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Complications of pediatric enteral nutrition at home: a systematic review of quantitative research

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ABSTRACT

Objective: Identifying complications related to enteral nutrition at home in children is important in terms of establishing standard discharge education and training programs to support parents in managing complications. The study aimed to synthesize current evidence on the complications of pediatric enteral nutrition at home.

Methods: The study was conducted according to PRISMA recommendations. Eight databases were reviewed between 2012 and 2022 in Turkish, German, and English languages. Articles were assessed in three stages: title, abstract, and full text. The review included 18 studies that met all the inclusion criteria. The Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instruments were used to assess the quality appraisal of the studies.

Results: A total of 18 studies with 19,531 children were included from 14 countries. The outcome measures were major and minor complications with pediatric enteral nutrition at home. 11 of the 18 papers included were retrospective studies on complications of PEG. In studies reporting the overall rate of major complications ranged from 0% to 14.3%, and the most common complications were reoperation (2.64%-12.4%), and gastrocolic fistula/perforation (0.9%-3.8%). In studies reporting the overall rate of minor complications, the rate ranged from 16.4%-73.6% and the most common complications were infection (8.2%-31.9%), dislodgement (1.6%-21%), skin granulation (4%-50.4%), and vomiting (1%-49.89%).

Conclusion: This systematic review reveals that the rate of complications in pediatric enteral nutrition at home cannot be underestimated. Healthcare providers should plan their practice considering these complications to support parents in managing complications of pediatric enteral nutrition at home.

Keywords: Complications, home enteral nutrition, enteral feeding, children

INTRODUCTION

Sufficient energy and critical nutrients are required for optimal growth and development in children.[1] In addition, nutrition has a pivotal role in the prevention of several diseases.[1-3] However, it is estimated that 25% of children have some degree of nutritional deficiency, with 3%-10% having severe feeding problems.[4-6] In a study of 39,674 children in the United States, gastrointestinal diseases were the primary cause of nutritional issues in children, with malnutrition, developmental and behavioral conditions, as well as neurological impairments constituting additional contributing factors.[4] Oral feeding is considered the optimal method for providing nutrition. Nevertheless, in cases where the gastrointestinal system is operational but oral energy and nutritional requirements cannot be adequately met, Enteral Nutrition (EN) is employed. The European Society for Pediatric Gastroenterology Hepatology and Nutrition (ESPGHAN) defines EN as the delivery of medical nutritional products into the stomach, duodenum, or jejunum through oral means, an intermediate tube, or an artificial opening.[7] While the Feeding Tube Awareness Foundation highlights various conditions necessitating enteral feeding in children, the

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predominant indication for EN is neurological disorders that compromise essential functions such as sucking, swallowing, and chewing. Common symptoms in children requiring EN include insufficient oral nutrient intake, developmental delays, challenges with absorption and digestion, increased nutritional requirements, and nutrient loss.[8]

The European Society for Clinical Nutrition and Metabolism (ESPEN) practical guideline recommends that patients who require home enteral nutrition (HEN) for a short period of time (up to 4-6 weeks) can receive it through a nasal feeding tube.[9] The ESPGHAN position paper recommends percutaneous endoscopic gastrostomy (PEG) when non-oral nutritional supplementation is expected to be required for more than 3-6 weeks or when trans-nasal tube feeding is unsafe.[10] Research has indicated that HEN support following discharge can effectively preserve or even increase body weight and nutritional parameters. Additionally, there is a notable improvement in the quality of skeletal muscle mass within the body composition.[11]

With growing recognition of the significance and advantages of enteral nutrition (EN), its administration has become increasingly important. Although it is commonly used and has many advantages, minor and major complications may occur in the early and late stages.[12,13] It has been reported that admissions to the pediatric emergency unit for minor complications are common, particularly throughout the EN process.[14,15] It has been stated that the caregivers who received treatment from the pediatric emergency department for complications were different, and they were unable to receive professional support.[16,17] According to the literature, parents with EN experience complications at home care and are unsuccessful in managing complications.[17-19] In this context, identifying the complications experienced by caregivers and patients due to EN is critical for planning care and discharge education. It is thought that the identification of currently prevalent complications of in EN would shed light on future planning and promote the sustainability of supportive care for EN at home. Nurses have a primary role in providing and maintaining EN support. In conclusion, identification of common complications may help to identify the needs of children and parents as well as to develop appropriate nursing care interventions and discharge education. In addition, there is no systematic review in the literature examining the studies on complications experienced in children with HEN. Therefore, this systematic review aimed to synthesize the current evidence on complications of pediatric enteral nutrition at home.

Main Points

- The most common major complication in pediatric enteral nutrition at home is reoperation related to enteral tubes.
- The most common minor complications reported were skin infection, leakage, granulation tissue, and vomiting.
- If children with complex care needs are to be cared for safely at home, the provision of services at home must be improved to support families.
- Adequate and accessible allied health services are important to support patients receiving enteral nutrition at home.

Study question

What are the complications of pediatric enteral nutrition at home?

METHODS

Study Design

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines.[20] It was also reported according to the PRISMA statement[21] and it was registered in the International Prospective Register of Systematic Reviews database (PROSPERO) (Registration no: CRD42022329008).

Eligibility Criteria

The Population, Intervention, Comparison, and Outcome (PICO) framework was used to guide the study selection.[22] It has been emphasized that when structuring a clinical question, all four elements must receive clear and focused elaboration: the patient or problem (P), the intervention or exposure (I), the relevant comparison intervention or exposure (C), if applicable, and the specific clinical outcome of interest (O).[23] The eligibility criteria for this study are explained in Table 1.

The inclusion criteria for this study encompassed both observational and experimental research articles published in English, German, or Turkish language between January 2012 and March 2022. These articles had to focus on the age group of children aged 0 to 18 years and involve home enteral nutrition for a minimum duration of one month.

The study's exclusion criteria encompassed the following: qualitative studies, grey literature sources, studies without accessible full-text, articles published in languages other than English, Deutsch, or Turkish, articles published before January 2012, research focused on oral enteral and parenteral nutrition, hospital nutrition, adults, or animals, conference abstracts, case studies, and literature reviews; all of which were excluded from consideration.

Table 1. Eligibility criteria of the study	
Criteria	**Eligibility**
Population (P)	The systematic review included the studies on child between 0 to 18 years feeding with enteral nutrition. The search strategy included child, children, pediatric and synonyms and related mesh terms. The studies on older children, adults and animal studies were excluded.
Exposure/ Intervention (I/E)	The systematic review included the studies related to difficulties, challenges, problems with home enteral nutrition. The reported problems not directly related to home enteral nutrition will be excluded
Comparison (C)	Not applicable
Outcomes (O)	The main outcome is problems/ challenges/complications of home enteral nutrition. Problems identified by health professionals, primary caregivers, parents, or children were examined.

Categories of Results

The main focus of this study is to evaluate the challenges faced by children who undergo tube insertion and subsequently receive home enteral nutrition. The goal is to offer valuable information that can support nurses in tailoring discharge instructions for parents, particularly in recognizing and dealing with relevant complications in their educational and counseling initiatives. This systematic review integrates data from quantitative studies to fulfill its objectives.

Sources and Search Strategy

To obtain a comprehensive overview of the available literature and to identify the most appropriate keywords, a preliminary scoping search was conducted on the PubMed and CINAHL databases. Following this initial search, both researchers meticulously explored the databases using various keywords and their synonyms to refine the search terms. In this comprehensive systematic review, we thoroughly searched eight electronic databases, including Cochrane, Ovid MEDLINE, CINAHL, PubMed, Scopus, Web of Sciences, ULAKBİM - National Academic Network and Information Center, and the National Thesis Center. Our search encompassed articles published between January 1, 2012, and January 1, 2022, in order to gather a comprehensive body of relevant literature. The search strategy involved screening titles and abstracts using keywords and Medical Subject Headings (MeSH) terms. A summarized version of the search strategy is outlined in Table 2. During the screening process, the following keywords were combined using the Boolean operator 'AND': "children" OR "pediatric", "enteral feeding" OR "enteral nutrition", "problems", "difficulties", "complication", "home enteral nutrition." These searches were conducted in English, German, and Turkish languages. The search string utilized for MEDLINE, PubMed, Scopus, Cochrane, Web of Science, CINAHL, and Ovid MEDLINE is provided in the Supplementary Data section.

Data Management and Screening Process

The process of study selection and data extraction was rigorously and impartially carried out by two reviewers. Each reviewer worked independently and blindly to the other's decisions, while remaining aware of journal titles, study authors, and institutions. To streamline the process, we utilized EndNote version 20.1, a reference management software, to identify and eliminate duplicate citations across the eight databases. In order to maintain data validity and ensure high quality, we employed standardized and predefined data extraction forms. Both reviewers initially evaluated the titles and abstracts of the studies retrieved by the search strategy, adhering to the predefined eligibility criteria. For studies that either met the inclusion criteria or couldn't be definitively

Table 2. Search concepts			
Concept 1	**Concept 2**	**Concept 3**	**Concept 4**
"Child" [Mesh] OR Children OR "Pediatrics" [Mesh] OR Pediatric	Gastrostomy OR "Gastrostomy" [Mesh] OR Gastrostomies OR "Enteral Nutrition" [Mesh] OR Enteral Feeding OR Home enteral nutrition	Gastrostomy OR "Gastrostomy" [Mesh] OR Gastrostomies OR "Enteral Nutrition" [Mesh] OR Enteral Feeding OR Home enteral nutrition	2012 OR 2013 OR 2014 OR 2015 OR 2016 OR 2017 OR 2018 OR 2019 OR 2020 OR 2021 OR 2022
Each concept combined with "AND"			

excluded based on the abstracts alone, full-text reports were obtained and further screened against the inclusion criteria. Subsequently, the findings of both reviewers were compared, and any disparities were resolved through discussion until a consensus was reached. To transparently document and report our screening process, we adopted a PRISMA flowchart to outline the outcomes of these procedures.

Data Extraction

Two authors, RS and HP, independently reviewed the articles against the eligibility criteria and quality assessment tools. The process of article selection is meticulously detailed in Figure 1 of the PRISMA flowchart. Initially, a comprehensive search across eight databases yielded a total of 3,940 articles. After removing 2,217 duplicate articles, we were left with 1,723 unique articles that underwent an initial screening based on their titles and abstracts. Subsequently, 1,700 articles that were unrelated to the study's subject matter were excluded, resulting in 23 full-text articles that were further assessed for relevance by the researchers. After a thorough evaluation, these 23 potential articles were subjected to a quality assessment. Five articles were excluded from the study following the quality assessment due to low quality scores. Ultimately, a total of 18 articles were deemed suitable for inclusion and are presented in this research, as summarized in Table 3.

The protocol for this systematic review, including all planned statistical analyses, was registered in PROSPERO before data collection. This proactive step was taken to prevent data-driven analyses and selective reporting and to ensure that all findings, not just statistically significant ones, are reported. Additionally, we have diligently adhered to all the requirements outlined in the current PRISMA guideline when preparing the publication of this systematic review.

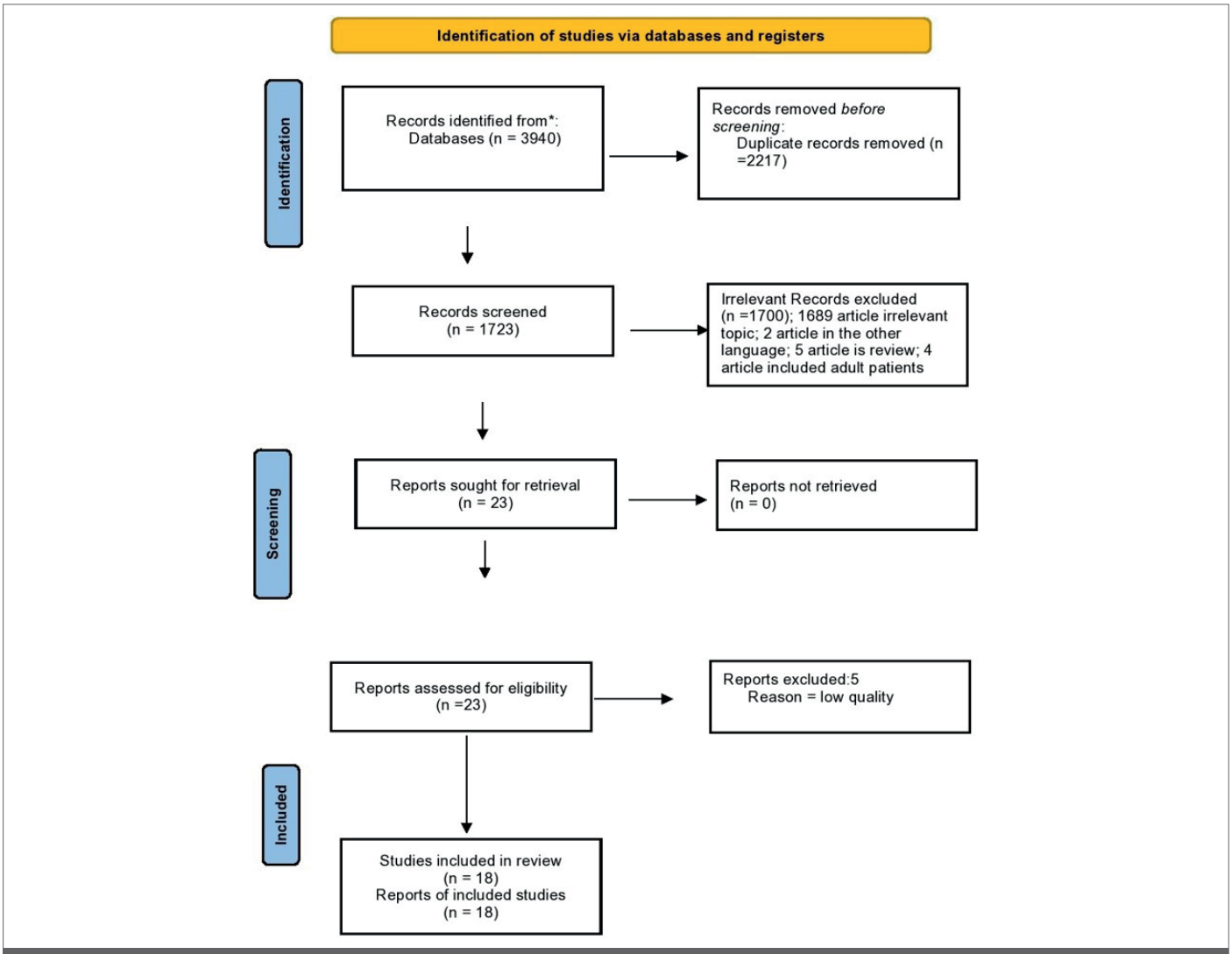

Figure 1. PRISMA flow chart of the research

Table 3. Summary of the included studies

Author, Year, Country	Study Type	Sample	Patients' Disease	Type of Enteral Nutrition	Study Period	Duration of Follow Up	Complication	Types of Complication
Landisch et al., 2016, USA	Cross-sectional	183 infants <1 year	Neurologic deficit=25.14% Pulmonary compromise=26.78% Cardiac diagnosis=80.60% Renal insufficiency=8.17% Ventriculoperitoneal shunt=2.20% Peritoneal dialysis catheter=0.57%	PEG and LG	2011–2015	Three months	Major=6.6% Minor= 38.8%	Gastrocolic fistula= 3.8% Reoperation= 12.4% Cellulitis=27.3% Skin granulation=50.4% Pneumonia=7.7% Early tube dislodgement (<6 weeks)=7.6% Late Tube Dislodgement (>6 weeks)=12.4%
Ronning et al., 2017, USA	Retrospective Cohort	161 children 1 months-17 years	Failure to thrive =41.94% Congenital heart disease =9.68% Cystic fibrosis =5.45% Total pancreatectomy auto-islet transplant =9.68% Bone marrow transplant =5.45% Short gut syndrome=12.9% Oesophageal atresia=16.13%	GT and GJT	2007–2012	Not reported	Major=0 Minor= 57.8%	Dislodgement=19.88% Clogging=4.35% Leaking=1.61%
McSweeney et al., 2015, USA	Retrospective Cohort	591 <6 months	Neurologic disorder=45.0% VP shunt=2.9% Metabolic/genetic disorder=27.4% Cardiac disease=18.3% Prematurity=17.9% Cancer=13.0% Oropharyngeal malformations=7.5% Cystic fibrosis=6.8% Other=4.7%	PEG	2006-2010	Not reported	Major= 10.5% Minor= 16.4%	Peritonitis=9.30% Skin granulation=0.33% Perforation=0.33% Pneumoperitoneum=0.17% Infection= 16.24% PEG tube dislodgement= 4.57%
Fascetti-Leon et al., 2012, Italy	Cross-sectional	239 children 10 days–25 years	Neurological impairment=79% Primary myopathy=6.2% Other dysphagia=3.3% Cystic fibrosis=2.5% Metabolic disorders=2% HIV infection=0.8% Miscellaneous=5.8%	PEG	2004-2007	1, 3, 6, 12, and 24 months after the procedure.	Major= 3.3% Minor= 47.7%	Gastrocolic fistula=2.5 % Haemorrhage=0.4% Peritonitis=0.4% Dislodgement=1.6% Granulation= 43.93 Infection=18.5% Leakage=16.8%

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Table 3. Continued

Author, Year, Country	Study Type	Sample	Patients' Disease	Type of Enteral Nutrition	Study Period	Duration of Follow Up	Complication	Types of Complication
Işık et al., 2021, Turkey	Cross-sectional	91 children 1 months-18 years	Neurological diseases=76.9% Metabolic diseases=20.9% Cystic fibrosis=2.2%	PEG	2014-2019	6 months to 5 years	Major= 3.3% Minor= 37.4%	Intraabdominal abscess=1.1% Peritonitis=1.1% Buried bumper syndrome=1.1% Over skin granulation=15.4% Tube blockage=6.6% External leakage=6.6% Tube degradation=4.4% Tube dislodgement=4.4%
Pahsini et al., 2016, Austria	Cross-sectional	425 children <18 years	Complicated premature birth =23.1% Congenital malformation Of the heart=12.7% Congenital metabolic disease=2.4% Malformation/disease of the GIT=15.3% Genetic syndromes/ Chromosomal abnormalities=23.5% Failure to thrive=6.8% Neurological conditions=8% Malformation/disease of the respiratory tract=5.4% Oncology and hematology=0.9% Renal problems=1.9%	NG and PEG	2009-2013	Not reported	Not reported	Nausea=14.8% Vomiting=49.89% Retching and gagging=56% Extreme nervous perspiration=7.5% Loss of appetite= 45.2% Local skin granulation tissue=5.2% Skin irritations=1.9% Sweating=7.53% No hunger=45.18%
Krom et al., 2019, Netherlands	Cross-sectional	279 children <17 years	Congenital abnormalities=42% Perinatal problems=38% Neurologic diseases=16% Others=4%	Gastrostomy Nasogastric Duodenal Jejunostomy Jejunal	2010-2014	Not reported	Not reported	Vomiting=36.6% Lack of appetite=28.7% Gagging=28.7% Nausea=26.2% Coughing=18.3% Arching=6.5% Skin irritation=34.5% Fibroma =31.6% Infection=13.0%

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Table 3. Continued

Author, Year, Country	Study Type	Sample	Patients' Disease	Type of Enteral Nutrition	Study Period	Duration of Follow Up	Complication	Types of Complication
Hajjat et al., 2017, USA	Retrospective Cohort	43 children <18 years	Neurologic disorder= 58% Genetic/metabolic disorder=26% Cardiac defect=16% Prematurity =14% Eosinophilic esophagitis =5% Chronic lung disease=9% Chronic renal disease=9% Oncology diagnosis=5% Cystic fibrosis=2% Immune deficiency=2% Oral/facial abnormality=7%	low-profile non-balloon GT	-	10 years	Not reported	Dislodgement= 14% Leakage=31% Tube breakdown=11% Bleeding=1%
Franken et al., 2015, Netherlands	Retrospective Cohort	300 patients median age of 2.66 years (IQR 1.28–7.44)	Neurologically impaired=75 % Others=25%	LAG	2004-2011	Median follow-up time was 2.63 years	Major= 2.0% Minor= 73.6%	Postoperative dehiscence of stomach wall=1.3% Intraoperative bleeding=0.3% Postoperative omental herniation=0.3% Skin hyper granulation=44% Stomal infection=24.7% Leakage=24% Dislodgement=21% Obstruction=6.3% Non-closure of gastrostomy site=4% Ectopic gastric mucosa=2.7%
Kidder et al., 2021, USA	Cross-sectional	49 children 1 month and 20 years	Pediatric oncology patients	PEG and PEG-J	2000-2026	6 months	Major= 10% Minor= 28.8%	Cellulitis=24% Buried bumper syndrome=10% Dislodgement=2% Peritonitis=2%
Di Leo et al., 2019, Italy	Cross-sectional	84 children <18 years	Cerebral palsy=66.7% Genetic disorder=15.5% Metabolic or other=10.7% Oesophageal atresia=7.1%	PEG	2003-2017	Not reported	Major= 14.3% Minor=20.2%	Surgical revision=3.6% Occlusion=2.4% Buried bumper syndrome=2.4% Dumping syndrome=5.9% Dislocation=11.9% Granuloma or skin infection=8.3%

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Table 3. Continued

Author, Year, Country	Study Type	Sample	Patients' Disease	Type of Enteral Nutrition	Study Period	Duration of Follow Up	Complication	Types of Complication
Khalil et al., 2017, USA	Cross-sectional	322 infants <37 weeks	Prematurity=55.9% Central nervous system=38.1% Cardiovascular system=25.0% Respiratory system=44.0% Gastrointestinal system=40.5% Genetics/metabolic=16.7% Renal=8.3 Other=34.5%	NG and GT	2009-2013	6 months	Major= 6% Minor=Not reported	Inadvertent removal/ misplacement=13.98% Broken/malfunctioning tube=5.28% G-tube site issues=5.59% Infection issues=3.73% Apparent life-threatening event=1.86% Aspiration pneumonia=0.93% Constant fussiness=0.31% Vomiting=0.31% Gastroesophageal reflux=0.31% Gastric outlet obstruction=0.31% Visceral perforation=0.31% Enterocutaneous fistula=0.31%
Mason et al., 2018, Utah	Retrospective Cohort	682 children <18 years	Malnutrition=10.3% Failure to thrive=54.5% Dysphagia=35.2%	GT	2012-2016	Not reported	Major= 8.3% Minor=22%	Tube dislodgment=5.13% Hospital readmission=2.79% Reoperation=2.64% Sch abscess=1.03% Surgical site infection=8.50%
Sakamoto et al., 2021, Japan	Cross-sectional	89 children <16 years	Cerebral damage in the neonatal period or infancy=75.61% Genetic or chromosomal anomaly=12.20% Metabolic disorder=4.88% Adrenoleukodystrophy=6.10% Mitochondrial disease=1.22%	VAG	2006-2015	Over 2 years	Not reported	Skin granulation tissue=38.41% Leakage=15.24% Skin trouble=15.24% Infection=6.09% Vomiting=7.31% Ileus=0.61% Peritonitis=0.61% Dumping syndrome=0.61%

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Table 3. Continued

Author, Year, Country	Study Type	Sample	Patients' Disease	Type of Enteral Nutrition	Study Period	Duration of Follow Up	Complication	Types of Complication
Khdair Ahmad et al., 2020, Jordan	Cross-sectional	25 children 1-18 years	Neurological=84% Ventriculo-peritoneal shunt=12% Hematological=44% Genetic/metabolic diseases =24% Respiratory conditions other than Cystic fibrosis =20% Cystic Fibrosis=8% Malignancy=4% Others=8%	PEG	2017-2019	Not reported	Major= 4% Minor=32%	Internal leak and peritonitis=4% Site infections=24% Tube dislodgements=12% Tube degradation=12% Over skin granulation=4%
Hansen et al., 2017, Denmark	Cross-sectional	229 children <16 years	Neurological disorders=49.3% Malformations of the gastrointestinal tract=10.5% Malignancy=19.2% Miscellaneous=17.9% Renal disease=5.2% Cardiac disease=3.9% Short bowel syndrome=2.6% HIV/AIDS=0.4%	PEG	2000-2012	36 months	Not reported	Grade 2, Skin infection=14.4% Infection=11.8% Miscellaneous=5.2% Dislodgement=4.4% Dysfunction of gastrostomy and/or gastrointestinal tract=2.2% Bleeding=1.7% Gastrocolic fistula=0.9% Peritonitis=0.9% Grade 1, Skin infection and/or irritation=31.9% Clogging of tube=3.5% Other=3.5%
Goldin et al., 2016, USA	Retrospective Cohort	15 642 children <18 years	Neurologic only=19.5% Cardiac only =8.3% Respiratory only =6.7% Congenital or genetic only=5.9% Cardiac + congenital or genetic=5.0% Cardiac + respiratory=4.9% Neurologic + congenital or genetic=4.5% Neurologic + cardiac=3.0% Cardiac + respiratory + congenital or genetic=2.8% Malignancy only =2.7%	GT	2010-2012	30 days	Not reported	Infection=27% Mechanical complication=22% Replacement=19%

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Table 3. Continued

Author, Year, Country	Study Type	Sample	Patients' Disease	Type of Enteral Nutrition	Study Period	Duration of Follow Up	Complication	Types of Complication
Wiernicka et al., 2021, Poland	Randomize controlled trial	97 children 1 month to 18 years	Feeding disorders=47% Cerebral palsy=17% Encephalopathy=9% Central nervous system defect=4% Epilepsy=4% Cystic fibrosis=4% Other =15%	PEG	2015-2016	12 months	Major= 6.1% Minor=32%	Displacement=3.1% Status epilepticus=1% Arrhythmia=1% Death=1% Pneumoperitoneum=1% Bleeding=1% Reddening around stoma canal=10.4% Leakage of gastric contents=6.3% Vomiting=14.6% Nausea=3.1% Regurgitation=5.2% Constipation=1% Infectious complications=8.2%

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For the purpose of quality assessment, we employed the Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instruments (JBI–MAStARI), specifically tailored to evaluate randomized controlled trials (RCTs)[24], cross-sectional research[25], and the JBI critical appraisal checklist for cohort studies.[25] The JBI critical appraisal checklist is tailored to the specific type of study being assessed, with variations in the number of questions depending on the study design. It comprises 13 questions for Randomized Controlled Trials (RCTs), while analytical cross-sectional studies involve 8 questions, and cohort studies entail 11 questions. In the case of RCTs, data quality is assessed by assigning one point for each applicable item, allowing for a maximum achievable score of 13. Similarly, analytical cross-sectional studies are scored with one point for each relevant item, resulting in a maximum score of 8. For cohort studies, data quality is appraised by awarding one point for each pertinent item, leading to a maximum possible score of 11. Respondents are required to answer all questions with 'Yes,' 'No,' 'Unclear,' or 'Not Applicable.' To ensure objectivity, two authors, RS and HP, independently evaluate each study and determine a risk of bias grade. The final score for each paper is then calculated as a percentage, with quality ratings falling into three categories: 'good' (80%–100%), 'fair' (50%–79%), and 'low' (< 50%)[26] (Table 4, 5, 6). Five studies were excluded because of the low-quality scores.

Data Synthesis and Analysis

Data collection was conducted by two independent researchers, RS and HP, who utilized a standardized form to compile the following information: 1) author, publication year, and study location; 2) study type; 3) characteristics of the study population; 4) specific medical conditions affecting the patients; 5) the specific type of enteral nutrition employed; 6) study duration and timeline; 7) duration of patient monitoring for complications; and 8) documented complications. Throughout the synthesis process, we utilized data extraction tables and incorporated the PICO framework elements from each study. These tools were employed to categorize and consolidate studies, facilitating the process of data synthesis and the integration of research findings. As part of the data synthesis process, the outcomes of the individual studies were thoroughly scrutinized. Given the diverse array of research types encompassed in this review, a descriptive analysis approach was adopted to effectively summarize the research results. Consequently, the research findings were concisely summarized through the application of descriptive analysis techniques.

Ethical considerations

Ethical approval was not deemed necessary for the conduct of this systematic review.

RESULTS

Study Characteristics

In this systematic review, a total of 18 articles were subjected to detailed examination. These studies were conducted in nine different countries, including the United States of America (USA; n = 8), Denmark (n = 1), Jordan (n = 1), Japan (n = 1), Türkiye (n = 1), the Netherlands (n = 2), Italy (n = 2), Poland (n=1), and Austria (n = 1). The sample sizes of these studies varied, ranging from 25 to 15,642 participants, ultimately encompassing a total of 19,531 children.

Three studies were conducted with infants[27-29] and fifteen studies[12,30-43] were conducted with children and adolescents. One study investigated complications of home enteral nutrition in pediatric oncology patients[30] and other studies investigated children with other diseases.[12,27-29,31-43] Most studies have investigated the complications of home enteral nutrition in children with neurological, genetic/chromosomal, metabolic, systemic, and nutritional disorders.

One study was conducted as an RCT[12], six studies were cohort[28,32,34-37], and 11 studies were cross-sectional.[27,29-31,33,38-43] Seven studies examined complications of PEG, one study examined complications of all enteral tubes[31], one study was related to PEG and LG[27], one study was related to Gastrostomy Tube (GT) and Gastrojejunostomy Tube (GJT)[32], one study was related to NG and PEG[33], three studies were related to GT[34-36], one study was related to Laparoscopic Gastrostomy (LAG)[37], one study was related to PEG and Gastro-Jejunostomy (PEG-J)[30], one study related to Nasogastric Tube (NG) and GT[29], and one study related to Video-Assisted Gastrostomy (VAG)[38].

In the included studies, it was determined that there was no standard time for follow-up of complications after tube placement. Landisch et al.[27] followed up in 3 months, Fascetti-Leon et al.[40] followed up in 1, 3, 6, 12, and 24 months after the procedure. Işık et al.[41] followed up for 6 months to 5 years, Hajjat et al.[36] followed up for 10 years, Franken et al.[37] followed up for about 2.63 years, Kidder et al.[30], and Khalil et al.[29] followed up in 6 months, Sakamoto et al.[38] followed up over 2 years, Hansen et al.[43] followed up 36 months, Goldin et al.[34] followed up in 30 days and Wiernicka et al.[12] followed up in 12 months. Seven studies did not report the following duration of complication after the enteral feeding tube placement (Table 3).

Quality Appraisal of the Included Reviews

The Joanna Briggs Institute critical appraisal tools were employed for the reviews. Both authors conducted evaluations on all the articles, and the quality of each paper was assessed by calculating a percentage score. Quality ratings were categorized as follows: 'good' (with a score falling within the range of 80%–100%), 'fair' (scores between 50%–79%), and 'low' (scores below 50%). Notably, four of the studies achieved a 'good' quality rating.[28,31,36,39] Of the studies assessed, 14 received a 'fair' quality rating based on the evaluation using the Joanna Briggs Institute critical appraisal tools. These studies scored within the range of 50% to 79% on the quality assessment (Table 4, 5, 6).

Table 4. Appraisal of methodological quality of the cross-sectional studies

Study Reference	Methodological Items								Quality Score
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	
Landisch et al., 2016, USA	Y	Y	Y	Y	N	N	Y	Y	%75
Fascetti-Leon et al., 2012, Italy	Y	Y	Y	Y	N	N	N	Y	%62.5
Işık et al., 2021, Turkey	Y	Y	N	Y	N	N	Y	Y	%62.5
Pahsini et al., 2016, Austria	Y	Y	N	N	Y	N	Y	Y	%62.5
Krom et al., 2019, Netherlands	Y	Y	Y	Y	N	N	Y	Y	%75
Kidder et al., 2021, USA	Y	Y	Y	Y	Y	N	N	Y	%75
Di Leo et al., 2019, Italy	Y	Y	Y	Y	N	N	Y	Y	%75
Khalil et al., 2017, USA	Y	Y	N	Y	Y	N	Y	N	%62.5
Sakamoto et al., 2021, Japan	N	Y	Y	Y	Y	N	Y	Y	%75
Khdair Ahmad et al., 2020, Jordan	Y	Y	Y	Y	Y	N	Y	Y	%87.5
Hansen et al., 2017, Denmark	Y	Y	Y	Y	N	N	Y	Y	%75

Y-Yes, N-No, U-Unclear, NA-Not Applicable

Table 5. Appraisal of methodological quality of the randomized controlled studies

Study Reference	Methodological Items													Quality Score
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	
Wiernicka et al., 2021, Poland	Y	N	Y	N	N	N	Y	N	Y	Y	Y	Y	Y	%61.54
Y-Yes, N-No, U-Unclear, NA-Not Applicable														

Table 6. Appraisal of methodological quality of the cohort studies

Study Reference	Methodological Items											Quality Score
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	
Hajjat et al., 2017, USA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	%100
Mason et al., 2018, USA	Y	Y	Y	Y	N	N	Y	Y	Y	Y	N	%72.73
Goldin et al., 2016, USA	Y	Y	N	Y	Y	Y	Y	Y	N	N	N	%63.64
Ronning et al., 2017, USA	Y	N	Y	N	N	Y	Y	Y	Y	N	N	%54.55
McSweeney et al., 2015, USA	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	%81.82
Franken et al., 2015, Netherlands	Y	Y	Y	N	N	Y	Y	Y	N	N	N	%54.55
Y-Yes, N-No, U-Unclear, NA-Not Applicable												

Complication Features

Major and minor complications were reported in 12 out of 18 studies. In studies reporting the overall rate of major complications, the rate ranged from 0%-14.3%. The most common major complications were reoperation (2.64%-12.4%), gastrocolic fistula/perforation (0.9%-3.8%), and peritonitis (0.4%-9.30%). The least common major complications were postoperative dehiscence of the stomach wall (1.3%), death (1%), intraabdominal abscess (1.1%), and postoperative omental hernia (0.3%).

In articles reporting the overall rate of minor complications, the rateo ranges from 16.4% to 73.6%. The most common minor complications were infection (8.2%-31.9%), dislodgement (1.6%-21%), skin granulation (4%-50.4%), vomiting (1%-49.89%), nausea (3.1%-26.2%), leakage of gastric contents (6.3%-31%), cellulitis (24%-27.3%), reddening around the stoma canal (10.4%-24.7%), buried bumper syndrome (1.1%-10%), and clogging (3.5%-4.35%). The least reported minor complications were ectopic gastric mucosa (2.7%) and stitch abscess (1.03%).

DISCUSSION

This systematic review highlights the importance of acknowledging the rate of complications associated with pediatric enteral nutrition administered at home. Many of the studies included in this review predominantly relied on retrospective cross-sectional analyses of hospital records. These comprehensive investigations consistently shed light on the occurrence of minor complications, some of which are preventable. Although EN and PEG insertion are generally considered safe procedures in pediatric patients and are widely utilized, it is imperative to recognize that complications can indeed arise. Minor complications, including tube obstruction, leakage from the tube edges, tube dislocation, and peristomal infections, were found to be notably prevalent, with reported rates spanning from 16.4% to 73.6%. These minor complications, while less severe, can have a significant impact on the well-being of pediatric patients and should not be underestimated. In contrast, major complications, such as aspiration, peritonitis, bleeding, and pneumoperitoneum, occurred at a lower frequency, with rates of approximately 0% to 14.3% for each of these more serious complications. While these major complications are less common, they demand close attention and swift intervention when they do occur due to their potential for severe consequences. This review emphasized the importance of continuous monitoring and careful management of pediatric patients receiving enteral nutrition at home, with particular emphasis on strategies to prevent minor complications.

Peristomal skin infections are the most common minor complications in pediatric enteral nutrition. Our study results corroborate this observation, revealing a notable incidence of peristomal skin problems. These issues encompassed leakage, which occurred in approximately 6.3% to 31% of cases, hyper granulation tissue on the skin, observed in roughly 4% to 50.4% of cases, and peristomal skin infections, with reported rates ranging from 3.73% to 31.9%.[42-44] Furthermore, our findings indicate that approximately 8.6% of pediatric patients sought medical attention in the pediatric emergency department within

30 days of tube insertion, primarily due to complications related to the procedure.[14,45] These statistics underscore the immediate impact of complications associated with tube insertion. Notably, reports suggest that around 73% of patients experience minor complications in the early post-insertion period, while 5% of patients develop complications in the late period.[15] These findings emphasize the significance of vigilance and prompt intervention in the management of complications related to pediatric enteral nutrition. It is crucial for healthcare providers to be prepared to address peristomal skin problems and other potential complications, particularly in the early stages following tube insertion, to ensure the well-being of pediatric patients in their care.

In this study, major complication rate ranged from 0% to 14.3%. Notably, reoperation emerged as one of the most frequently encountered major complications, with reported rates spanning from 2.64% to 12.4%. Gastrocolic fistula or perforation was another significant major complication, with incidence rates ranging from 0.33% to 3.8%. These findings showed the potential for major complications in the context of pediatric enteral nutrition, while also highlighting the variability in their occurrence across the included studies. It emphasizes the need for careful monitoring and proactive management to mitigate the impact of these complications on the well-being of pediatric patients undergoing HEN. All these findings underscore the considerable significance of complications associated with enteral nutrition, particularly the challenges families face in preventing and managing these complications. It is evident that discharge education plays a vital role in a patient's recovery process, as it has the potential to reduce both the frequency and severity of complications that may arise following the procedure.[41] Schweitzer et al. (2014) demonstrated that the implementation of a systematic and family-centered interdisciplinary approach to caregiver education has a significant positive impact on patient care and outcomes.[46] Similarly, according to Pars & Soyer, enhancements in caregivers' knowledge reduced anxiety levels, and diminished burden have been associated with a decrease in the occurrence of common, minor, and preventable complications.[19] Based on moderate-quality evidence (III-IV B), it is clear that standardized discharge education plays a crucial role in facilitating a smooth transition to home for patients. This is achieved by reducing psychosocial and economic stress, primarily through the active involvement of families in the treatment process.[19,42] The available evidence, predominantly of moderate quality (III-IV B), strongly indicates that gastrostomy tube (g-tube) complications are prevalent and often result in unplanned healthcare utilization. It is imperative to address these common complications, such as dislodgement, leaking, and clogs, as they play a critical role in a patient's recovery. Effective management of these complications can substantially reduce both the frequency and severity of post-procedure complications.[41] Caregivers who did not receive standardized, evidence-based discharge education were found to have significantly higher rates of complications, including issues like infections and clogs. This underscores the importance of providing caregivers with structured and evidence-based guidance during the discharge process to enhance patient care and reduce the risk of complications.[19,42] This systematic review aimed to address a gap in the existing literature concerning the essential components of pediatric home enteral nutrition and enteral tube education. The results obtained from this review underscore the importance of comprehensive and high-quality education for caregivers, including nursing staff. Furthermore, these findings align with the existing literature, emphasizing that multidisciplinary and standardized discharge education not only reduces anxiety and complications but also enhances caregiver knowledge. This highlights the critical role of such education in improving patient outcomes in the context of pediatric home enteral nutrition.[15]

Limitations of the Study

This study has several limitations that should be acknowledged. Firstly, the included studies had diverse indications for the disease, and it is important to note that wound healing may be influenced, particularly in oncology patients, those using corticosteroids, and individuals with suppressed immune systems. Secondly, various factors, such as the individual's diagnosis, medication usage, the type and size of the enteral feeding tract, and the use of prophylactic antibiotics, can impact the occurrence of peristomal skin infections. Third, because most of the included studies were based on hospital records, few studies described complications by families. In this case, it constitutes the limitations of the study results. There is a need for studies with a high level of evidence in which confounding factors are controlled, complications of individuals are evaluated with valid and reliable measurement tools, and patients are followed up prospectively. Lastly, the follow-up period for symptoms that may occur at home in pediatric patients varies between 1 month and two years in the studies. This difference in follow-up time limits the interpretation of the timing of complications.

Strength of the Study

The strength of this systematic review lies in its comprehensive analysis of the complications associated with pediatric HEN. It provides a thorough examination of the existing literature on this critical topic, offering valuable insights into the prevalence and types of complications encountered in children receiving enteral nutrition at home. The review encompasses a wide range

of studies conducted in various countries, which enhances the generalizability of the findings. Additionally, the inclusion of both major and minor complications, along with an assessment of the quality of the included studies, contributes to the robustness of the review's conclusions. The study's implications for practice emphasize the importance of educating caregivers and healthcare professionals about the management of complications related to HEN access, ultimately promoting better patient outcomes. This systematic review fills a significant gap in the literature and provides essential information for healthcare providers, caregivers, and researchers involved in pediatric enteral nutrition care. Priorities include handovers from hospital to community, training for family carers, provision and expertise of services in the community and availability and reliability of equipment.

CONCLUSION

This review represents the first attempt to investigate the complications associated with pediatric home enteral nutrition comprehensively. The outcomes of this study highlight the need for more robust research, encompassing both retrospective and prospective studies. The prevalence of minor complications observed in the studies underscores the significance of equipping all individuals involved in the care of home enteral nutrition (HEN) patients with fundamental knowledge of access tube management. Moreover, it is of utmost importance for families to receive comprehensive discharge training, as well as ongoing home follow-up to ensure the well-being of HEN patients and minimize the occurrence of complications.

Future research in the field of pediatric home enteral nutrition should prioritize prospective studies, measurement tool development, patient-related factors, education programs, device comparisons, long-term follow-up, psychosocial impacts, multidisciplinary collaboration, and cost-effectiveness analyses. These research avenues can contribute to better care for pediatric patients receiving home enteral nutrition and enhance the management of complications in this population.

IMPLICATIONS FOR PRACTICE

HEN is a critical component of care for patients facing various underlying conditions that hinder their ability to meet their nutritional needs through regular eating alone. The provision of long-term enteral access is essential for those who cannot achieve their energy or protein requirements solely through regular eating, especially in the home setting. Several methods are available for establishing enteral access, and the choice should be tailored to the patient's characteristics. Despite the development of minimally invasive techniques for accessing enteral nutrition, long-term complications continue to be a concern both in terms of nature and frequency. To optimize outcomes in the HEN setting, it is crucial to have dedicated multidisciplinary teams and well-informed patients who actively participate in their care. Complications related to enteral access are issues that healthcare professionals from various disciplines may encounter at different points in the healthcare system. Therefore, it is imperative that all those who may be involved in the care of HEN patients possess fundamental knowledge about the management of access tubes.

Complications related to these devices can be challenging, especially when they occur in the home setting as opposed to a hospital environment. The key to achieving positive outcomes for patients receiving HEN lies in having specialized multidisciplinary teams and maintaining close follow-up. Nonetheless, all healthcare providers should have a foundational understanding of the common complications associated with HEN access and how to initiate their management. This systematic review underscores the significance of complications associated with pediatric enteral nutrition at home, emphasizing that these should not be underestimated. It highlights the importance of developing and implementing future strategies to support parents in effectively managing complications related to pediatric enteral nutrition care in the home setting.

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REFERENCES

1. Bawazir O, Banaja AM, Bawazir R, Bawazir AO. Percutaneous endoscopic gastrostomy in children: A tertiary center experience. *Asian J Endosc Surg*. 2022;15:524-530. [Crossref]
2. Volpe A, Malakounides G. Feeding tubes in children. *Curr Opin Pediatr*. 2018;30:665-670. [Crossref]
3. Balogh B, Kovács T, Saxena AK. Complications in children with percutaneous endoscopic gastrostomy (PEG) placement. *World J Pediatr*. 2019;15:12-16. [Crossref]

4. Edwards ST, Glynn EF, Slogic M, et al. Demographics of children with feeding difficulties from a large electronic health record database. *JPEN J Parenter Enteral Nutr*. 2022;46:1022-1030. [Crossref]
5. Kovacic K, Rein LE, Szabo A, Kommareddy S, Bhagavatula P, Goday PS. Pediatric Feeding Disorder: A Nationwide Prevalence Study. *J Pediatr*. 2021;228:126-131.e3. [Crossref]
6. Benjasuwantep B, Chaithirayanon S, Eiamudomkan M. Feeding problems in healthy young children: prevalence, related factors and feeding practices. *Pediatr Rep*. 2013;5:38-42. [Crossref]
7. Braegger C, Decsi T, Dias JA, et al. Practical approach to paediatric enteral nutrition: a comment by the ESPGHAN committee on nutrition. *J Pediatr Gastroenterol Nutr*. 2010;51:110-122. [Crossref]
8. Feeding Tube Awareness Foundation. Conditions that can require tube feeding in children. Available at: https://www.feedingtubeawareness.org/condition-list (Accessed on 21 May, 2022).
9. Bischoff SC, Austin P, Boeykens K, et al. ESPEN practical guideline: Home enteral nutrition. *Clin Nutr*. 2022;41:468-488. [Crossref]
10. Homan M, Hauser B, Romano C, et al. Percutaneous Endoscopic Gastrostomy in Children: An Update to the ESPGHAN Position Paper. *J Pediatr Gastroenterol Nutr*. 2021;73:415-426. [Crossref]
11. Gao X, Zhang Y, Zhang L, et al. Effect of Home Enteral Nutrition on Nutritional Status, Body Composition and Quality of Life in Patients With Malnourished Intestinal Failure. *Front Nutr*. 2021;8:643907. [Crossref]
12. Wiernicka A, Matuszczyk M, Szlagatys-Sidorkiewicz A, et al. Analysis of frequency and risk factors for complications of enteral nutrition in children in Poland after percutaneous endoscopic gastrostomy placement. *Nutrition*. 2021;89:111265. [Crossref]
13. Piening N, Osei H, Munoz Abraham AS, Piening A, Greenspon J, Villalona GA. Open Gastrostomy Tube Placement is Associated With Higher Complications in Infants: A National Surgical Quality Improvement Program Database Analysis. *J Surg Res*. 2021;260:345-349. [Crossref]
14. Arca MJ, Rangel SJ, Hall M, et al. Case Volume and Revisits in Children Undergoing Gastrostomy Tube Placement. *J Pediatr Gastroenterol Nutr*. 2017;65:232-236. [Crossref]
15. Naiditch JA, Lautz T, Barsness KA. Postoperative complications in children undergoing gastrostomy tube placement. *J Laparoendosc Adv Surg Tech A*. 2010;20:781-785. [Crossref]
16. Weszelits SM, Ridosh MM, O'Connor A. Displaced Gastrostomy Tube in the Pediatric Emergency Department: Implementing an Evidence-based Algorithm and Quality Improvement Project. *J Emerg Nurs*. 2021;47:113-122. [Crossref]
17. Suluhan D, Yildiz D, Surer I, Fidanci Eren B, Balamtekin N. Effect of Gastrostomy Tube Feeding Education on Parents of Children with Gastrostomy. *Nutr Clin Pract*. 2021;36:1220-1229. [Crossref]
18. Mohamed Elfadil O, Ewy M, Patel J, Patel I, Mundi MS. Growing use of home enteral nutrition: a great tool in nutrition practice toolbox. *Curr Opin Clin Nutr Metab Care*. 2021;24:446-452. [Crossref]
19. Pars H, Soyer T. Home Gastrostomy Feeding Education Program: Effects on the Caregiving Burden, Knowledge, and Anxiety Level of Mothers. *JPEN J Parenter Enteral Nutr*. 2020;44:1029-1037. [Crossref]
20. Moher D, Shamseer L, Clarke M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst Rev*. 2015;4:1. [Crossref]
21. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Int J Surg*. 2021;88:105906. [Crossref]
22. Eriksen MB, Frandsen TF. The impact of patient, intervention, comparison, outcome (PICO) as a search strategy tool on literature search quality: a systematic review. *J Med Libr Assoc*. 2018;106:420-431. [Crossref]
23. Richardson WS, Wilson MC, Nishikawa J, et al. The well-built clinical question: a key to evidence-based decisions. *ACP J Club*. 1995;123:A12-A13. [Crossref]
24. Tufanaru C, Munn Z, Aromataris E, Campbell J, Hopp L. Systematic reviews of effectiveness. In: Aromataris E, Munn Z, editors. *Joanna Briggs Institute Reviewer's Manual*. The Joanna Briggs Institute; 2020: chap 3. [Crossref]
25. Moola S, Munn Z, Sears K, et al. Conducting systematic reviews of association (etiology): The Joanna Briggs Institute's approach. *Int J Evid Based Healthc*. 2015;13:163-169. [Crossref]
26. Goldsmith MR, Bankhead CR, Austoker J. Synthesising quantitative and qualitative research in evidence-based patient information. *J Epidemiol Community Health*. 2007;61:262-270. [Crossref]
27. Landisch RM, Colwell RC, Densmore JC. Infant gastrostomy outcomes: The cost of complications. *J Pediatr Surg*. 2016;51:1976-1982. [Crossref]
28. McSweeney ME, Kerr J, Jiang H, Lightdale JR. Risk factors for complications in infants and children with percutaneous endoscopic gastrostomy tubes. *J Pediatr*. 2015;166:1514-1519.e1. [Crossref]
29. Khalil ST, Uhing MR, Duesing L, Visotcky A, Tarima S, Nghiem-Rao TH. Outcomes of Infants With Home Tube Feeding: Comparing Nasogastric vs Gastrostomy Tubes. *JPEN J Parenter Enteral Nutr*. 2017;41:1380-1385. [Crossref]
30. Kidder M, Phen C, Brown J, et al. Effectiveness and Complication Rate of Percutaneous Endoscopic Gastrostomy Placement in Pediatric Oncology Patients. *Pediatr Gastroenterol Hepatol Nutr*. 2021;24:546-554. [Crossref]
31. Krom H, van Zundert SMC, Otten MAGM, van der Sluijs Veer L, Benninga MA, Kindermann A. Prevalence and side effects of pediatric home tube feeding. *Clin Nutr*. 2019;38:234-239. [Crossref]
32. Ronning MM, Gaillard P, Wey A, Roback MG. Comparison of Emergency Department Visits for Complications of Gastrostomy Versus Gastrojejunostomy Tubes in Children. *Pediatr Emerg Care*. 2017;33:e71-e74. [Crossref]

33. Pahsini K, Marinschek S, Khan Z, Dunitz-Scheer M, Scheer PJ. Unintended Adverse Effects of Enteral Nutrition Support: Parental Perspective. *J Pediatr Gastroenterol Nutr*. 2016;62:169-173. **[Crossref]**
34. Goldin AB, Heiss KF, Hall M, et al. Emergency Department Visits and Readmissions among Children after Gastrostomy Tube Placement. *J Pediatr*. 2016;174:139-145.e2. **[Crossref]**
35. Mason CA, Skarda DE, Bucher BT. Outcomes After Laparoscopic Gastrostomy Suture Techniques in Children. *J Surg Res*. 2018;232:26-32. **[Crossref]**
36. Hajjat T, Rahhal RM. Differences in Durability, Dislodgement, and Other Complications With Use of Low-Profile Nonballoon Gastrostomy Tubes in Children. *Nutr Clin Pract*. 2017;32:219-224. **[Crossref]**
37. Franken J, Mauritz FA, Suksamanapun N, Hulsker CC, van der Zee DC, van Herwaarden-Lindeboom MY. Efficacy and adverse events of laparoscopic gastrostomy placement in children: results of a large cohort study. *Surg Endosc*. 2015;29:1545-1552. **[Crossref]**
38. Sakamoto S, Hashizume N, Fukahori S, et al. Complications in patients with neurological impairment after gastrostomy. *Pediatr Int*. 2021;63:1357-1362. **[Crossref]**
39. Khdair Ahmad F, Younes D, Al Darwish MB, Aljubain MA, Dweik M, Alda'as Y. Safety and outcomes of percutaneous endoscopic gastrostomy tubes in children. *Clin Nutr ESPEN*. 2020;38:160-164. **[Crossref]**
40. Fascetti-Leon F, Gamba P, Dall'Oglio L, et al. Complications of percutaneous endoscopic gastrostomy in children: results of an Italian multicenter observational study. *Dig Liver Dis*. 2012;44:655-659. **[Crossref]**
41. Işık İA, Akbulut UE, Atalay A, et al. Complications of percutaneous endoscopic gastrostomy in children: a single centre experience. *J Pediatr Res*. 2021;8:377-381. **[Crossref]**
42. Di Leo G, Pascolo P, Hamadeh K, et al. Gastrostomy Placement and Management in Children: A Single-Center Experience. *Nutrients*. 2019;11:1555. **[Crossref]**
43. Hansen E, Qvist N, Rasmussen L, Ellebaek MB. Postoperative complications following percutaneous endoscopic gastrostomy are common in children. *Acta Paediatr*. 2017;106:1165-1169. **[Crossref]**
44. Friedman JN, Ahmed S, Connolly B, Chait P, Mahant S. Complications associated with image-guided gastrostomy and gastrojejunostomy tubes in children. *Pediatrics*. 2004;114:458-461. **[Crossref]**
45. Frank C, Williams RF, Boulden T, Kink R, Paton EA. Ultrasound is safe and highly specific for confirmation of proper gastrostomy tube replacement in pediatric patients. *J Pediatr Surg*. 2022;57:390-395. **[Crossref]**
46. Schweitzer M, Aucoin J, Docherty SL, Rice HE, Thompson J, Sullivan DT. Evaluation of a discharge education protocol for pediatric patients with gastrostomy tubes. *J Pediatr Health Care*. 2014;28:420-428. **[Crossref]**