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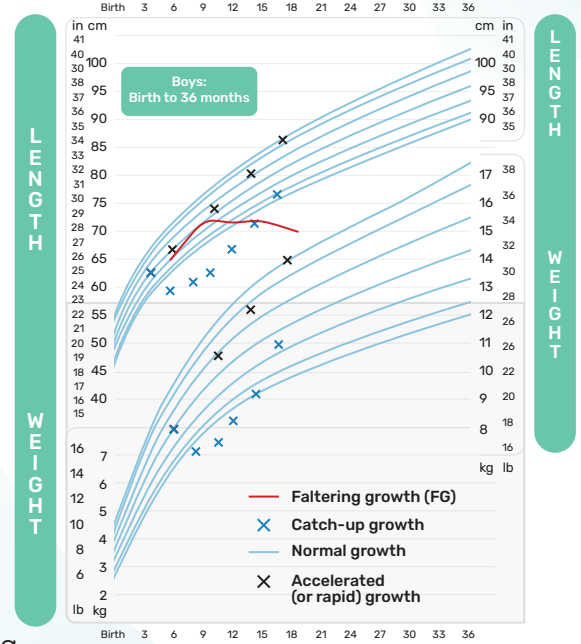
Nutrition Essentials: Faltering Growth

The role of nutrition in overcoming faltering growth in the first 1000 days of life

Faltering growth is a common pediatric problem

The first few years of life represent the fastest period of growth and development. Typically, **normal growth occurs within the centile space of growth** in terms of increasing weight or height*[1]

Faltering growth (FG)	**Reduction in weight-for-age (WFA) z score of ≥1.0** over a period of ≥1 months excluding the first 2 months after birth[1]
Catch-up growth	**Increase in growth velocity**† represented by a physiologic **increase in WFA z score after a period of FG;** important in infants with FG[1]
Normal growth	**Achieved following catch-up growth to the relevant WFA z score** or centile before growth faltered[1]
Accelerated (or rapid) growth	**Increase in WFA z score of ≥1.0**‡ not preceded by FG[1]



Some clinicians may be unnecessarily hesitant in addressing FG due to concerns in promoting rapid (or accelerated) growth.[1]

*1 centile space = 0.67 z scores. †Following recovery from illness or starvation. ‡This could occur either spontaneously or be promoted due to overfeeding or formula-feeding.

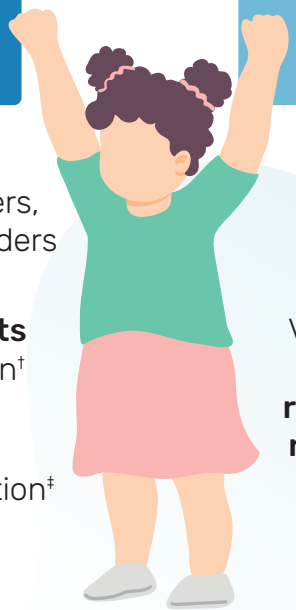
Faltering growth may or may not be disease-related

Disease-related FG maybe caused by one of the following factors or their combination:[1]

Decreased or restricted intake
due to suckling or swallowing disorders, or secondary anorexia* or eating disorders

Increased nutritional requirements
due to infection and/or inflammation†

Excessive losses
due to vomiting, intestinal malabsorption‡ or protein-losing enteropathy§



Non-disease-related FG maybe caused by:[1]

Psychosocial, socio-economic, and environmental factors

Vulnerability to undernutrition and FG due to **limited body reserves and higher nutrient requirements** for growth and development in infanthood

*For example, cardiac and/or lung diseases, cancer, cerebral palsy. †For example, pulmonary, cardiac, renal, hemato-oncologic, neurologic, endocrine diseases. ‡For example, untreated celiac disease, cystic fibrosis, cholestasis, or intestinal failure including short bowel syndrome, intractable diarrhea and chronic intestinal pseudo-obstruction. §For example, intestinal lymphangiectasia, inflammatory bowel disease and severe dermatologic disease.

Chronic diseases are common causes for disease-related faltering growth in infants

Apart from infection and inflammation, chronic conditions that may contribute to FG include:[1,2]

- Congenital heart disease (CHD)
- Chronic lung disease
- Cystic fibrosis
- Cerebral palsy
- Inflammatory bowel disease (IBD) and other gastrointestinal diseases
- Cancer
- Other critical illnesses

For example, in infants with CHD

May have higher metabolic demand due to increased resting oxygen consumption, chronic hypoxia, and increased cardio-respiratory work.[1]

Nutrient intake maybe reduced due to anorexia, fatigue, tachypnea, breathlessness, early satiety, interruption or discontinuation of feeding.[3]

Up to 51% of infants with CHD may be undernourished[3-6]

Disease-related faltering growth is common among hospitalized children

Disease-related undernutrition in hospitalized infants and children ranges from **5% to 50%**[7,8]

In infants with CHD, the prevalence of malnutrition can be as high as **51%**[3-6]

14%–32%
of infants admitted to pediatric intensive care units (PICU) are reportedly malnourished at admission[1]

A Canadian study showed that hospitalization may further exacerbate malnourishment in infants and children:[9]

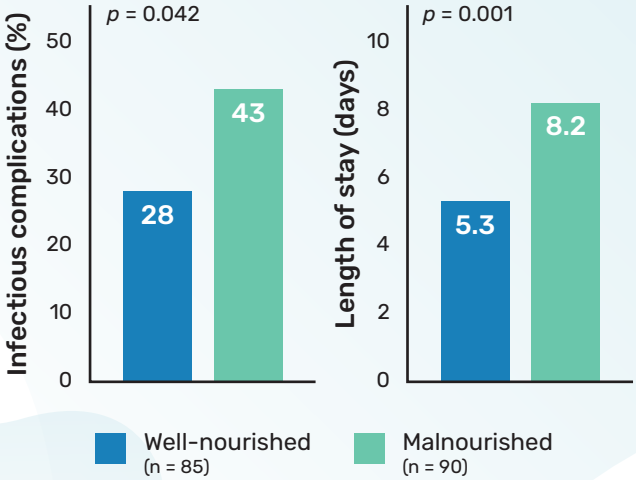
- Mean WFA z score was lower at discharge compared with admission
- ~ 50% of children lost weight during their hospital stay

Impact of faltering growth on infant health: Short-term consequences

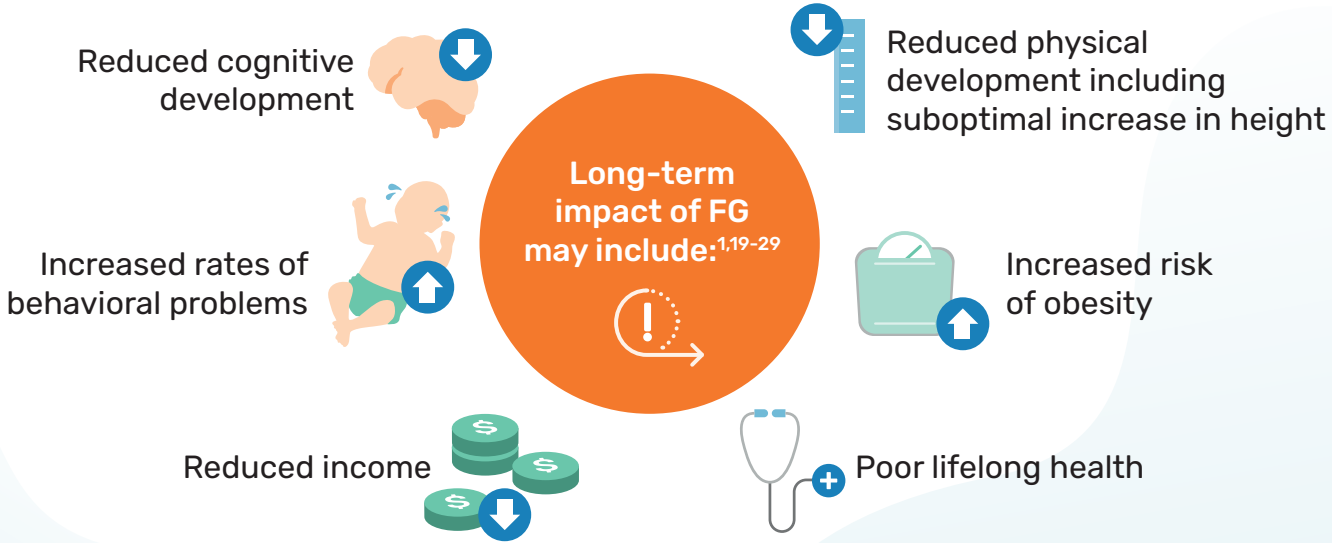
The short-term impact of FG on infants include:[10-18]

- Impaired immune function
- Increased risk of recurrent infections
- Poor wound healing and higher risk of complications
- Longer hospital stays (including in PICU) and higher readmission rates
- Increased duration of mechanical ventilation
- Delayed surgery, longer recovery time and higher mortality rates

Malnutrition increases infectious complications and length of stay in pediatric surgery patients



Impact of faltering growth on infant health: Long-term consequences



Faltering growth places a significant burden on health care systems

Delayed recovery and prolonged hospitalization significantly contribute to burdening the healthcare system[24-26]

Compared to non-malnourished infants:

Length of hospital stay in undernourished children has been reported to be **~2.5 times longer**.[25]

Hospital costs for undernourished children are reportedly **>3 times higher**.[25]

Disease-related undernourishment leads to an **additional medical cost** of €80 million in children (aged 1 months to 17 years) hospitalized in The Netherlands.[26]

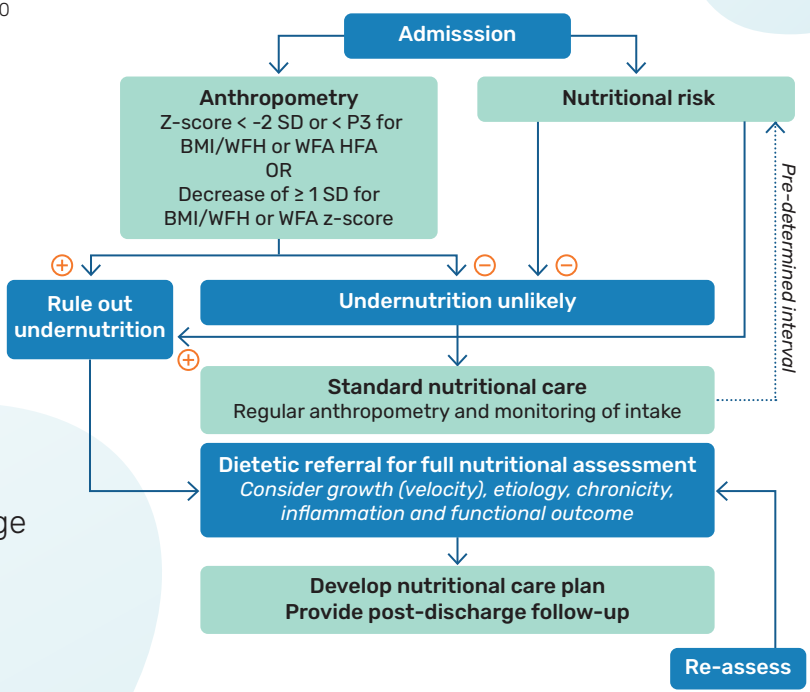
Hospitalized children with undernourishment were reported to be **~3.5 times** more likely to require **post-discharge home care**.[25]

Screening, assessment and diagnosis of faltering growth or disease-related undernourishment

- Disease-associated undernourishment is a **widely recognized pediatric problem.**[30]
- However, **lack of standardized clinical definitions** may preclude efficient screening, assessment and diagnosis.[30]
- The **European Society for Paediatric Gastroenterology Hepatology and Nutrition (ESPGHAN) algorithm** allows rapid identification of undernourished children or those at risk of nutritional deterioration.[30]
- A **multi-disciplinary team** involving nutrition nurses, dietitians, gastroenterologists, speech and language therapists, psychologists, gastrostomy nurses, and parenteral nutrition nurses, must be consolidated for best results.[30]

BMI, body mass index; SD, standard deviation.

The ESPGHAN algorithm



Several nutritional screening tools are available

The following table lists several different screening tools along with their key features[30]

Screening tool	Need for measurements	Tied to action plan	Predict outcome	Different populations	Current nutritional status	Weight loss/ recent changes	Anticipated decline/ reduced intake	Disease severity
NRS	✓	✓	✗	✗	✓	✓	✓	✓
PNRS	✗	✓	✓	✗	✗	✗	✓	✓
STAMP	✓	✓	✗	✓	✓	✗	✓	✓
PYMS	✓	✓	✓	✓	✓	✓	✓	✓
$STRONG_{KIDS}$	✗	✓	✓	✓	✓	✓	✓	✓
PeDiSMART	✓	✓	✗	✗	✓	✓	✓	✓
PNST	✗	✓	✗	✗	✓	✓	✗	✗
SPENS	✗	✓	✗	✗	✓	✓	✓	✗

NRS, Nutrition Risk Score; PNRS, Pediatric Nutritional Risk Score; STAMP, Screening Tool for the Assessment of Malnutrition and Growth; PYMS, Paediatric Yorkhill Malnutrition Score; $STRONG_{kids}$, Screening Tool for Risk on Nutritional Status and Growth, PeDiSMART: Pediatric Digital Scaled Malnutrition Risk screening Tool, PNST: Pediatric Nutrition Screening Tool, PNSS: Pediatric Nutrition Screening Score.

Specific nutritional screening tools are available for specific pediatric populations

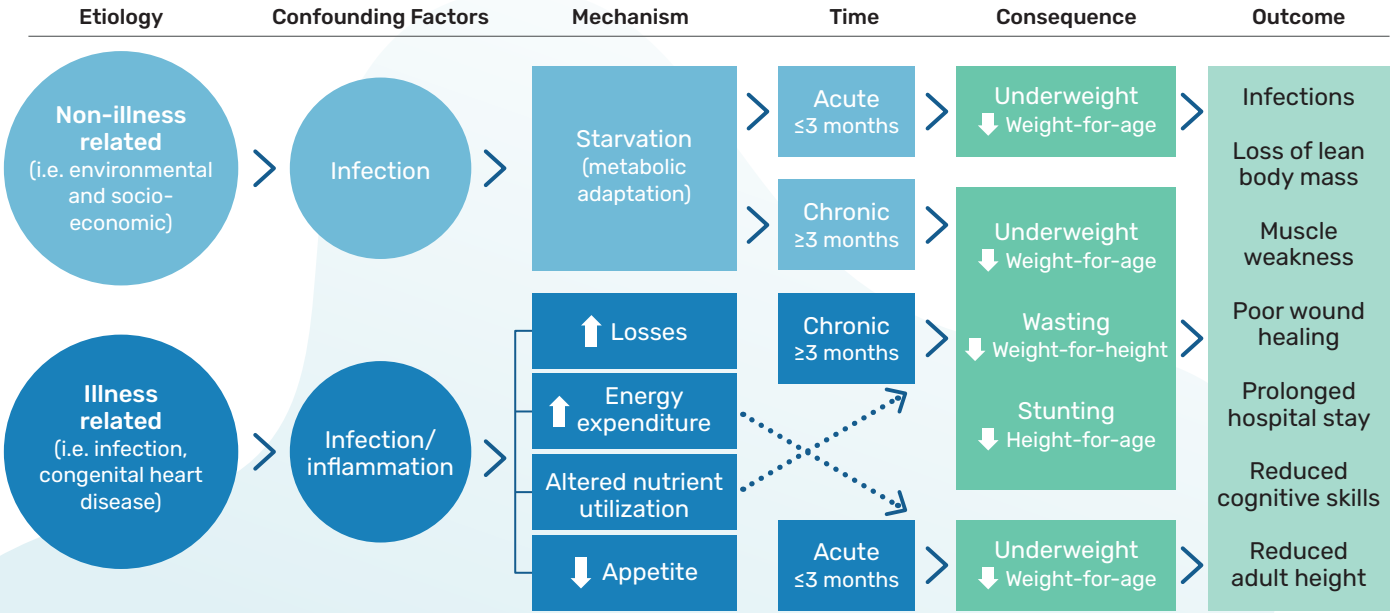
Appropriate screening tools based on the presence of specific conditions are listed below:[31]

	PNRS	STAMP	PYMS	$STRONG_{kids}$	SGNA	iNEWS	OTHER
DIAGNOSES							
Anesthesia	✓						
Biliary atresia				✓			
Burns		✓	✓	✓			
Cancer				✓	✓ (PG-SGA)		SCAN TOOL
Cerebral palsy					✓		Malnutrition risk score
Cystic fibrosis							2 NST
IBD		✓	✓	✓			
Spinal cord injury		✓					
Surgical patients				✓			
SETTING							
Chronic illness (mixed)-special schools				✓			
Ambulatory clinic		✓					
AGE							
Infants		✓		✓	✓	✓	NNST

iNews, Infant Nutrition Early Warning Score; NNST, Neonatal Nutritional Risk Score; PG-SGA, Patient-generated Subjective Global Assessment; PNRS, Pediatric Nutritional Risk Screening; PYMS, Pediatric Yorkhill Malnutrition Score; SCAN, Nutrition Screening Tool for Childhood Cancer; SGNA, subjective global nutritional assessment; STAMP, Screening Tool for the Assessment for Malnutrition in Pediatrics; $STRONG_{kids}$, Screening Tool for Risk on Nutritional Status and Growth.

Nutritional management of faltering growth necessitates an understanding of the underlying condition

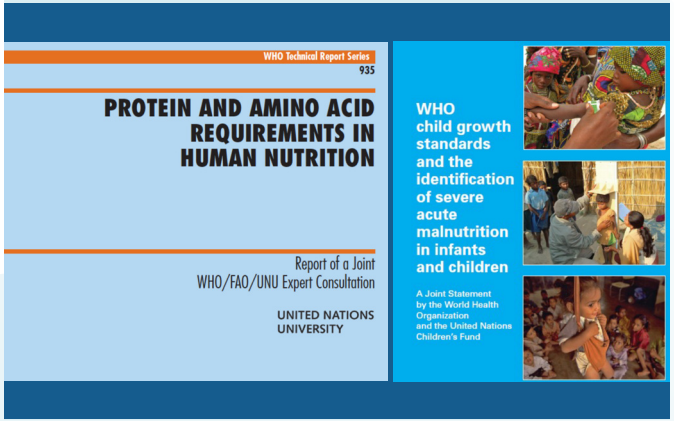
Factors to consider when planning intervention strategies to manage FG:[1]



International and regional guideline recommendations advise on strategies for the nutritional management of faltering growth[32-35]

Proposed recommended nutrient densities for moderately malnourished children

Michael H. Golden



NICE National Institute for Health and Care Excellence

Faltering growth: recognition and management of faltering growth in children

NICE guideline
Published: 27 September 2017
www.nice.org.uk/guidance/ng75

NICE National Institute for Health and Care Excellence

Faltering growth overview

NICE Pathways bring together everything NICE says on a topic in an interactive flowchart. NICE Pathways are interactive and designed to be used online.

NICE Pathway last updated: 22 October 2021
http://pathways.nice.org.uk/pathways/faltering-growth

Optimal management of faltering growth requires an appropriate intake of key macronutrients

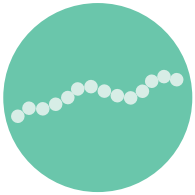
Energy

To account for decreased intake, increased needs and/or increased losses.[35]

Protein

Age, nutritional status and clinical condition impact the protein requirements of infants.[35]

Long chain polyunsaturated fatty acids



Critical for cognitive development and immune response.[36-40]

Prebiotics
including HMOs and well-researched prebiotic oligosaccharides

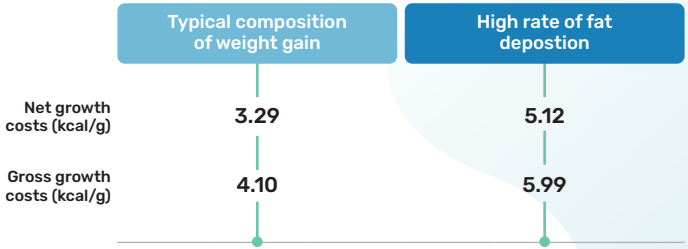
For maintenance of favorable gut microbiota and development of immune system in infants.[41]

HMOs, human milk oligosaccharides.

A balanced protein: Energy ratio promotes high quality catch-up growth

The 2007 WHO/FAO/UNU report recommended specific protein requirements for catch-up growth[35]

- The recommendation considered diverse populations, including from countries with widespread severe undernutrition.
- Protein needs of wasted infants and children were estimated to be 9%-11.5% of total energy, depending on the rate and composition of weight gain required (see table) to achieve an appropriate proportion of lean and fat tissue.



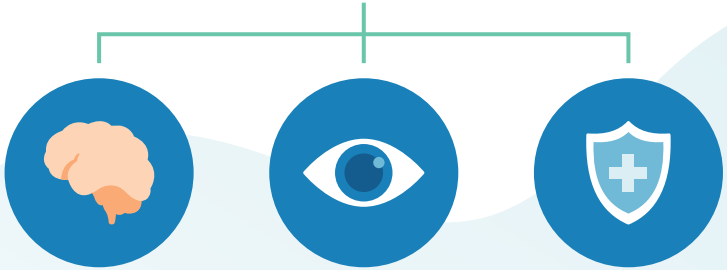
Rate of gain (g/kg per day)	Typical composition of weight gain: Protein (g/kg/day)	Energy (kcal/kg/day)	Protein/ energy (%)	High rate of fat depostion: Protein (g/kg/day)	Energy (kcal/kg/day)	Protein/ energy (%)
1	1.02	89	4.6	1.0	91	4.2
2	1.22	93	5.2	1.1	97	4.5
5	1.82	105	6.9	1.5	115	5.2
10	2.82	126	8.9	2.2	145	6.0
20	4.82	167	11.5	3.6	205	6.9

A protein level of 2.6 g/100 kcal (10.4% of protein) for feeds is recommended for moderately malnourished children.[32]

FAO, Food and Agriculture Organization; UNU, United Nations University; WHO, World Health Organization.

Long chain polyunsaturated fatty acids are essential for cognitive and immune function development

Long chain polyunsaturated (LCP) fatty acids like docosahexaenoic acid (DHA) and arachidonic acid (ARA) contribute to:[36-40]



Infants with FG are at **particular risk** of experiencing **cognitive skills impairment**

Experts recommend that infant formulae should contain DHA and ARA at levels which provide 100 mg DHA/day and 140 mg ARA/day[42,43]

Prebiotics, including HMOs, are critical in immune function development in infants

Infants with FG need additional nutritional support to assist the development of their impaired immune system and circumvent the higher risk of infections. **Prebiotics are substrates which are selectively utilized by host microorganisms thereby conferring a health benefit.**[44]

HMOs

- HMOs are beneficial in preventing bifidobacterial infection, while also promoting gut maturation and strengthening the intestinal barrier in vitro.[41, 45-56]
- HMOs may modulate neonatal immune response development via direct interactions with dendritic cells, affecting immune cell populations and cytokine secretion.[41,57]
- Infant milk formulae supplemented with manufactured HMOs have been reported to shift outcomes towards those observed in breastfed infants, including gut microbiome composition and intestinal immune markers.[58]
- The beneficial effects of HMOs are manifested as a combination of the effects of several oligosachcarides.[59-63]

While there are several prebiotics suitable for use in infant milk, the mixture of scGOS/lcFOS is the most studied (>40 studies; 90 publications)[64-66]

The mixture of scGOS/lcFOS:[64,67-69]

- Reflects the **quantity, diversity,** and **functionality** of oligosaccharides in breast milk
- **Softens the stool**
- **Modulates the gut microbiota** closer to that of breastfed infants
- **Reduces infections** and **fever episodes**

HMOs, human milk oligosaccharide; scGOS/lcFOS, short-chain galacto-oligosaccharide/long-chain fructo-oligosaccharide.

Micronutrient deficiency may have serious consequences in infant growth and development

Mild or marginal inadequacy of micronutrients is common among infants and may impact their susceptibility to infection, and **impact growth and development.**[70]

Consensus-based recommendations regarding the micronutrient requirements of moderately malnourished children are available, to guide the micronutrient needs of infants in need of nutritional support.[32]

Breastfeeding should be supported in infants with faltering growth, and ENDF provided in those who are formula fed

Expert opinion on nutrition al management in infants with FG recommends that:[1]

- Disease- and non-disease-related FG should be supported by breastfeeding, with fortified infant milk, cup feeding or supplementary formula considered when appropriate.
- Ready-to-use, energy-dense therapeutic feeds with proven efficacy should be used in formula-fed infants, where available. *Otherwise, suitable locally available powdered feeds can be used, provided WHO standards for hygienic mixing are applied.*
- Modular additions of fat or carbohydrates alone to feed/food should be avoided since this would reduce the protein and energy ratio.
- Nutritional management for medical and non-medical FG should include the fortification of accepted foods and/or advice on naturally energy dense and locally available foods.
- Enteral (or tube) feeding should be included if nutritional requirements according to the nutritional management plan cannot be met by oral intake.
- A multidisciplinary nutrition support team should monitor nutritional management to minimize the risk of enteral nutrition-associated complications.
- The nutritional management plan should include a target for appropriate catch-up growth that is monitored at an interval that is deemed appropriate by the healthcare professional, the available healthcare service and the severity of the faltering growth.

Further research is required in improving the understanding of the causes and management of FG and in implementing cost-effective and implementable community interventions to combat FG in under-privileged populations[32]

ENDF, energy-nutrient dense feed.

References

1. Cooke R, et al. J Pediatr Gastroenterol Nutr. 2023 Jul 1;77(1):7-15
2. Mehta NM, et al. and American Society for Parenteral and Enteral Nutrition (ASPEN) Board of Directors. JPEN J Parenter Enteral Nutr. 2013;37:460-81.
3. Miller AN, Naples A. Neoreviews. 2023;24(8):e492-e503.
4. Toole BJ, et al. Congenit Heart Dis. 2014;9:15-25.
5. Diao J, et al. J Pediatr. 2022;242:39-47.e4.
6. Murni IK, et al. PLoS One. 2023;18(2):e0281753.
7. Pawellek I, Dokoupil K, Koletzko B. Clin Nutr 2008; 27: 72-6.
8. Joosten KFM and Hulst JM. Curr Opin Pediatr 2008; 20: 590-6
9. Bélanger V, et al. J Pediatr. 2019;205:160-167.e6
10. Aguilera et al. BMC public health. 2019;19(1):1419.
11. Meyer R, et al. Journal of human nutrition and dietetics. 2019;32(2):175-84.
12. Le TN, et al. Journal of cystic fibrosis. 2019;18 Suppl 2:S82-s7.
13. Capriati T, et al. Expert review of clinical immunology. 2019;15(1):97-104.
14. Marino LV JM, et al. Nutrition C, editor. 2019.
15. Marino LV, et al. Clinical nutrition (Edinburgh, Scotland). 2018;37(4):1430-6.
16. Larson-Nath C, St Clair N, Goday P. Clinical Pediatrics. 2018;57(2):212-219.
17. Larson-Nath C, Goday P. Nutrition in Clinical Practice. 2019. 57(2):212-219.
18. Secker et al. American Journal of Clinical Nutrition 2007 85(4): 1083-1089.
19. Rudolf MC, Logan S. Archives of disease in childhood. 2005;90(9):925-31.
20. World Health O. Global Database on Child Growth and Malnutrition: Child growth indicators and their interpretation. www.who.int/nutgrowthdb/about/introudction/en/index2html. 2012.
21. World Health Organization, UNICEF. WHO child growth standards and the identification of severe acute malnutrition in infants and children. 2009.
22. Fink G, et al. The American journal of clinical nutrition. 2016;104(1):104-12.
23. Crookston BT, et al. The American journal of clinical nutrition. 2013;98(6):1555-63.
24. Kittisakmontri K, Sukhosa O. Clin Nutr ESPEN. 2016;15:38-43.
25. Abdelhadi RA, et al. JPEN J Parenter Enteral Nutr. 2016;40(5):623-35.
26. Freijer K, et al. Clin Nutr. ESPEN 2018;23:228–233.
27. Huysentruyt K, et al. Acta Paediatr. 2013;102(10):e460-6.
28. Gambra-Arzoz M, et al. Nutr Clin Pract. 2020;35(1):157-63.
29. McCarthy A, et al. Nutrients. 2019;11(2):236.
30. Hulst JM, et al. J Pediatr Gastroenterol Nutr. 2022 May 1;74(5):693-70
31. Hulst JM, et al. Curr Opin Clin Nutr Metab Care. 2020 May;23(3):203-9
32. Golden MH. Food Nutr Bull. 2009 Sep;30(3 Suppl):S267-342
33. National Institute for Health and Care Excellence. Faltering growth: recognition and management of faltering growth in children. NICE Guideline, 2017. Available at: https://www.nice.org.uk/guidance/ng75/ resources/faltering-growth-recognition-and-management-of-falteringgrowth-in-children-pdf-1837635907525.
34. National Institute for Health and Care Excellence. Faltering growth overview: recognition and management of faltering growth in children. NICE Pathways bring together everything NICE says on a topic in an interactive flowchart. NICE Pathways are interactive and designed to be used online. Available at: http://pathways.nice.org.uk/pathways/faltering-growth
35. World Health Organization. Protein and amino acid requirements in human nutrition. Report of a Joint WHO/FAO/UNU Expert Consultation. World Health Organ Tech Rep Ser. 2007;(935):1-265.
36. Gould JF, Smithers LG, Makrides M. Am J Clin Nutr. 2013;97:531–44.
37. Janssen CI, Kiliaan AJ. Prog Lipid Res. 2014;53: 1–17.
38. Shulkin M, et al. J Nutr. 2018;148:409-18.
39. Lepping RJ, et al. Dev Psychobiol. 2019;61:5-16.
40. Richard C, Lewis ED, Field CJ. Appl Physiol Nutr Metab. 2016;41:461-75.
41. Vandenplas Y, Ludwig T, Bouritius H, et al. Acta Paediatr. 2017;106(7):1150-1158.
42. EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2013. Scientific opinion on nutrient requirements and dietary intakes of infants and young children in the European Union. EFSA Journal. 2013;11:3408
43. Koletzko B, et al. Ann Nutr Metab. 2014;65:49-80.
44. International Scientific Association for Probiotics and Prebiotics. A roundup of the ISAPP consensus definitions: probiotics, prebiotics, synbiotics, postbiotics and fermented foods. Available at: https://isappscience.org/a-roundup-of-the-isapp-consensus-definitions-probiotics-prebiotics-synbiotics-postbiotics-and-fermented-foods/. Accessed January 2024.
45. Bode L. Glycobiology. 2012;22(9):1147-62.
46. Carr LE, et al, Front Immunol. 2021;12:604080
47. Kostopoulos I, et al, Sci Rep. 2020;10(1):14330
48. Musilova S, et al, Benef Microbes. 2014;5(3):273-83
49. Holscher HD, et al. J Nutr. 2014;144(5):586-91
50. Holscher HD, Bode L, Tappenden KA. J Pediatr Gastroenterol Nutr. 2017;64(2):296-301.
51. Kuntz S, et al, Br J Nutr. 2008;99(3):462-71
52. Perdijk O, et al, Front Immunol. 2019;10:94.
53. Cheng L, et al, Mol Nutr Food Res. 2020;64(5):e1900976.
54. Natividad JM, et al, Nutrients. 2020;12(10):3047
55. Varasteh S, et al, J Pediatr Gastroenterol Nutr. 2019;68(S1):N-P-016
56. Wu RY, et al, Mol Nutr Food Res. 2019;63(3):e1800658
57. Xiao L, Leusink-Muis T, Kettelarij N, et al. Front Immunol. 2018;9:452
58. Schönknecht YB, et al. Nutrients. 2023; 15(16):3622
59. Boehm G, Moro G. J Nutr. 2008;138(9):1818S–1828S
60. Scholtens PA, et al, World J Gastroenterol. 2014;20(37):13446-52
61. Miqdady M, et al, Pediatr Gastroenterol Hepatol Nutr. 2020; 23(1):1-14
62. Moro G, Boehm G. Funct Food Rev. 2012;4:101–13
63. Salminen S, et al, Nutrients. 2020;12(7):1952
64. Salminen S, Szajewska H, Knol J, Eds. The Biotics Family in Early Life. Chichester, UK: John Wiley and Sons Ltd, 2019
65. Patel RM, Denning PW. Clin Perinatol. 2013;40:11-25.
66. Boehm G, Stahl B, Jelinek J, et al. Acta Paediatr Suppl. 2005;94:18-21.67. Joint FAO/WHO Expert Consultation on Evaluation of Health and Nutritional Properties of Probiotics in Food including Powder Milk with Live Lactic Acid Bacteria. Cordoba, Argentina. 1–4 October 2001
68. Ayechu-Muruzabal V, van Stigt AH, Mank M, et al. Front Pediatr. 2018;6:239.
69. Fanaro S, Jelinek J, Stahl B, et al. J Pediatr Gastroenterol Nutr. 2005;41:186-90
70. Bender DA. J R Soc Health. 2003;123:154-8.

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