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Implementation of an evidence-based guideline of enteral nutrition for infants with congenital heart disease: a controlled before-and-after study

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Authors' contributions:

YG and YH were responsible for the study protocol, the design, training of nurses and funding application. YG and HZ were responsible for data analysis. HZ, WF and YY were responsible for data collection and supporting the implementation of the guidelines. YG, HZ and JML were responsible for writing the first draft of the manuscript. JML provided external advice during the implementation process and revised the manuscript. All authors approved the final version of the manuscript.

Ethical approval

The study was approved by the Pediatric Research Ethics Board of the children's hospital of Fudan University, on June 6th, 2016 (Approval number: 2016134).

ABSTRACT

Objective: To describe the implementation process of a nutrition risk screening and assessment guideline for infants with congenital heart disease and to assess the impact of nurses' behavior and the effect on infants' outcomes.

Design: A controlled before-and-after implementation study. The three dimensions of the integrated-Promoting Action on Research Implementation in Health Services (i-PARIHS) framework were used to assess barriers and promoting factors.

Setting: Cardiac center at Children's Hospital of Fudan University, Shanghai, China.

Patients: Infants with congenital heart disease (n=142) and nurses (n=100).

Intervention: Implementation of an evidenced-based nutrition risk screening and assessment guideline.

Measurements and Main Results: Implementation processes were assessed on nurses' knowledge, attitude, behavior and compliance of the guideline. Infants' clinical outcomes were evaluated before-and-after the implementation. Knowledge, attitude and behavior of nurses about nutrition risk screening and assessment increased significantly after implementing the guideline. Nurses' compliance with the recommendations for nutritional risk screening improved significantly on three criteria; Assessment of nutritional status stability ($p<0.001$), assessment of nutritional status deterioration ($p=0.003$), and nutritional assessment among infants with moderate risk and above ($p<0.001$). The nurses' compliance with the recommendations for nutrition assessment improved significantly in eight of the 10 criteria ($p<0.001$). The proportion of infants receiving comprehensive nutrition assessment when they were first screened with moderate or high nutritional risk were higher in the intervention group (24.3% versus 83.3%, $p<0.001$). The accuracy rates of nutrition risk screening were higher in the intervention group (52.9% versus 81.9%, $p<0.001$).

Conclusions: Using the i-PARIHS framework contributed to a successful implementation of the nutrition guideline. The nurses' knowledge, attitude and behavior towards the nutrition guideline were positive resulting in a significantly higher nutrition assessments in infants with moderate or high nutritional risk.

Key Words: congenital heart disease; infant; nutrition; guideline; nurses; implementation science.

INTRODUCTION

Congenital heart disease (CHD) caused by abnormal vascular development in the fetal period is one of the most common congenital malformations in infants. The prevalence of the congenital heart disease range between 9.6 to 26.6 per 1000 live births (1-3). Malnutrition in infants and children with congenital heart disease is a common phenomenon, with the highest incidence occurring specifically in infants (4-6).

With the development of medical care, the nutritional problems of hospitalized children are increasingly recognized by doctors, nurses and dieticians. Currently in China, nutrition management for infants with CHD still faces many obstacles during hospitalization. The first obstacle is that nutritional risk screening system is not recognized as a priority by doctors and nurses, paying insufficient attention to comprehensive nutritional assessment in children that was recommended by the American Society for Parenteral and Enteral Nutrition guidelines (7-9). Therefore, we might not be able to implement timely nutritional support according to the nutritional status and needs of children (10, 11). Secondly, the start of enteral nutrition is often delayed in postoperative infants with CHD. Nearly all infants would be fed within 12–24 hours after surgery in only 30% of European Pediatric Intensive Care Units (PICUs) (12). In china, these practices seem to have similar challenges where enteral feeding starts in the 1-2 days after cardiac surgery (13). The third obstacle is that children's energy intake is insufficient and nutrient intake is not balanced (14). Finally, the frequent interruption of enteral nutrition in hospitalized children with CHD can contribute to insufficient nutrition intake (15).

Fortunately, many experts are trying to establish clinical guidelines of enteral nutrition in children with CHD. For example, a clinical practice guideline of enteral nutrition for children with hypoplastic left heart syndrome is available to promote nutrition in these specialized group of patients (16). Another nutrition guideline has been published recently and was designed for a wider population; critically ill children in the pediatric intensive care (9). However, a publicly available clinical practice guideline for infants with CHD including nutrition risk screening, nutrition assessment,

feeding program development, feeding initiation and advancement, and feeding monitoring has not been developed. Therefore, our team developed a clinical practice guideline for enteral nutrition in infants with CHD based on Chinese national standards.

Implementation of guidelines can be a challenge for clinical healthcare professionals. A framework for successful implementation of guidelines into clinical practice is the integrated-Promoting Action on Research Implementation in Health Services (i-PARIHS) (17,18). This framework describes four concepts for successful implementation of guidelines; facilitation, innovation, recipients and context (17). Facilitation is important to the implementation process including the content of the innovation and the alignment with the recipients within the local, organizational and wider context. In health care systems, the i-PARISH framework might be suitable to implement guidelines within a complex environment such as a cardiac center in a children's hospital having infants admitted with complex nutritional healthcare needs. Therefore, and using the i-PARIHS framework, the aim of this study was to implement an evidenced-based nutrition risk screening and assessment guideline for infants with CHD and to assess the impact of nurses' knowledge, attitude and behavior, and to measure the effect on infants' outcomes during the implementation process.

METHODS

Design

The study used the i-PARIHS framework with a before-and-after study. The Standards for Reporting Implementation Studies (StaRI) statement has been used to report our study (19). The flow diagram of the study is presented in figure 1.

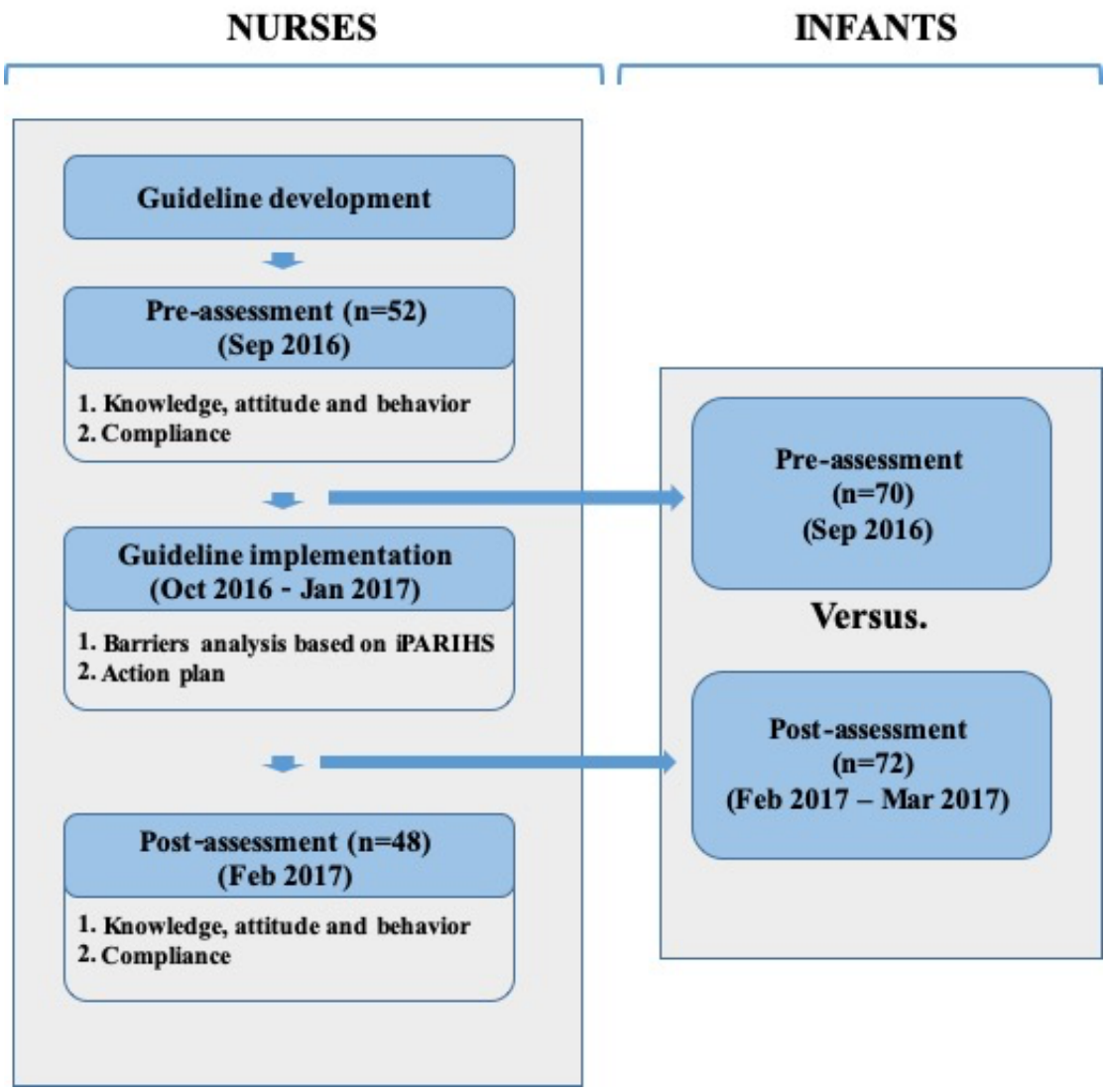

Figure 1. Study flow diagram

Setting

The study was conducted at the Cardiac Center of the Children's Hospital of Fudan University in Shanghai, China. The Cardiac Center has three wards: Cardiology, Cardiac surgery; Cardiac Intensive Care. Approximately 5,000 infants and children are annually treated at the cardiac center of which 1,600 have a cardiac surgical intervention. The implementation project took place on the Cardiac Intensive Care and the cardiac surgery unit. The healthcare professionals involved were pediatric cardiac intensivists, cardiac surgeons and nurses taking care of children and their families. The dieticians were only taking care of the children on a consultancy basis as they were working across

the hospital.

Participants

The study included nurses and infants. The inclusion criteria for nurses were: nurses working at the cardiac center for more than 3 months. The exclusion criteria of the nurses were: nurses without a nurse practice certification and not providing consent to participate in the study.

The infants included in the study were infants below 1 year of age with a CHD and admitted to the cardiac center. Infants were excluded if they had any co-morbidities that might influence the nutritional intake, such as congenital esophageal atresia or congenital gastrointestinal malformations.

Nutrition Guideline

The clinical practice guideline was developed by systematic reviews. The development of the guideline was based on the WHO Handbook for Guideline Development as a methodology guide (20). The adjustment of the evidence grade was based on the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) criteria (21). The clinical guideline named 'Clinical Practice Guidelines of Enteral Nutrition for Infants with Congenital Heart Disease' included 7 recommendations of nutrition risk screening, 5 recommendations of nutrition assessment, 13 recommendations of feeding program development, 4 recommendation of feeding initiation and advancement, 9 recommendations of feeding monitoring. The full guideline is available at the author's institutional website (22). In this study, the first two parts of the guideline (nutrition risk screening and nutrition assessment) were implemented into clinical practice based on the i-PARIHS framework (Electronic Supplement Material 1).

Guideline implementation plan

The duration of the implementation process was four months (October 1, 2016 - January 31st, 2017). We considered 11 barriers during implementation process based on the core dimensions of the i-PARIHS framework; Innovation (new evidence-based guidelines), Recipients (nurses), and Context (cardiac center and hospital). We developed several

specific action plans for the barriers, such as knowledge training, tools improvement, skills training, clinical roles redistributing, Hospital Information System (HIS) update, and establishing communication and feedback processes to share information (Table 1). The HIS update included that if children scored high risk on the $STRONG_{kids}$ scale, this would automatically trigger a dietician review via the HIS.

Table 1. Guideline implementation plan

i-PARIHS dimensions	Identified barriers	Action plan
Innovation (Nutrition guidelines for infants with CHD)	• Guideline is not available in an accessible and usable form • Guideline is perceived as beyond the scope of nursing duties	• Knowledge training: o Face-to-face lecture o WeChat platform • Tools improvement: o Transform 4 items of the $STRONG_{kids}$ scale into 10 questions related to "look, ask, weight, and check" o Develop a nutrition assessment scheme list • Skills training: o Use of $STRONG_{kids}$ scale (all nurses) o Comprehensive nutritional assessment (three CNSs) • Redistribution of clinical roles: o Infants with moderate nutritional risk: A CNS instead of a clinical dietitian was conducting the nutritional assessments o Infants with high nutritional risk: A clinical dietitian was conducting the nutritional assessment • Update Hospital Information System (HIS): o Set up a warning mechanism: Results of moderate and high risk of nutrition screening were highlight on the main screen o Software change to calculate WAZ-score and WHZ-score • Establishing communication and feedback processes: o Weekly multi-disciplinary meetings o Nutrition discussion at daily bedside rounds; o WeChat group for quick Q&A feedback.
Recipient (Nurses)	• Lack of knowledge and skills of nutrition risk screening and nutrition assessment in infants with CHD • Not considering nutrition risk screening and nutrition assessment as important • Not conducting nutritional risk screening accurately • Not completing nutritional assessment for infants independently • Limited communication between doctors and nurses about the nutritional care of infants	
Context (Cardiac Center)	• Lack of human resources, such as clinical dieticians • Lack of multidisciplinary cooperation mechanism and working processes • Involvement in department affairs decision-making is not high • Lack of incentives (job prospects, learning opportunities, remuneration, personal honors, etc.)	

CHD=Congenital Heart Disease; CNS=Clinical Nurse Specialist;

STRONG$_{kids}$=Screening Tool Risk on Nutritional Status and Growth; WAZ=Weight for Age Z-score; WHZ=Weight for Height Z-score; Q&A=Questions and Answers; WeChat is an app with similar features as WhatsApp

Outcomes and Measurements

Outcome measures for the before-and-after assessment were developed to assess nurses' knowledge, attitude and behavior of the guideline for nutritional risk screening and nutritional assessment. A survey was developed in two parts; the first part comprised the characteristics of nurses and the second part included 11 questions about knowledge, attitude and behavior of nutritional risk screening and nutritional assessment in infants with CHD. The knowledge, attitude and behavior individually were scored on a 5-point answer option scale. For knowledge: 5=very familiar, 4=familiar, 3=partly familiar, 2=not very familiar, 1 completely not familiar; for attitude: 5=very important, 4=important, 3=not sure, 2=not important, 1=completely not important; for behavior: 5=completely do, 4=often do, 3=sometimes do, 2=rarely do, 1=completely not do. (Electronic Supplement Material 2). The questionnaires were distributed to the nurses two weeks before the implementation and two weeks after the implementation. An explanatory letter of the study procedures was attached to the questionnaire.

Nurses' compliance to the guideline criteria were measured. The authors converted the 11 recommendations of the guidelines into 17 measurable criteria (7 items about nutritional risk screening; 10 items about nutrition assessment) to evaluate the compliance. (Electronic Supplement Material 3). The answer option scale of the 17 items was a yes or no option. The first four criteria (assessment of nutritional status, nutritional status stability, nutritional status deterioration and the impact of diseases on nutritional status during nutritional risk screening) were reviewed by on-site observations to collect data in a cyclical manner to ensure that nurses' behaviors were observed during each working session (day and night shift). There were six trained nurses in day shifts for on-site observation and three nurses in night shifts. Results of the other criteria were obtained by reviewing the medical records.

Infants' clinical outcomes were collected. The before-assessment data were

collected in one months (September 2016), the after-assessment data was collected in one month (February 2017). The clinical outcomes included the proportion of infants receiving comprehensive nutrition assessment when they were first screened with moderate or high nutritional risk and the accuracy rate of nutrition risk screening. The Z-value was used as the gold standard to evaluate the accuracy rate of nutrition risk screening for nurses, including weight for height score (WHZ-score) and weight for age score (WAZ-score). When WHZ-score or WAZ-score of the infant was less than -2, we assumed that the infant was malnourished (23). Other clinical outcome measures were mean time to initiation of enteral nutrition in hours, length of hospital stay, weight gain during hospitalization and total hospitalization expenses.

Data analysis

All data were initially tested for normal distribution. The independent Student's t-test was used for normally distributed data. Data that were not normally distributed, we used the Mann-Whitney U test. Fisher's exact and Chi Square tests were used to assess frequency distribution. The results are presented by mean and SD (for normally distributed variables) or median and quartile for non-normally distributed variables or frequency/percentage for categorical variables. The analysis of the 11 questions of knowledge, attitude and behavior were as follows. The 5-point scales were summarized to a 3-point scale by combining the first two and the last two options. The results are presented in percentages of the first option. SPSS version 22 (IBM Corp., Armonk, NY, USA) was used for the analysis. $P<0.05$ was considered statistically significant.

Ethics

The study was approved by the Pediatric Research Ethics Board of the children's hospital of Fudan University, on June 6th, 2016 (Approval number: 2016134). No written consent of nurses and parents was required by the Board for the implementation of the nutrition screening and assessment guideline.

RESULTS

Before and after implementation, there were 52 and 48 nurses respectively who

completed the questionnaire of knowledge, attitude and behavior for nutritional risk screening and nutritional assessment. Eight nurses were rotated out of the cardiac center and six new nurses joined the cardiac center, one nurse was on maternity leave, and one nurse resigned. There were no differences between the two groups of nurses in terms of working years at the cardiac center, education grade, job title, and job position (Table 2).

Table 2. Characteristics of Nurses

Characteristics	Before (n=52)	After (n=48)	p-value
Years of working; mean, (SD)	6.06 (5.46)	7.63 (5.32)	0.147
Education; n (%)			
Technical secondary school	3 (5.8)	2 (4.2)	0.718
Junior college	32 (61.5)	25 (52.1)	
Undergraduate	16 (30.8)	20 (41.7)	
Postgraduate	1 (1.9)	1 (2.1)	
Job title; n (%)			
Junior nurse	24 (46.2)	17 (35.4)	0.275
Senior nurse	28 (53.8)	31 (64.6)	
Job position; n (%)			
Head nurse	3 (5.8)	3 (6.3)	0.109
Specialist nurse	3 (5.8)	3 (6.3)	
Charge nurse leader	3 (5.8)	5 (10.4)	
Clinical nurse	43 (82.6)	37 (77.1)	

SD=Standard Deviation

The knowledge, attitude and behavior of nurses about the guideline for nutritional risk screening and nutritional assessment increased significantly after implementation except for three items in the attitude domain; first-time nutritional risk screening, content of nutrition assessment, and assessment of feeding difficulties and risk factors. (Table 3).

Table 3. Before- and after-assessment of nurses' knowledge, attitude and behavior of the guideline for nutritional risk screening and nutritional assessment.

Contents	Knowledge			Attitude			Behavior		
	Before n=52 n (%)	After n=48 n (%)	p-value	Before n=52 n (%)	After n=48 n (%)	*p*-value	Before n=52 n (%)	After n=48 n (%)	p-value
Nutrition risk screening content	18 (34.6)	39 (81.3)	<0.001	43 (82.7)	47 (97.9)	0.017	19 (36.5)	42 (87.5)	<0.001
Selection of nutritional risk screening tools	20 (38.5)	41 (85.4)	<0.001	41 (78.8)	48 (100.0)	0.003	21 (40.4)	42 (87.5)	<0.001
$STRONG_{kids}$ is recommended for nutritional risk screening in infants with CHD	20 (38.5)	41 (85.4)	<0.001	41 (78.8)	48 (100.0)	0.003	21 (40.4)	42 (87.5)	<0.001
The first-time nutritional risk screening（within 24h）	41 (78.8)	42 (87.0)	0.037	50 (96.2)	48 (100.0)	0.496	44 (84.6)	48 (100.0)	0.045
Nutritional risk screening frequency（every week）	37 (71.2)	44 (91.7)	0.024	45 (86.5)	48 (100.0)	0.013	33 (63.5)	44 (91.7)	0.003
The executor of nutritional risk screening	28 (53.8)	43 (89.6)	<0.001	38 (73.1)	47 (97.9)	0.002	27 (51.9)	46 (95.8)	<0.001
How to deal with nutritional screening results	23 (44.2)	42 (87.5)	<0.001	42 (80.8)	48 (100.0)	0.006	15 (28.8)	38 (79.2)	<0.001
Content of nutrition assessment	28 (53.8)	41 (85.4)	0.001	47 (90.4)	47 (97.9)	0.204	18 (34.6)	43 (89.6)	<0.001
Assessment of feeding difficulties and the risk factors	22 (42.3)	43 (89.6)	<0.001	47 (90.4)	48 (100.0)	0.057	25 (48.1)	44 (91.7)	<0.001
Use Z-score for nutritional assessment	11 (21.2)	36 (75.0)	<0.001	37 (71.2)	44 (91.7)	0.024	9 (17.3)	30 (62.5)	<0.001

Make a summary and intervention plan after nutrition assessment	15 (28.8)	38 (79.2)	<0.001	35 (67.3)	47 (97.9)	<0.001	9 (17.3)	35 (72.9)	<0.001

$STRONG_{kids}$= Screening Tool for Risk on Nutritional Status and Growth (as used in China in children with CHD (29).

Nurses' compliance with the guideline criteria for nutrition risk screening improved significantly except for four criteria. Nurses' compliance with the criteria for nutrition assessment improved significantly except for two criteria (Table 4).

Table 4. Nurses' compliance with audit criteria for nutritional risk screening and nutrition assessment

Audit criteria	Before n, (% of yes)	After n, (% of yes)	p-value
Assess nutritional status during nutritional risk screening	95 (99.0%)	188 (99.5%)	1.000[a]
Assess nutritional status stability during nutritional risk screening	78 (81.3%)	183 (96.8%)	<0.001[b]
Assess nutritional status deterioration during nutritional risk screening	82 (85.4%)	182 (96.3%)	0.003[b]
Assess impact of diseases on nutritional status during nutritional risk screening	96 (100.0%)	186 (98.4%)	0.553[a]
Nutritional risk screening was completed within 24 hours of admission	82 (100.0%)	189 (100.0%)	1.000 [a]
Do nutritional risk screening once a week	94 (100.0%)	174 (92.1%)	1.000 [a]
Do comprehensive nutritional assessment infants with moderate risk and above	0 (0)	174 (92.1%)	<0.001[a]
Assess medical History during nutrition assessment	92 (100.0%)	185 (97.9%)	0.304[a]
Assess nutritional history during nutrition assessment	76 (75.0%)	187 (98.9%)	<0.001 [b]
Assess diet history during nutrition assessment	64 (66.7%)	189 (100.0%)	<0.001 [b]
Assess medication history during nutrition assessment	95 (99.0%)	189 (100.0%)	0.337[a]
Do physical examination during nutrition assessment	81 (84.4%)	187 (98.9%)	<0.001[a]
Check clinical laboratory result during nutrition assessment	1 (1.0%)	161 (85.2%)	<0.001 [b]
Assess feeding difficulties during nutrition assessment	28 (29.2%)	188 (99.5%)	<0.001 [b]
Assess feeding difficulties risk factors during nutrition assessment	7 (7.3%)	184 (97.4%)	<0.001 [b]
Use WAZ/HAZ/WHZ and growth curve during nutrition assessment	0 (0)	132 (69.8%)	<0.001[a]
Make a summary and intervention plan after nutrition assessment	0 (0)	159 (84.1%)	<0.001 [b]

Notes: a=Fisher test; b=Chi Square test

There were 70 and 72 infants included in the before- and after-assessment respectively. There were no differences in age, sex, diagnosis, and Risk Adjustment for Congenital Heart Surgery (RACHS) scores between the two groups (Table 5). There were no differences observed between the pre and post implementation groups in length

of hospital stay, median weight gain during hospitalization, median weight gain of difference nutrition risk group during hospitalization, median total hospitalization expenses and the mean time to initiation of EN in hours (Table 5). The proportion of infants receiving comprehensive nutrition assessment when they were first screened with moderate or high nutritional risk were higher after the guideline was implemented (24.3% versus 83.3%, P＜0.001). The accuracy rate of nutrition risk screening was higher in the after group compared to the before group (52.9% versus 81.9%, P＜0.001).

Table 5. Infant demographics and outcomes

Characteristics	Before（n=70）	After（n=72）	*p*-value
Age; (n; %)			
≤1 month	23（32.9）	11（15.3）	0.109
2-3 months	13（18.6）	17（23.6）	
4-6 months	17（24.3）	21（29.2）	
≥6 months to ≤12 months	17（24.3）	23（31.9）	
Gender; (n; %)			
Male	40（57.1）	46（63.9）	0.411
Female	30（42.9）	26（36.1）	
RACHS; (n; %)			
RACHS-1	13（18.6）	18（25.0）	0.109
RACHS-2	39（55.7）	46（63.9）	
RACHS-3	7（10.0）	5（6.9）	
RACHS-4	4（5.7）	1（1.4）	
RACHS-5	0（0）	1（1.4）	
un-operated	7（10.0）	1（1.4）	
Length of hospital stay; days (SD)	15.0 (9.45)	17.1 (8.06)	0.139
Total hospitalization expenses; RMB (SD)	54,746.86 (24362.94)	57,548.39 (47486.03)	0.660
Median weight gain during hospitalization; grams (IQR)	100 (200)	10 (428)	[a)]0.507
Median weight gain adjusted by $STRONG_{kids}$ score			
Low risk; grams (IQR)	0 (160)	0 (500)	[a)]0.310
Medium risk; grams (IQR)	100 (200)	50 (491.5)	[a)]0.383
High risk; grams (IQR)	360 (170)	100 (440.0)	[a)]0.458
Mean time to initiation of EN in hours (SD)	35.41 (26.58)	25.21 (12.40)	0.071

EN=Enteral Nutrition; RACHS=Risk Adjustment for Congenital Heart Surgery;

RMB=RenMinBi (Chinese Yuan); weight gain=weight of discharge-weight of admission

Mann-Whitney U test

DISCUSSION

This study focused on the implementation of an evidence-based nutritional risk screening and nutritional assessment guideline for infants with CHD. The implementation process used the i-PARIHS framework for scenario analysis identifying barriers on individual, organizational and system level, which resulted in a successful implementation. The main findings of our study suggest that nurses' knowledge, attitude and behavior of the nutrition guideline for infants with CHD were increased. Overall, the nurses' compliance with the new guideline improved. The proportion of infants receiving comprehensive nutrition assessment when they were first screened with moderate or high nutritional risk were higher after the implementation. Also, the accuracy rate of nutrition risk screening was higher after implementing the guideline.

Transferring knowledge was the basis of action in our study by using the i-PARIHS framework. Nurses in our study had a positive attitude towards the acquisition of new knowledge and were able to adapt new behaviors to change clinical practice. Understanding the nurses' attitude and behavior are key for any implementation process (24). The professional knowledge in our study was insufficient before the implementation. This is consistent with other clinical practices. A survey study in French speaking PICUs showed that nurses in only 19 (49%) PICUs felt confident with nutrition goals and know how to assess nutritional requirements (25). Thus, it seems that education of nutrition in the children's nursing curriculum might not comply to current clinical practice.

Continuing training of nutritional needs and requirements in children might improve the knowledge of nurses in various clinical settings and should be regularly provided (26). A study providing training over a one-year period with five sessions, including issue on implementation, documented an improvement of patients' knowledge and nurses support to patients (27). In our study, the knowledge training was spread over

three months with various teaching strategies and content. In the initial month, the weekly sessions were directly to theory and knowledge building while the consecutive months the training sessions were more case based sessions. Providing these continuous training sessions increased the engagement and compliance of the nurses.

The acquisition of knowledge further strengthened the nurses' practice behavior. In our study, the nurses' compliance with the new guideline improved significantly except for a few guideline criteria. The reason was that nurses already had a high compliance rate before the implementation. It is worth mentioning that the nurses' compliance of two criteria (laboratory results and growth curve) was increased significantly but did not exceed 90 percent. A study testing compliance among nurses when implementing a feeding protocol in neonates also reached a maximum of 90% compliance (28). Thus, the challenge remains to engage staff in providing quality of care by adhering to the implemented protocols and guidelines.

Evidence-based nursing practice is to support nurses' clinical activities by establishing a scientific and professional attitude to improve health outcomes of infants (12). The findings in our study suggests that nurses had performed more accurate nutritional risk screening and more infants receiving comprehensive nutrition assessment. However, the outcome indicators in our study, such as the weight gain during hospitalization, did not improve significantly after the implementation of the guideline. The reasons might be that the sample included in the two cohorts were not large enough to demonstrate differences.

There are a number of limitations that warrants mentioning. The implementation process of the nutrition guideline was scheduled over a 4-month period. We assessed the knowledge, attitude and behavior of nurses and measured the compliance. These outcome measures were assessed two weeks before and after the implementation time. Knowing that compliance might be difficult to maintain over time, a follow-up evaluation would be recommended. During the implementation process, we had limited support from clinical dieticians which may have affected our outcomes. Another important limitation is that we did not account for the multiple patient co-morbidities

and factors that may impact on nutrition in this patient population. We also need to address the limitation of the influence of the nurse observers collecting data may have had on the staff's behavior. A further limitation was that we did not account for feeding intolerance and other factors impacting on nutritional delivery and possibly on the weight gain of the infant during admission. Despite these limitations, this is the first study using the i-PARIHS model to implement an evidence-based guideline of enteral nutrition for infants with CHD. We are continuing to follow-up to improve the nutritional care of our infants with CHD.

CONCLUSIONS

Identifying barriers and promoting factors during the implementation of a nutrition guidelines based on the i-PARIHS framework was an effective way to transfer the evidence into practice. The implementation of our nutrition risk screening and assessment guideline in the cardiac center was successful. The nurses' knowledge, attitude and behavior towards the nutrition guideline were positive resulting in a significantly higher nutrition assessment in infants with CHD with moderate or high nutritional risk. Our findings might be used as a reference for colleagues in similar settings when implementing nutrition guidelines into clinical practice.

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REFERENCES

1. Wu MH, Chen HC, Lu CW, Wang JK, Huang SC, Huang SK: Prevalence of congenital heart disease at live birth in Taiwan. *J Pediatr* 2010; 156:782-785
2. Amorim LF, Pires CA, Lana AM, et al: Presentation of congenital heart disease diagnosed at birth: analysis of 29,770 newborn infants. *J Pediatr (Rio J)* 2008; 84:83-90
3. Zhao QM, Ma XJ, Jia B, Huang GY: Prevalence of congenital heart disease at live birth: an accurate assessment by echocardiographic screening. *Acta Paediatr* 2013; 102:397-402
4. Dalili M, Meraji SM, Davari P, et al: Growth status of Iranian children with hemodynamically important congenital heart disease. *Acta Med Iran* 2011; 49:103-108
5. Monteiro FP, de Araujo TL, Lopes MV, Chaves DB, Beltrao BA, Costa AG: Nutritional status of children with congenital heart disease. *Rev Lat Am Enfermagem* 2012; 20:1024-1032
6. Ratanachu-Ek S, Pongdara A: Nutritional status of pediatric patients with congenital heart disease: pre- and post-cardiac surgery. *J Med Assoc Thai* 2011; 94 Suppl 3:S133-137
7. Mehta NM, Duggan CP: Nutritional deficiencies during critical illness. *Pediatr Clin North Am* 2009; 56:1143-1160
8. Mehta NM, Compher C: A.S.P.E.N. Clinical Guidelines: nutrition support of the critically ill child. *J Parenter Enteral Nutr* 2009; 33:260-276
9. Mehta NM, Skillman HE, Irving SY, 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* 2017; 18:675-715
10. Hamilton S, McAleer DM, Ariagno K, et al: A stepwise enteral nutrition algorithm for critically ill children helps achieve nutrient delivery goals*. *Pediatr Crit Care Med* 2014; 15:583-589

11. Petrillo-Albarano T, Pettignano R, Asfaw M, Easley K: Use of a feeding protocol to improve nutritional support through early, aggressive, enteral nutrition in the pediatric intensive care unit. *Pediatr Crit Care Med* 2006; 7:340-344
12. Tume LN, Balmaks R, Da CE, Latten L, Verbruggen S, Valla FV: Enteral feeding practices in infants with congenital heart disease across European PICUs: A European Society of Pediatric and Neonatal Intensive Care survey. *Pediatr Crit Care Med* 2018; 19:137-144
13. Zhang H, Gu Y, Mi Y, Jin Y, Fu W, Latour JM: High-energy nutrition in paediatric cardiac critical care patients: a randomized controlled trial. *Nurs Crit Care* 2019; 24:97-102
14. Vieira TC, Trigo M, Alonso RR, et al: Assessment of food intake in infants between 0 and 24 months with congenital heart disease. *Arq Bras Cardiol* 2007; 89:219-224
15. Qi J, Li Z, Cun Y, Li X: Causes of interruptions in postoperative enteral nutrition in children with congenital heart disease. *Asia Pac J Clin Nutr* 2017; 26:402-405
16. Slicker J, Hehir DA, Horsley M, et al: Nutrition algorithms for infants with hypoplastic left heart syndrome; birth through the first interstage period. *Congenit Heart Dis* 2013; 8:89-102
17. Harvey G, Kitson A: PARIHS revisited: from heuristic to integrated framework for the successful implementation of knowledge into practice. *Implement Sci* 2016; 11:33
18. Stetler CB, Damschroder LJ, Helfrich CD, Hagedorn HJ: A Guide for applying a revised version of the PARIHS framework for implementation. *Implement Sci* 2011; 6:99
19. Pinnock H, Barwick M, Carpenter CR, et al: Standards for Reporting Implementation Studies (StaRI) statement. *BMJ* 2017; 356:i6795
20. Yang KH: WHO Handbook for Guideline Development Lanzhou: Lanzhou university press, 2013

21. Guyatt G, Oxman AD, Akl EA, et al: GRADE guidelines: 1. Introduction-GRADE evidence profiles and summary of findings tables. *J Clin Epidemiol* 2011; 64:383-394
22. Fudan university collaboration center of the Joanna Briggs Institute, Shanghai evidence-based nursing center, Children's Hospital of Fudan University. Clinical Practice Guidelines for Enteral Nutrition of Infants with Congenital Heart Disease. 2019 http://nursing.ebn.fudan.edu.cn/Upfile/OtherInfo/2019/1/201901242006519494_1.pdf (Accessed 4 September 2019)
23. Hulst JM, Zwart H, Hop WC, Joosten KF: Dutch national survey to test the STRONGkids nutritional risk screening tool in hospitalized children. *Clin Nutr* 2010; 29:106-111
24. Price B: Understanding attitudes and their effects on nursing practice. *Nurs Stand* 2015; 30:50-57, 60
25. Valla FV, Gaillard-Le Roux B, Ford-Chessel C, et al: A Nursing Survey on Nutritional Care Practices in French-Speaking Pediatric Intensive Care Units. *J Pediatr Gastroenterol Nutr* 2016; 62:174-179
26. Valla FV, Ford-Chessel C, Meyer R, et al: A training program for anthropometric measurements by a dedicated nutrition support team improves nutritional status assessment of the critically ill child. *Pediatr Crit Care Med* 2015; 16:e82-e88
27. Pedersen PU, Tewes M, Bjerrum M: Implementing nutritional guidelines -- the effect of systematic training for nurse nutrition practitioners. *Scand J Caring Sci* 2012; 26:178-185
28. Furlong-Dillard J, Neary A, Marietta J, et al: Evaluating the Impact of a Feeding Protocol in Neonates before and after Biventricular Cardiac Surgery. *Pediatr Qual Saf* 2018; 3:1-9
29. Jirong Qi, Xuming Mo, Rong Li. Xiaonan Li: STRONGkids for congenital heart disease perioperative nutritional risk screening. *Chin J Clin Nutr* 2014; 22:38-42