen, Jos M Latour, Renate Eveleens

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Table 6. Differences in perceived important barrier across Europe

Figure 1: Countries of which the survey correspondents work

Supplementary Files

Supplemental Figure 1: Barriers to Delivery of Enteral Nutrition in PICU survey

Supplement file 2: Differences in perceived barriers by years' experience

Supplementary file 3: Differences in perceived important barrier across the world

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Table 1: Characteristics of the responders

Characteristics	No. of surveys (n=920)
Continent	
Europe	517 (56%)
Northern region	220 (24%)
Central region	171 (19%)
Southern region	126 (14%)
Asia	314 (34%)
Latin America	48 (5%)
North America	31 (3%)
Oceania	8 (1%)
Africa	2 (0%)
Type of PICU	
General	453 (49%)
General and Cardiac	319 (35%)
PICU and NICU combined	125 (14%)
Other or missing	23 (3%)
Primary clinical specialty	
Nurse	477 (52%)
Physician	407 (44%)
Dietitian	36 (4%)
Years of working experience	
0 – 5 years	356 (39%)
6 – 10 years	215 (24%)
11 – 15 years	133 (15%)
> 15 years	211 (23%)
Missing	5 (1%)
PICU: Pediatric intensive care unit; NICU: Neonatal intensive care unit	

Table 2: Descriptive statistics of Barriers for Enteral Nutrition survey in 920 respondents

	Median [IQR], (range 0-6)	Not a barrier (0), %	Important barrier (4-6), %
Delivery of Enteral Nutrition to the Patient			
1. Delay in physicians ordering the initiation of EN.	2 [1-3]	11.9%	20.1%
2. Waiting for physician to order and check x-ray to confirm tube placement.	1 [0-2]	29.8%	13.6%
3. Frequent displacement of feeding tube, requiring reinsertion.	1 [1-1]	17.1%	12.1%
4. Delays in initiating motility agents in patients not tolerating enteral nutrition (i.e. high gastric residual volumes).	2 [1-3]	11.0%	19.1%
5. Delays and difficulties in obtaining small bowel access in patients not tolerating enteral nutrition (i.e. high gastric residual volumes).	3 [2-4]	5.1%	30.9%
6. In resuscitated, hemodynamically stable patients, other aspects of patient care still take priority over nutrition.	3 [1-4]	8.1%	33.0%
7. Nutrition therapy not routinely discussed on ward rounds.	1 [0-3]	30.1%	18.5%
8. Severe fluid restriction (especially post-operative cardiac surgery).	2 [1-4]	9.8%	29.2%
9. Conservative PICU feeding protocol.	2 [1-3]	23.2%	16.4%
10. Difficulty in delivering enteral feed due to feeding tube obstruction or pump delivery problems with thickened formula.	1 [0-2]	26.9%	10.8%
Dietitian Support (Only if dietitian present; n=728)			
11. Waiting for the dietitian to assess the patient.	2 [1-3]	17.2%	15.2%
12. Dietitian not routinely present on weekday patient rounds.	2 [1-4]	24.2%	29.6%
13. No or not enough dietitian coverage during evenings, weekends and holidays.	3 [1-4]	11.5%	38.4%
14. Not enough time dedicated to education and training on how to optimally feed patients.	3 [1-4]	9.7%	33.7%
PICU Resources			
15. Delays to preparing or obtaining non-standard enteral feeds	2 [1-3]	13.6%	15.7%
16. No or not enough feeding pumps on the unit.	1 [0-2]	49.7%	12.0%
Healthcare Professional Attitudes and Behaviour			
17. Non-PICU physicians (i.e. surgeons, gastroenterologists) requesting patients not be fed enterally.	2 [1-3]	12.1%	17.4%
18. Nurses failing to progress feeds as per the feeding protocol.	1 [0-2]	28.2%	10.3%
19. Enteral feeds withheld due to diarrhoea.	2 [1-3]	12.6%	13.0%
20. Fear of adverse events due to aggressively enterally feeding patients.	2 [1-3]	13.4%	18.4%
21. Enteral feeds withheld for bedside procedures, such as physiotherapy, turns, and administration of certain medications.	2 [1-3]	12.0%	20.5%
22. Enteral feeds being withheld in advance of procedures or operating department visits.	3 [2-4]	4.6%	42.7%

23. Lack of familiarity with current guidelines for nutrition in the PICU.	2 [1-3]	14.9%	22.9%
24. General belief among PICU team that provision of adequate nutrition does not affect patient outcomes.	1 [0-2]	36.1%	15.4%
25. Lack of staff knowledge and support around breastfeeding mothers	2 [1-3]	23.0%	19.7%

Abbreviations: EN: Enteral Nutrition; PICU: Pediatric intensive care unit

Responders answered the questionnaire through Likert scale (range 0-6). Median [IQR] refers to the full Likert scale (0-6).

Not a barrier were the percentage of responders who answered with "not a barrier (0)". Important barrier is indicated by the percentage of responders who answered with "a lot (4)", "a great deal (5)", and "an extreme amount (6)"

Table 3: Top 3 barriers to deliver enteral nutrition in the PICU reported per clinical specialty

Primary Clinical Specialty		
Nurse (n=477)	% Important barrier (score with 4-6)	Median [IQR], (range 0-6)
1. No or not enough dietitian coverage during evenings, weekends and holidays.	44.0%	3 [2-4]
2. Enteral feeds being withheld in advance of procedures or operating department visits	40.3%	3 [2-4]
3. In resuscitated, hemodynamically stable patients, other aspects of patient care still take priority over nutrition.	33.5%	3 [2-4]
Physician (n=407)		
1. Enteral feeds being withheld in advance of procedures or operating department visits.	46.4%	3 [2-5]
2. Not enough time dedicated to education and training on how to optimally feed patients.	38.1%	3 [1-4]
3. Delays and difficulties in obtaining small bowel access in patients not tolerating enteral nutrition (i.e. high gastric residual volumes).	36.7%	3 [2-4]
Dietitian (n=36)		
1. Severe fluid restriction (especially post-operative cardiac surgery)	68.6%	5 [3-6]
2. No or not enough dietitian coverage during evenings, weekends and holidays.	41.2%	3 [1-5]
3. Enteral feeds being withheld in advance of procedures or operating department visits.	33.3%	3 [1-4]
Abbreviations: PICU: Paediatric intensive care unit		
Responders answered the questionnaire through Likert scale (range 0-6). Median [IQR] refers to the full Likert scale (0-6)		
Important barrier is indicated by the percentage of responders who answered with “a lot (4)”, “a great deal (5)”, and “an extreme amount (6)”		

Table 4. Differences in perceived important barriers by professional group

	Total group N=844	Physician N=407	Nurse N=477	Dietitian N=36	P-value
Delivery of Enteral Nutrition to the Patient					
1. Delay in physicians ordering the initiation of EN.	20.1%	21.1%	20.3%	5.6%	0.081
2. Waiting for physician to order and check x-ray to confirm tube placement.	13.6%	9.6% ^a	16.8% ^b	17.1% ^{a,b}	0.006
3. Frequent displacement of feeding tube, requiring reinsertion.	12.1%	10.6%	14.1%	2.9%	0.066
4. Delays in initiating motility agents in patients not tolerating enteral nutrition (i.e. high gastric residual volumes).	19.1%	15.5% ^a	22.5% ^b	14.3% ^{a,b}	0.023
5. Delays and difficulties in obtaining small bowel access in patients not tolerating enteral nutrition (i.e. high gastric residual volumes).	30.9%	36.7% ^a	26.7% ^b	20.0% ^{a,b}	0.002
6. In resuscitated, hemodynamically stable patients, other aspects of patient care still take priority over nutrition.	33.0%	31.9%	33.5%	37.1%	0.763
7. Nutrition therapy not routinely discussed on ward rounds.	18.5%	19.9%	18.3%	5.7%	0.144
8. Severe fluid restriction (especially post-operative cardiac surgery)	29.2%	27.8% ^a	27.5% ^a	68.6%	<0.001
9. Conservative PICU feeding protocol	16.4%	15.7%	16.4%	22.9%	0.547
10. Difficulty in delivering enteral feed due to feeding tube obstruction or pump delivery problems with thickened formula	10.8%	5.9% ^a	15.4% ^b	5.7% ^{a,b}	<0.001
Dietitian Support (Only if dietitian present; n=465)					
11. Waiting for the dietitian to assess the patient.	15.2%	10.6% ^a	18.9% ^b	14.7% ^{a,b}	0.008
12. Dietitian not routinely present on weekday patient rounds.	29.6%	25.7%	33.5%	20.6%	0.037
13. No or not enough dietitian coverage during evenings, weekends and holidays.	38.4%	31.0% ^a	44.0% ^b	41.2% ^{a,b}	0.002
14. Not enough time dedicated to education and training on how to optimally feed patients.	33.7%	38.1%	30.7%	29.4%	0.100
PICU Resources					
15. Delays to preparing or obtaining non-standard enteral feeds	15.7%	15.6%	16.1%	11.4%	0.757
16. No or not enough feeding pumps on the unit.	12.0%	6.9%	15.7% ^a	19.4% ^a	<0.001
Healthcare Professional Attitudes and Behaviour					
17. Non-PICU physicians (i.e. surgeons, gastroenterologists) requesting patients not be fed enterally.	17.4%	21.0% ^a	14.7% ^b	13.9% ^{a,b}	0.041
18. Nurses failing to progress feeds as per the feeding protocol.	10.3%	12.1%	9.4%	2.8%	0.136
19. Enteral feeds withheld due to diarrhoea.	13.0%	13.6%	11.9%	19.4%	0.385
20. Fear of adverse events due to aggressively enterally feeding patients.	18.4%	23.2% ^a	14.7% ^b	13.9% ^{a,b}	0.004
21. Enteral feeds withheld for bedside procedures, such as physiotherapy, turns, and administration of certain medications.	20.5%	22.0%	19.3%	19.4%	0.608
22. Enteral feeds being withheld in advance of procedures or operating department visits.	42.7%	46.4%	40.3%	33.3%	0.093
23. Lack of familiarity with current guidelines for nutrition in the PICU.	22.9%	26.4%	20.3%	19.4%	0.089

24. General belief among PICU team that provision of adequate nutrition does not affect patient outcomes.	15.4%	16.0%	15.3%	8.3%	0.468
25. Lack of staff knowledge and support around breastfeeding mothers	19.7%	17.3%	21.2%	28.6%	0.143

Abbreviations: EN: Enteral Nutrition; PICU: Pediatric intensive care unit

Responders answered the questionnaire through Likert scale (range 0-6). Important barrier is indicated by the percentage of respondents who answered with “a lot (4)”, “a great deal (5)”, and “an extreme amount (6)”

The subscript letters “a” and “b” denote categories in which proportions did not significantly differ from each other.

Table 5. Differences in perceived important barrier by PICU type (n = 897)

	General N=453	General -Cardiac N=319	PICU-NICU N=125	P-value
Delivery of Enteral Nutrition to the Patient				
1. Delay in physicians ordering the initiation of EN.	21.1%	19.7%	16.0%	0.435
2. Waiting for physician to order and check x-ray to confirm tube placement.	16.0%	11.9%	8.0%	0.043
3. Frequent displacement of feeding tube, requiring reinsertion.	12.4%	11.9%	11.3%	0.942
4. Delays in initiating motility agents in patients not tolerating enteral nutrition (i.e. high gastric residual volumes).	16.9%	20.1%	22.4%	0.286
5. Delays and difficulties in obtaining small bowel access in patients not tolerating enteral nutrition (i.e. high gastric residual volumes).	29.8%	32.0%	34.4%	0.574
6. In resuscitated, hemodynamically stable patients, other aspects of patient care still take priority over nutrition.	35.0%	31.7%	30.4%	0.494
7. Nutrition therapy not routinely discussed on ward rounds.	19.1%	15.0%	20.8%	0.234
8. Severe fluid restriction (especially post-operative cardiac surgery)	27.4%	31.4%	25.8%	0.354
9. Conservative PICU feeding protocol	16.5%	17.4%	10.6%	0.198
10. Difficulty in delivering enteral feed due to feeding tube obstruction or pump delivery problems with thickened formula	13.1% ^a	7.2% ^b	12.0% ^{a,b}	0.033
Dietitian Support (Only if dietitian present; n=465)				
11. Waiting for the dietitian to assess the patient.	16.5%	14.1%	12.2%	0.505
12. Dietitian not routinely present on weekday patient rounds.	28.2%	30.5%	33.3%	0.590
13. No or not enough dietitian coverage during evenings, weekends and holidays.	39.5%	36.3%	40.0%	0.664
14. Not enough time dedicated to education and training on how to optimally feed patients.	32.6%	34.2%	37.1%	0.701
PICU Resources				
15. Delays to preparing or obtaining non-standard enteral feeds	15.7%	16.4%	12.9%	0.661
16. No or not enough feeding pumps on the unit.	12.8% ^a	7.9% ^a	15.3%	0.035
Healthcare Professional Attitudes and Behaviour				
17. Non-PICU physicians (i.e. surgeons, gastroenterologists) requesting patients not be fed enterally.	18.3%	16.4%	16.1%	0.723
18. Nurses failing to progress feeds as per the feeding protocol.	9.9%	8.5%	12.9%	0.373
19. Enteral feeds withheld due to diarrhoea.	11.5%	13.8%	13.7%	0.579
20. Fear of adverse events due to aggressively enterally feeding patients.	15.0% ^a	20.2% ^{a,b}	26.6% ^b	0.008
21. Enteral feeds withheld for bedside procedures, such as physiotherapy, turns, and administration of certain medications.	22.7%	17.9%	21.0%	0.268
22. Enteral feeds being withheld in advance of procedures or operating department visits.	43.3%	44.3%	38.7%	0.555
23. Lack of familiarity with current guidelines for nutrition in the PICU.	23.4%	21.4%	25.8%	0.588

24. General belief among PICU team that provision of adequate nutrition does not affect patient outcomes.	15.0%	13.1%	20.2%	0.185
25. Lack of staff knowledge and support around breastfeeding mothers	19.0%	19.5%	23.4%	0.551

Abbreviations: EN: Enteral Nutrition; PICU: Pediatric intensive care unit

Responders answered the questionnaire through Likert scale (range 0-6). Important barrier is indicated by the percentage of responders who answered with “a lot (4)”, “a great deal (5)”, and “an extreme amount (6)”.

The subscript letters “a” and “b” denote categories in which proportions did not significantly differ from each other.

Other or Missing PICU type were not included in the table and analyses.

Table 6. Differences in perceived important barrier across Europe (n =517)

	North Europe N=220	Central Europe N=171	South Europe N=126	P value
Delivery of Enteral Nutrition to the Patient				
1. Delay in physicians ordering the initiation of EN.	18.2%	22.8%	20.6%	0.527
2. Waiting for physician to order and check x-ray to confirm tube placement.	10.9%	4.7%	6.3%	0.062
3. Frequent displacement of feeding tube, requiring reinsertion.	10.0%	14.9%	8.7%	0.187
4. Delays in initiating motility agents in patients not tolerating enteral nutrition (i.e. high gastric residual volumes).	21.0%	17.9%	23.0%	0.537
5. Delays and difficulties in obtaining small bowel access in patients not tolerating enteral nutrition (i.e. high gastric residual volumes).	36.5%	38.8%	30.2%	0.290
6. In resuscitated, hemodynamically stable patients, other aspects of patient care still take priority over nutrition.	25.5%	37.6%	34.9%	0.026
7. Nutrition therapy not routinely discussed on ward rounds.	10.5%	25.3% ^a	24.6% ^a	<0.001
8. Severe fluid restriction (especially post-operative cardiac surgery)	28.1%	30.8%	26.8%	0.740
9. Conservative PICU feeding protocol	8.4%	13.6%	18.3%	0.026
10. Difficulty in delivering enteral feed due to feeding tube obstruction or pump delivery problems with thickened formula	5.5%	14.8%	6.3%	0.003
Dietitian Support (Only if dietitian present; n=465)				
11. Waiting for the dietitian to assess the patient.	7.3%	17.9% ^a	19.4% ^a	0.004
12. Dietitian not routinely present on weekday patient rounds.	27.0% ^a	31.6% ^a	58.1%	<0.001
13. No or not enough dietitian coverage during evenings, weekends and holidays.	33.8% ^a	33.3% ^{a,b}	50.8% ^b	0.038
14. Not enough time dedicated to education and training on how to optimally feed patients.	29.9%	43.6% ^a	56.5% ^a	<0.001
PICU Resources				
15. Delays to preparing or obtaining non-standard enteral feeds	19.1%	12.9%	12.0%	0.112
16. No or not enough feeding pumps on the unit.	11.8%	12.9%	7.2%	0.274
Healthcare Professional Attitudes and Behaviour				
17. Non-PICU physicians (i.e. surgeons, gastroenterologists) requesting patients not be fed enterally.	17.3%	17.0%	25.6%	0.112
18. Nurses failing to progress feeds as per the feeding protocol.	10.9%	9.9%	8.0%	0.684
19. Enteral feeds withheld due to diarrhoea.	6.8% ^a	14.0% ^{a,b}	16.7% ^b	0.015
20. Fear of adverse events due to aggressively enterally feeding patients.	16.8%	22.2%	16.0%	0.394
21. Enteral feeds withheld for bedside procedures, such as physiotherapy, turns, and administration of certain medications.	13.2% ^a	28.1% ^b	18.4% ^{a,b}	0.001
22. Enteral feeds being withheld in advance of procedures or operating department visits.	42.3% ^a	43.3% ^a	57.6%	0.014

23. Lack of familiarity with current guidelines for nutrition in the PICU.	16.4%	31.6% ^a	28.0% ^a	0.001
24. General belief among PICU team that provision of adequate nutrition does not affect patient outcomes.	11.8%	17.0%	17.6%	0.231
25. Lack of staff knowledge and support around breastfeeding mothers	17.3%	21.6%	20.8%	0.516

Abbreviations: EN: Enteral Nutrition; PICU: Pediatric intensive care unit

Responders answered the questionnaire through Likert scale (range 0-6). Important barrier is indicated by the percentage of respondents who answered with “a lot (4)”, “a great deal (5)”, and “an extreme amount (6)”

The subscript letters “a” and “b” denote categories in which proportions did not significantly differ from each other.

Supplement Figure 1: Countries of which the survey correspondents work; 920 responses from 57 countries



Created with: https://www.amcharts.com/visited_countries/#

Argentina, Austria, Australia, Belgian, Bolivia, Brazil, Bulgaria, Canada, Chile, China, Cuba, Colombia, Ecuador, France, Germany, Guatemala, Honduras, Hong Kong, India, Iraq, Ireland, Israel, Italy, Latvia, Lebanon, Lithuania, Luxemburg, Malaysia, Mexico, Netherlands, Nicaragua, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Puerto Ricco, Republic Dominica, Reunion, Russia, Saudi Arabia, Singapore, Spain, South Africa, Suriname, Sweden, Switzerland, Taiwan, Thailand, Turkey, USA, Uruguay, Uzbekistan, UK, Vatican, Vietnam

Supplementary file 2. Differences in perceived important barrier divided by years of experience (n = 920)

	0-5 years N=356	6-10 years N=215	11-15 years N=113	> 15 years N=211	P-value
of Enteral Nutrition to the Patient					
1. Delay in physicians ordering the initiation of EN.	21.1%	20.9%	23.3%	15.6%	0.288
2. Waiting for physician to order and check x-ray to confirm tube placement.	15.7%	16.3%	10.6%	9.0%	0.060
3. Frequent displacement of feeding tube, requiring reinsertion.	18.3% ^a	12.1% ^{a,b}	6.0% ^b	5.8% ^b	<0.001
4. Delays in initiating motility agents in patients not tolerating enteral nutrition (i.e. high gastric residual volumes).	24.4% ^a	15.0% ^{a,b}	18.9% ^{a,b}	14.8% ^b	0.013
5. Delays and difficulties in obtaining small bowel access in patients not tolerating enteral nutrition (i.e. high gastric residual volumes).	32.7%	29.3%	31.8%	29.0%	0.760
6. In resuscitated, hemodynamically stable patients, other aspects of patient care still take priority over nutrition.	34.6%	32.1%	36.8%	28.6%	0.359
7. Nutrition therapy not routinely discussed on ward rounds.	19.7%	20.9%	19.5%	13.8%	0.229
8. Severe fluid restriction (especially post-operative cardiac surgery)	27.9%	31.8%	30.2%	26.9%	0.672
9. Conservative PICU feeding protocol	19.3% ^a	16.9% ^{a,b}	17.4% ^{a,b}	10.1% ^b	0.040
10. Difficulty in delivering enteral feed due to feeding tube obstruction or pump delivery problems with thickened formula	14.9% ^a	11.2% ^{a,b}	7.5% ^{a,b}	5.8% ^b	<0.001
Dietitian Support (Only if dietitian present; n=465)					
11. Waiting for the dietitian to assess the patient.	20.1% ^a	15.0% ^{a,b}	16.2% ^{a,b}	6.5% ^b	0.002
12. Dietitian not routinely present on weekday patient rounds.	33.9%	28.7%	30.6%	22.2%	0.065
13. No or not enough dietitian coverage during evenings, weekends and holidays.	40.9%	37.1%	38.2%	34.7%	0.595
14. Not enough time dedicated to education and training on how to optimally feed patients.	34.6%	35.6%	34.2%	30.4%	0.746
PICU Resources					
15. Delays to preparing or obtaining non-standard enteral feeds	18.8%	14.0%	17.4%	11.1%	0.079
16. No or not enough feeding pumps on the unit.	13.8%	13.5%	10.6%	8.1%	0.188
are Professional Attitudes and Behaviour					
17. Non-PICU physicians (i.e. surgeons, gastroenterologists) requesting patients not be fed enterally.	19.4%	18.1%	20.5%	11.9%	0.099
18. Nurses failing to progress feeds as per the feeding protocol.	10.4%	9.8%	12.1%	10.0%	0.908
19. Enteral feeds withheld due to diarrhoea.	14.3%	14.9%	12.1%	9.5%	0.314
20. Fear of adverse events due to aggressively enterally feeding patients.	19.4%	19.6%	19.7%	15.2%	0.579
21. Enteral feeds withheld for bedside procedures, such as physiotherapy, turns, and administration of certain medications.	22.5% ^a	22.3% ^a	25.8% ^a	12.4%	0.007
22. Enteral feeds being withheld in advance of procedures or operating department visits.	41.6%	47.9%	50.0%	35.7%	0.022

23. Lack of familiarity with current guidelines for nutrition in the PICU.	23.9%	23.7%	25.8%	19.2%	0.531
24. General belief among PICU team that provision of adequate nutrition does not affect patient outcomes.	16.9%	15.8%	11.4%	15.2%	0.521
25. Lack of staff knowledge and support around breastfeeding mothers	18.5%	25.6%	17.6%	16.2%	0.070

Abbreviations: EN: Enteral Nutrition; PICU: Pediatric intensive care unit

Responders answered the questionnaire through Likert scale (0-6). Important barrier is indicated by the percentage of responders who answered with “a lot (4)”, “a great deal (5)”, and “an extreme amount (6)”

The subscript letters denote categories in which proportions did not significantly differ from each other.

Supplement table 3. Differences in perceived important barrier across the world (n = 918)

	Northern Americas N=31	Southern Americas N=48	Europe N=517	Australasia N=322	P value
Delivery of Enteral Nutrition to the Patient					
1. Delay in physicians ordering the initiation of EN.	29.0%	20.8%	20.3%	18.6%	0.572
2. Waiting for physician to order and check x-ray to confirm tube placement.	22.6% ^{a,b}	12.5% ^{a,b}	7.8% ^b	22.4% ^a	<0.001
3. Frequent displacement of feeding tube, requiring reinsertion.	12.9%	8.3%	11.3%	14.0%	0.564
4. Delays in initiating motility agents in patients not tolerating enteral nutrition (i.e. high gastric residual volumes).	19.4%	12.5%	20.5%	17.7%	0.496
5. Delays and difficulties in obtaining small bowel access in patients not tolerating enteral nutrition (i.e. high gastric residual volumes).	35.5% ^{a,b}	31.9% ^{a,b}	35.7% ^b	22.4% ^a	<0.001
6. In resuscitated, hemodynamically stable patients, other aspects of patient care still take priority over nutrition.	41.9%	35.4%	31.8%	33.9%	0.647
7. Nutrition therapy not routinely discussed on ward rounds.	35.5% ^a	27.1% ^{a,b}	18.8% ^{a,b}	15.2% ^b	0.014
8. Severe fluid restriction (especially post-operative cardiac surgery)	35.5%	29.8%	28.7%	29.2%	0.881
9. Conservative PICU feeding protocol	41.9% ^a	8.3% ^{b,c}	12.5% ^c	21.3% ^{a,b}	<0.001
10. Difficulty in delivering enteral feed due to feeding tube obstruction or pump delivery problems with thickened formula	16.1% ^{a,b}	4.2% ^{a,b}	8.8% ^b	14.6% ^a	0.017
Dietitian Support (Only if dietitian present; n=465)					
11. Waiting for the dietitian to assess the patient.	16.0%	5.0%	12.5%	19.6%	0.017
12. Dietitian not routinely present on weekday patient rounds.	44.0% ^a	12.5% ^b	33.4% ^a	25.9% ^{a,b}	0.005
13. No or not enough dietitian coverage during evenings, weekends and holidays.	56.0% ^a	22.5% ^b	36.4% ^{a,b}	41.4% ^{a,b}	0.024
14. Not enough time dedicated to education and training on how to optimally feed patients.	56.0% ^a	30.0% ^{a,b}	38.4% ^a	26.5% ^b	0.001
PICU Resources					
15. Delays to preparing or obtaining non-standard enteral feeds	25.8%	19.6%	15.3%	14.3%	0.326
16. No or not enough feeding pumps on the unit.	29.0% ^a	14.9% ^{a,b}	11.0% ^b	11.5% ^b	0.024
Healthcare Professional Attitudes and Behaviour					
17. Non-PICU physicians (i.e. surgeons, gastroenterologists) requesting patients not be fed enterally.	29.0%	14.9%	19.2%	13.7%	0.060
18. Nurses failing to progress feeds as per the feeding protocol.	22.6%	12.8%	9.9%	9.6%	0.134
19. Enteral feeds withheld due to diarrhoea.	19.4%	14.9%	11.4%	14.6%	0.376
20. Fear of adverse events due to aggressively enterally feeding patients.	35.5% ^a	21.3% ^{a,b}	19.0% ^{a,b}	15.6% ^b	0.044
21. Enteral feeds withheld for bedside procedures, such as physiotherapy, turns, and administration of certain medications.	22.6%	21.3%	19.8%	21.4%	0.932

22. Enteral feeds being withheld in advance of procedures or operating department visits.	45.2% ^{a,b}	53.2% ^{a,b}	46.3% ^b	35.4% ^a	0.008
23. Lack of familiarity with current guidelines for nutrition in the PICU.	38.7% ^a	29.8% ^{a,b}	24.2% ^{a,b}	18.3% ^b	0.019
24. General belief among PICU team that provision of adequate nutrition does not affect patient outcomes.	32.3%	12.8%	14.9%	14.9%	0.067
25. Lack of staff knowledge and support around breastfeeding mothers	48.4%	19.1% ^a	19.6% ^a	17.4% ^a	0.001

Abbreviations: EN: Enteral Nutrition; PICU: Pediatric intensive care unit

Responders answered the questionnaire through Likert scale (range 0-6). Important barrier is indicated by the percentage of responders who answered with “a lot (4)”, “a great deal (5)”, and “an extreme amount (6)”.

The subscript letters “a” and “b” denote categories in which proportions did not significantly differ from each other.
