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# Oral Bacterial Therapy Reduces the Duration of Symptoms and of Viral Excretion in Children with Mild Diarrhea

**Guarino, Alfredo; Canani, Roberto Berni; Spagnuolo, Maria Immacolata; Albano, Fabio; Di Benedetto, Linda**

**Author Information**

*Department of Pediatrics, University Federico II of Naples, Italy*

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Address correspondence and reprint requests to Dr. A. Guarino, Department of Pediatrics, University Federico II, Via S. Pansini, 5-80131 Naples, Italy.

**Abstract**

Background: Oral administration of live *Lactobacillus casei* strain *GG* is associated with the reduction of duration of diarrhea in children admitted to the hospital because of diarrhea. The purposes of this work were to investigate the clinical efficacy of oral administration of *Lactobacillus* in children with mild diarrhea who were observed as outpatients, and to see whether *Lactobacillus GG* can reduce the duration of rotavirus excretion.

Methods: Duration of diarrhea was recorded in 100 children seen by family pediatricians and randomly assigned to receive oral rehydration or oral rehydration followed by the administration of lyophilized *Lactobacillus casei,* strain *GG*. Rotavirus was looked for in the stools of all children and, in those in whom results were positive, stools were examined again 6 days after the onset of diarrhea.

Results: In 61 children results were positive for rotavirus and in 39 results were negative. Duration of diarrhea was reduced from 6 to 3 days in children receiving *Lactobacillus GG,* with a similar pattern in rotavirus-positive and -negative children. Six days after the onset of diarrhea, stools in only 4 out of 31 children that received *Lactobacillus GG* were positive for rotavirus compared with positive findings in 25 out of 30 control subjects.

Conclusions: Oral administration of *Lactobacillus GG* is effective in rotavirus-positive and rotavirus-negative ambulatory children with diarrhea. Furthermore, it reduces the duration of rotavirus excretion.

Diarrhea is still a major problem in industrialized countries with 21 to 37 million diarrheal episodes occurring in the United States in 16.5 million children annually. The vast majority of these cases are mild and selflimiting, but 2.1 to 3.7 million lead to a physician's office visit and 200,000 required hospital admission. A similar epidemiologic pattern applies to European countries [1,2].

Rotavirus is the most common agent of infantile gastroenteritis worldwide. No specific therapy is available for rotavirus, and treatment is limited to rehydration. However, we have reported that oral administration of human serum immunoglobulin to children admitted because of rotavirus-induced diarrhea reduced the duration and severity of symptoms, the duration of viral excretion, and the length of hospital stay [3,4].

An alternative therapeutic approach, based on oral administration of live bacteria is currently under active investigation [5]. Isolauri et al. have shown that oral bacterial therapy with *Lactobacillus casei* strain *GG* promotes clinical recovery from rotavirus gastroenteritis in hospitalized children [6]. Oral bacterial therapy also reduced the stool frequency in Pakistani children with acute nonbloody diarrhea in whom rotavirus accounted for 20% of cases. However, the total duration of diarrhea was not reported in the results of that study nor were the other causes indicated [7].

Several clinical studies on the efficacy of *Lactobacillus* were conducted in children admitted to hospitals because of diarrhea [6-11]. Whether such treatment would be effective also in ambulatory children, who are less severely ill and are under observation as outpatients, is presently unknown.

This is an important matter, because it is obvious that the number of children seen in primary care or as outpatients greatly exceeds the number of inpatients. Therefore, a prospective study was conducted, in collaboration with family pediatricians, to evaluate the clinical efficacy of oral bacterial therapy in children with acute gastroenteritis, and to establish whether oral bacterial therapy reduced viral excretion.

## PATIENTS AND METHODS

All children, between 3 and 36 months old, consecutively seen by three family pediatricians (AF, MIS, RBC) because of diarrhea in the period from November 1995 to January 1996, were enrolled in the study and randomly assigned to receive oral rehydration alone or oral rehydration therapy followed by oral bacterial therapy. The treatment was allocated by odds-on pairing from a random-number table. Informed consent was obtained from the parents of the children enrolled.

The bacterial preparation consisted of lyophilized *Lactobacillus casei* strain *GG* ($3 \times 10^9$ CFU; Dicoflor 30, Dicofarm SpA; Rome, Italy), which was resuspended in 200 ml of milk or formula, according to the manufacturer's instructions. The solution was given twice a day for a maximum of 5 days, starting after 6 hours of oral rehydration with a 60-mmol Na

concentration in solution. This was offered ad libitum to patients until recovery from diarrhea was achieved. Full, age-appropriate feeding was reintroduced soon after initial rehydration [12]. Diarrhea was defined as three or more watery stools per day.

Exclusion criteria were the administration of antibiotics in the previous 3 weeks, the onset of diarrhea more than 48 hours before the visit, breast-feeding, and a weight:height ratio below the fifth percentile.

Recovery from diarrhea was defined as the time since the last loose or liquid stools. The outcome of diarrhea was evaluated by the mothers of enrolled children, who had been appropriately instructed, and it was checked daily by telephone calls.

An enzyme-linked immunosorbent assay (Rotazyme II, Abbott Laboratories; Rome, Italy) was used to detect rotavirus in stools collected at the first visit and 6 days after the onset of diarrhea. This test was done because children with untreated rotavirus gastroenteritis excrete the virus for a mean of 7 days after the onset of diarrhea [4].

### Statistical Analysis

An analysis of variance was used to evaluate inter-group differences. Duration of diarrhea was expressed as mean ± standard deviation. The *t*-test and the chi-square test were applied where appropriate.

## RESULTS

A total of 100 children were enrolled in the study. All patients had mild to moderate dehydration. Forty-eight received oral rehydration therapy only and 52 received oral rehydration therapy and oral bacterial therapy. All children were fed again with full-strength, lactose-containing formula or milk, given soon after completion of rehydration, which usually lasted 6 to 8 hours. The two groups were similar in sex, age, and body weight. The duration of diarrhea before enrollment was also similar (Table 1). All children were well nourished and in no case was a risk factor for chronic diarrhea recorded.

Table 1

Diarrheal duration was reduced by approximately 50% ($p < 0.01$) in children receiving oral bacterial therapy compared with control subjects (Fig. 1).

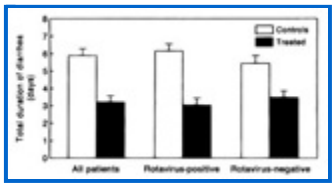


Fig. 1

Both control and treated children were divided into two groups, according to the presence or absence of rotavirus. In each group, the features of children receiving oral bacterial therapy,

as well as the duration of diarrhea at enrollment, were similar to the features and duration in control subjects (Table 1).

Within each group, the administration of oral bacterial therapy as an adjunct to rehydration was associated with a significant reduction of the duration of diarrhea compared with untreated control subjects (Fig. 1). The efficacy of *Lactobacillus GG* was slightly, though not significantly, greater in rotavirus-positive children than in those who were rotavirus-negative.

Finally, the number of children who were excreting the virus 6 days after the onset of diarrhea was significantly ($p < 0.01$) reduced in the treated group compared with the number in the control group (Fig. 2).

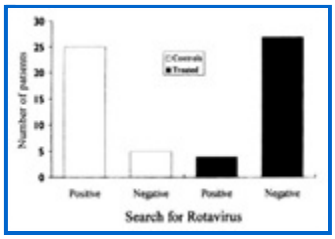

Fig. 2

## DISCUSSION

Previous studies reporting the efficacy of *Lactobacillus GG,* included only hospitalized children [6-8], a population that represents only a minority of children with viral gastroenteritis, in that most children need only ambulatory care [1,2].

The results in this study show that oral administration of *Lactobacillus GG* is effective in reducing the duration of symptoms in well-nourished infants and children affected by mild diarrhea-the ones that are more commonly seen by primary pediatricians.

*Lactobacillus GG* was effective both in children with rotavirus gastroenteritis and in those whose fecal samples were negative for rotavirus. Cultures were not performed, thus we do not know the cause of the diarrhea in rotavirus-negative children. However, this finding suggests that the effect of oral bacterial therapy is not limited to rotavirus-induced diarrhea.

We also provide the first evidence that *Lactobacillus GG* administration is associated with a significant reduction of viral excretion. This finding is in agreement with the observed reduction of diarrhea and suggests that oral bacterial therapy may also inhibit spread of the disease in day care and health care centers. This finding has relevance in light of the major role of rotavirus as the agent of nosocomial infections [13].

We have recently shown that the efficacy of immunoglobulin against rotavirus is related to a direct neutralization of the virus [14]. A similar mechanism could explain the efficacy of oral bacterial therapy, inasmuch as it has been suggested that the efficacy of *Lactobacillus GG* administration may be related to an enhancement of the immune response against rotavirus [15]. Stimulation of immune response may be a nonspecific mechanism and could explain the efficacy of bacterial therapy observed in children with rotavirus-negative diarrhea. Alternatively, the efficacy of *Lactobacillus GG* in children without rotavirus could be related

to an antimicrobial substance produced by *Lactobacillus GG* that inhibits the growth of Gram-negative and Gram-positive bacteria [(16)].

In the light of the relatively low cost (10 U.S. dollars per child) and of its proven efficacy, oral bacterial therapy, given as an adjunct to oral rehydration, may have a great impact on infantile gastroenteritis both in terms of health care and of its economic consequences. Finally, it would be useful to compare the efficacy of oral bacterial therapy with that of passive immunotherapy in children admitted to hospitals with viral diarrhea.

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**REFERENCES**

1. Haffejee IE. The epidemiology of rotavirus infections: A global prospective. *J Pediatr Gastroenterol Nutr* 1995;20:275-86.

2. Glass RI, Lew JF, Gangarosa RE, LeBaron CW, Ho MS. Estimates of morbidity and mortality rates for diarrheal diseases in American children. *J Pediatr* 1991;118:S27-S33.

3. Guarino A, Guandalini S, Albano F, et al. Enteral immunoglobulins for treatment of protracted rotaviral diarrhea. *Pediatr Infect Dis J* 1991;10:612-4.

4. Guarino A, Berni Canani R, Russo S, et al. Oral immunoglobulins for treatment of acute rotaviral gastroenteritis. *Pediatrics* 1994;93:12-6.

5. Roffe C. Biotherapy for antibiotic-associated and other diarrhoeas. *J Infect* 1996;32:1-10.

6. Isolauri E, Juntunen M, Rautanen T, Sillanaukee P, Koivula T. A human *Lactobacillus* strain (*Lactobacillus casei* sp strain GG) promotes recovery from acute diarrhea in children. *Pediatrics* 1991;88:90-7.

7. Raza S, Graham M, Allen J, Sultana S, Cuevas L, Hart CA. *Lactobacillus GG* promotes recovery from acute nonbloody diarrhea in Pakistan. *Pediatr Infect Dis J* 1995;14:107-11.

8. Isolauri E, Kaila M, Mykkanen H, Ling WH, Salminen S. Oral bacteriotherapy for viral gastroenteritis. *Dig Dis Sci* 1994;39:2595-600.

9. Kaila M, Isolauri E, Saxelin M, Arvilommi H, Vesikari T. Viable versus inactivated *Lactobacillus* strain *GG* in acute rotavirus diarrhoea. *Arch Dis Child* 1995;72:51-3.

10. Majamaa H, Isolauri E, Saxelin M, Vesikari T. Lactic acid bacteria in the treatment of acute rotavirus gastroenteritis. *J Pediatr Gastroenterol Nutr* 1995;20:333-8.

11. Pant AR, Graham SM, Allen SJ, et al. *Lactobacillus GG* and acute diarrhoea in young children in the tropics. *J Trop Pediatr* 1996;42:162-5.

12. Sandhu BK. Early re-feeding in the management of acute diarrhoea. *Acta Paediatr* 1995;84:986-7.

13. Anglim AM, Schaffner W, Farr BM. Prevention and control of nosocomial enteric infections. In: Blaser MJ, Smith PD, Ravdin JI, Greenberg HB, Guerrant RL, eds. *Infections of the Gastrointestinal Tract*. New York: Raven Press, 1995:1525-45.

14. Guarino A, Casola A, Bruzzese E, Saini M, Nitsch L, Rubino A. Human serum immunoglobulin counteract rotaviral infection in Caco-2 cells. *Pediatr Res* 1996;40:881-7.

15. Kaila M, Isolauri E, Soppi E, Virtanen E, Laine S, Arvilommi H. Enhancement of the circulating antibody secreting-cell response in human diarrhea by a human *Lactobacillus* strain. *Pediatr Res* 1992;32:141-4.

16. Silva M, Jacobus NV, Deneke C, Gorbach SL. Antimicrobial substance from a human *Lactobacillus* strain. *Antimicrob Agents Che-mother* 1987;31:1231-3.

**Cited By:**

This article has been cited **121** time(s).

Acta Paediatrica
Guidelines for the approach to outpatient children with acute diarrhoea
Guarino, A; Albano, F
Acta Paediatrica, 90(): 1087-1095.

Gut
A prospective randomised study of the probiotic Lactobacillus plantarum 299V on indices of gut barrier function in elective surgical patients
McNaught, CE; Woodcock, NP; MacFie, J; Mitchell, CJ
Gut, 51(6): 827-831.

Hiv Clinical Trials
The efficacy and safety of probiotic Lactobacillus rhamnosus GG on prolonged, noninfectious diarrhea in HIV patients on antiretroviral therapy: A randomized, placebo-controlled, crossover study
Salminen, MK; Tynkkynen, S; Rautelin, H; Poussa, T; Saxelin, M; Ristola, M; Valtonen, V; Jarvinen, A
Hiv Clinical Trials, 5(4): 183-191.

Journal of Veterinary Internal Medicine
Lactobacillus GG does not affect D-lactic acidosis in diarrheic calves, in a clinical setting
Ewaschuk, JB; Zello, GA; Naylor, JA
Journal of Veterinary Internal Medicine, 20(3): 614-619.

Alimentary Pharmacology & Therapeutics
Meta-analysis: Lactobacillus GG for treating acute diarrhoea in children
Szajewska, H; Skorka, A; Ruszczynski, M; Gieruszczak-Bialek, D
Alimentary Pharmacology & Therapeutics, 25(8): 871-881.

10.1111/j.1365-2036.2007.03282.x
CrossRef
American Journal of Clinical Nutrition
Effects of probiotic bacteria on diarrhea, lipid metabolism, and carcinogenesis: a review of papers published between 1988 and 1998
de Roos, NM; Katan, MB
American Journal of Clinical Nutrition, 71(2): 405-411.

Nutrition Research
Probiotics in clinical practice: a critical review of the evidence
McNaught, CE; MacFie, J
Nutrition Research, 21(): 343-353.

Digestive and Liver Disease
New therapeutic approach in the management of intestinal disease: probiotics in intestinal disease in paediatric age
Cucchiara, S; Falconieri, P; Di Nardo, G; Porcelli, MA; Dito, L; Grandinetti, A
Digestive and Liver Disease, 34(): S44-S47.

Nature Reviews Immunology
Complementary and alternative medicine: assessing the evidence for immunological benefits
Goldrosen, MH; Straus, SE
Nature Reviews Immunology, 4(): 912-921.
10.1038/nri1486
CrossRef
Clinical Microbiology and Infection
Probiotics: facts and myths
Senok, AC; Ismaeel, AY; Botta, GA
Clinical Microbiology and Infection, 11(): 958-966.
10.1111/j.1469-0691.2005.01228.x
CrossRef
Fems Microbiology Ecology
Pattern extraction of structural responses of gut microbiota to rotavirus infection via multivariate statistical analysis of clone library data
Zhang, ML; Zhang, MH; Zhang, CH; Du, HM; Wei, GF; Pang, XY; Zhou, HK; Liu, BB; Zhao, LP
Fems Microbiology Ecology, 70(2): 177-185.
10.1111/j.1574-6941.2009.00694.x
CrossRef
Scandinavian Journal of Gastroenterology
Probiotics in gastroenterology: Indications and future perspectives
Goossens, D; Jonkers, D; Stobberingh, E; van den Bogaard, A; Russel, M; Stockbrugger, R
Scandinavian Journal of Gastroenterology, 38(): 15-23.
10.1080/00855920310002645
CrossRef
Kidney International
Use of a probiotic to decrease enteric hyperoxaluria
Lieske, JC; Goldfarb, DS; De Simone, C; Regnier, C
Kidney International, 68(3): 1244-1249.

Clinical Infectious Diseases
The safety of probiotics
Snydman, DR
Clinical Infectious Diseases, 46(): S104-S111.
10.1086/523331
CrossRef
Alimentary Pharmacology & Therapeutics
Review article: probiotics in gastrointestinal and liver diseases
Jonkers, D; Stockbrugger, R
Alimentary Pharmacology & Therapeutics, 26(): 133-148.
10.1111/j.1365-2036.2007.03480.x
CrossRef
Current Pharmaceutical Design
Probiotics, Immune Function, Infection and Inflammation: A Review of the Evidence from Studies Conducted in Humans
Lomax, AR; Calder, PC
Current Pharmaceutical Design, 15(): 1428-1518.

European Journal of Clinical Nutrition
Lactic acid bacteria and the human gastrointestinal tract
Hove, H; Norgaard, H; Mortensen, PB
European Journal of Clinical Nutrition, 53(5): 339-350.

Journal of Applied Poultry Research
Digestive physiology and the role of microorganisms
Tellez, G; Higgins, SE; Donoghue, AM; Hargis, BM
Journal of Applied Poultry Research, 15(1): 136-144.

Viral Immunology
Porcine Small Intestinal Epithelial Cell Line (IPEC-J2) of Rotavirus Infection As a New Model for the Study of Innate Immune Responses to Rotaviruses and Probiotics
Liu, FN; Li, GH; Wen, K; Bui, T; Cao, DJ; Zhang, YM; Yuan, LJ
Viral Immunology, 23(2): 135-149.
10.1089/vim.2009.0088
CrossRef
Current Opinion in Biotechnology
Interaction of probiotics and pathogens-benefits to human health?
Salminen, S; Nybom, S; Meriluoto, J; Collado, MC; Vesterlund, S; El-Nezami, H
Current Opinion in Biotechnology, 21(2): 157-167.
10.1016/j.copbio.2010.03.016
CrossRef
International Dairy Journal
Clinical applications of probiotic bacteria
Salminen, S; Ouwehand, AC; Isolauri, E
International Dairy Journal, 8(): 563-572.

Clinical and Diagnostic Laboratory Immunology
Adherence of probiotic bacteria to human intestinal mucus in healthy infants and during rotavirus infection
Juntunen, M; Kirjavainen, PV; Ouwehand, AC; Salminen, SJ; Isolauri, E

Clinical and Diagnostic Laboratory Immunology, 8(2): 293-296.

Seminars in Fetal & Neonatal Medicine
Potential uses of probiotics in the neonate
Rautava, S
Seminars in Fetal & Neonatal Medicine, 12(1): 45-53.
10.1016/j.siny.2006.10.006
CrossRef
Food Research International
Trends in non-dairy probiotic beverages
Prado, FC; Parada, JL; Pandey, A; Soccol, CR
Food Research International, 41(2): 111-123.
10.1016/j.foodres.2007.10.010
CrossRef
Indian Journal of Pediatrics
Randomized double blinded controlled trial to evaluate the efficacy and safety of Bifilac in patients with acute viral diarrhea
Narayanappa, D
Indian Journal of Pediatrics, 75(7): 709-713.

Journal of Tropical Pediatrics
Dose-dependent effect of Lactobacillus rhamnosus on quantitative reduction of faecal rotavirus shedding in children
Fang, SB; Lee, HC; Hu, JJ; Hou, SY; Liu, HL; Fang, HW
Journal of Tropical Pediatrics, 55(5): 297-301.
10.1093/tropej/fmp001
CrossRef
Journal of Food Science
Manufacture of fermented lactic beverages containing probiotic cultures
Oliveira, MN; Sodini, I; Remeuf, F; Tissier, JP; Corrieu, G
Journal of Food Science, 67(6): 2336-2341.

Nutrition
Probiotics and zinc in acute infectious gastroenteritis in children: are they effective?
Salvatore, S; Hauser, B; Devreker, T; Vieira, MC; Luini, C; Arrigo, S; Nespoli, L; Vandenplas, Y
Nutrition, 23(6): 498-506.
10.1016/j.nut.2007.03.008
CrossRef
Agro Food Industry Hi-Tech
From gut to urogenital tract - Probiotic-microbes descending and ascending
Anukam, KC
Agro Food Industry Hi-Tech, 18(2): 10-13.

International Journal of Food Microbiology
Effects of different probiotic strains of Lactobacillus and Bifidobacterium on bacterial translocation and liver injury in an acute liver injury model
Adawi, D; Ahrne, S; Molin, G
International Journal of Food Microbiology, 70(3): 213-220.

Bioactive Components of Human Milk
Biotherapeutic agents and disease in infants
Pickering, LK
Bioactive Components of Human Milk, 501(): 365-373.

Digestive Diseases and Sciences
Efficacy of probiotic use in acute diarrhea in children - A meta-analysis
Huang, JS; Bousvaros, A; Lee, JW; Diaz, A; Davidson, EJ
Digestive Diseases and Sciences, 47(): 2625-2634.

Journal of Applied Microbiology
Antimicrobial potential of four Lactobacillus strains isolated from breast milk
Olivares, M; Diaz-Ropero, MP; Martin, R; Rodriguez, M; Xaus, J
Journal of Applied Microbiology, 101(1): 72-79.
10.1111/j.1365-2672.2006.02981.x
CrossRef
Clinical Pediatrics
Parental Management of Childhood Diarrhea
Li, STT; Klein, EJ; Tarr, PI; Denno, DM
Clinical Pediatrics, 48(3): 295-303.
10.1177/0009922808327057
CrossRef
Pediatric Surgery International
Evaluation of probiotic treatment in a neonatal animal model
Lee, DJ; Drongowski, RA; Coran, AG; Harmon, CM
Pediatric Surgery International, 16(4): 237-242.

Journal of Pediatrics
Efficacy of Lactobacillus GG in prevention of nosocomial diarrhea in infants
Szajewska, H; Kotowska, M; Mrukowicz, JZ; Armanska, M; Mikolajczyk, W
Journal of Pediatrics, 138(3): 361-365.
10.1067/mpd.2001.111321
CrossRef
Clinical Infectious Diseases
Probiotic agents and infectious diseases: A modern perspective on a traditional therapy
Alvarez-Olmos, MI; Oberhelman, RA
Clinical Infectious Diseases, 32(): 1567-1576.

Australian Journal of Dairy Technology
Probiotic health benefits - reality or myth?
Stanton, C; Desmond, C; Fitzgerald, G; Ross, RP
Australian Journal of Dairy Technology, 58(2): 107-113.

Clinical Microbiology Reviews
Potential uses of Probiotics in clinical practice
Reid, G; Jass, J; Sebulsky, MT; McCormick, JK
Clinical Microbiology Reviews, 16(4): 658-+.
10.1128/CMR.16.4.658-672.2003
CrossRef

World Journal of Gastroenterology
Do probiotics have a therapeutic role in gastroenterology?
Limdi, JK; O'Neill, C; McLaughlin, J
World Journal of Gastroenterology, 12(): 5447-5457.

Expert Opinion on Pharmacotherapy
Acute infectious pediatric gastroenteritis: beyond oral rehydration therapy
Freedman, SB
Expert Opinion on Pharmacotherapy, 8(): 1651-1665.
10.1517/14656566.8.11.1651
CrossRef
British Medical Journal
Probiotics for treatment of acute diarrhoea in children: randomised clinical trial of five different preparations
Canani, RB; Cirillo, P; Terrin, G; Cesarano, L; Spagnuolo, MI; De Vincenzo, A; Albano, F; Passariello, A; De Marco, G; Manguso, F; Guarino, A
British Medical Journal, 335(): 340-+.
10.1136/bmj.39272.581736.55
CrossRef
Clinical Infectious Diseases
Probiotics in the United States
Vanderhoof, JA; Young, R
Clinical Infectious Diseases, 46(): S67-S72.
10.1086/523339
CrossRef
Journal of International Medical Research
Probiotics in clinical practice: An overview
Zuccotti, GV; Meneghin, F; Raimondo, C; Dilillo, D; Agostoni, C; Riva, E; Giovannini, M
Journal of International Medical Research, 36(): 1A-53A.

Periodontology 2000
Probiotics and oral healthcare
Teughels, W; Van Essche, M; Sliepen, I; Quirynen, M
Periodontology 2000, 48(): 111-147.

Clinical Pediatrics
Considerations in assessing the clinical course and severity of rotavirus gastroenteritis
D'Agostino, J
Clinical Pediatrics, 45(3): 203-212.

Agro Food Industry Hi-Tech
Strain-specific effects of probiotic bacteria
Herzog, A; Henriksson, A
Agro Food Industry Hi-Tech, 16(4): 9-11.

American Journal of Physiology-Gastrointestinal and Liver Physiology
Probiotics inhibit enteropathogenic E-coli adherence in vitro by inducing intestinal mucin gene expression
Mack, DR; Michail, S; Wei, S; McDougall, L; Hollingsworth, MA

American Journal of Physiology-Gastrointestinal and Liver Physiology, 276(4): G941-G950.

Environmental Microbiology
Probiotics - snake oil for the new millennium?
Atlas, RM
Environmental Microbiology, 1(5): 377-382.

Thorax
Pro and anti: The biotics of allergic disease
Crane, J
Thorax, 57(): 40-46.

Journal of Medicinal Food
African Traditional Fermented Foods and Probiotics
Anukam, KC; Reid, G
Journal of Medicinal Food, 12(6): 1177-1184.
10.1089/jmf.2008.0163
CrossRef
Applied and Environmental Microbiology
Increased enterocyte production in gnotobiotic rats mono-associated with Lactobacillus rhamnosus GG
Banasaz, M; Norin, E; Holma, R; Midtvedt, T
Applied and Environmental Microbiology, 68(6): 3031-3034.
10.1128/AEM.68.6.3031-3034.2002
CrossRef
British Journal of Nutrition
Human studies with probiotics and prebiotics: clinical implications
Saavedra, JM; Tschernia, A
British Journal of Nutrition, 87(): S241-S246.
10.1079/BJN/2002543
CrossRef
Journal of Paediatrics and Child Health
Use of complementary and alternative therapies and probiotic agents by children attending gastroenterology outpatient clinics
Day, AS
Journal of Paediatrics and Child Health, 38(4): 343-346.

Journal of Chemotherapy
Acid tolerance and fecal recovery following oral administration of Saccharomyces cerevisiae
Scevola, D; Perversi, L; Cavanna, C; Candiani, C; Uberti, F; Castiglioni, B; Marone, P
Journal of Chemotherapy, 15(2): 143-147.

Idrugs
Microecology as a target for therapeutic intervention in inflammatory bowel disease
Guarner, F
Idrugs, 6(9): 868-873.

Fems Microbiology Reviews
Antagonistic activities of lactobacilli and bifidobacteria against microbial pathogens
Servin, AL

Fems Microbiology Reviews, 28(4): 405-440.
10.1016/j.femsre.2004.01.003
CrossRef
Gastroenterology Clinics of North America
Use of probiotics in humans: An analysis of the literature
Floch, MH; Montrose, DC
Gastroenterology Clinics of North America, 34(3): 547-+.
10.1016/j.gtc.2005.05.004
CrossRef
Proceedings of the Nutrition Society
Probiotics and prebiotics in infant nutrition
Parracho, H; McCartney, AL; Gibson, GR
Proceedings of the Nutrition Society, 66(3): 405-411.
10.1017/S0029665107005678
CrossRef
Acta Alimentaria
Adhesion of lactic acid bacteria to Caco-2 cells - evaluation of different detection methods
Szeker, K; Nemeth, E; Kun, S; Beczner, J; Galfi, P
Acta Alimentaria, 36(3): 365-371.
10.1556/AAlim.36.2007.3.8
CrossRef
Journal of Nutrition
Generic and product-specific health claim processes for functional foods across global jurisdictions
Jew, S; Vanstone, CA; Antoine, JM; Jones, PJH
Journal of Nutrition, 138(6): 1228S-1236S.

Nutrition
Use of fermented foods to combat stunting and failure to thrive
Saran, S; Gopalan, S; Krishna, TP
Nutrition, 18(5): 393-396.
PII S0899-9007(01)00790-0
CrossRef
Archives of Disease in Childhood
Micronutrients (including zinc) reduce diarrhoea in children: The Pakistan sprinkles diarrhoea study
Sharieff, W; Bhutta, Z; Schauer, C; Tomlinson, G; Zlotkin, S
Archives of Disease in Childhood, 91(7): 573-579.
10.1136/adc.2005.086199
CrossRef
Nutrition in Clinical Practice
Clinical Use of Probiotics in the Pediatric Population
Wallace, B
Nutrition in Clinical Practice, 24(1): 50-59.
10.1177/0884533608329298
CrossRef
Current Pharmaceutical Design
Probiotics as biotherapeutic agents: Present knowledge and future prospects
Mercenier, A; Pavan, S; Pot, B

Current Pharmaceutical Design, 9(2): 175-191.

Journal of Korean Medical Science
The Effect of Lactic Acid Bacteria Isolates on the Urinary Tract Pathogens to Infants In Vitro
Lim, IS; Lee, HS; Kim, WY
Journal of Korean Medical Science, 24(): S57-S62.
10.3346/jkms.2009.24.S1.S57
CrossRef
Archives of Disease in Childhood
Management of acute diarrhoea with low osmolarity oral rehydration solutions and Lactobacillus strain GG
Rautanen, T; Isolauri, E; Salo, E; Vesikari, T
Archives of Disease in Childhood, 79(2): 157-160.

American Journal of Clinical Nutrition
Market potential for probiotics
Stanton, C; Gardiner, G; Meehan, H; Collins, K; Fitzgerald, G; Lynch, PB; Ross, RP
American Journal of Clinical Nutrition, 73(2): 476S-483S.

Gastroenterology Clinics of North America
Viral causes of diarrhea
Goodgame, RW
Gastroenterology Clinics of North America, 30(3): 779-+.

Pediatrics
Lactobacillus therapy for acute infectious diarrhea in children: A meta-analysis
Van Niel, CW; Feudtner, C; Garrison, MM; Christakis, DA
Pediatrics, 109(4): 678-684.

Gut
Probiotics: a role in the treatment of intestinal infection and inflammation?
Isolauri, E; Kirjavainen, PV; Salminen, S
Gut, 50(): 54-59.

Veterinary Research
Health effects of lactic acid bacteria ingested in fermented milk
Drouault, S; Corthier, G
Veterinary Research, 32(2): 101-117.

American Journal of Clinical Nutrition
Clinical applications of probiotic agents
Saavedra, JM
American Journal of Clinical Nutrition, 73(6): 1147S-1151S.

Nutrition Research
Effect of Lactobacillus on the incidence and severity of acute rotavirus diarrhoea in infants. A prospective placebo-controlled double-blind study
Chandra, RK
Nutrition Research, 22(): 65-69.

International Journal of Food Microbiology
Gut bacteria and health foods - the European perspective
Saarela, M; Lahteenmaki, L; Crittenden, R; Salminen, S; Mattila-Sandholm, T
International Journal of Food Microbiology, 78(): 99-117.
PII S0168-1605(02)00235-0
CrossRef
Alimentary Pharmacology & Therapeutics
Intestinal inflammation is a frequent feature of cystic fibrosis and is reduced by probiotic administration
Bruzzese, E; Raia, V; Gaudiello, G; Polito, G; Buccigrossi, V; Formicola, V; Guarino, A
Alimentary Pharmacology & Therapeutics, 20(7): 813-819.
10.1111/j.1365-2036.2004.02174.x
CrossRef
Chest
Probiotics for preventing and treating nosocomial infections - Review of current evidence and recommendations
Isakow, W; Morrow, LE; Kollef, MH
Chest, 132(1): 286-294.
10.1378/chest.06-2156
CrossRef
Pediatrics International
Lactobacillus casei rhamnosus Lcr35 in children with chronic constipation
Bu, LN; Chang, MH; Ni, YH; Chen, HL; Cheng, CC
Pediatrics International, 49(4): 485-490.
10.1111/j.1442-200X.2007.02397.x
CrossRef
Explore-the Journal of Science and Healing
Probiotics in Pediatric Care
Sethi, T
Explore-the Journal of Science and Healing, 5(4): 245-249.

Pediatrics International
Development of antirotavirus agents in Asia
Gu, YH; Gu, QJ; Kodama, H; Mueller, WE; Ushijima, H
Pediatrics International, 42(4): 440-447.

Current Opinion in Gastroenterology
Viral infections of the gastrointestinal tract
Shaw, RD
Current Opinion in Gastroenterology, 15(1): 53-58.

Pharmacotherapy
Rotavirus disease and its prevention in infants and children
Raebel, MA; Ou, BS
Pharmacotherapy, 19(): 1279-1295.

International Journal of Food Microbiology
Spontaneously fermented millet product as a natural probiotic treatment for diarrhoea in young children: An intervention study in Northern Ghana
Lei, V; Friis, H; Michaelsen, KF

International Journal of Food Microbiology, 110(3): 246-253.
10.1016/j.ijfoodmicro.2006.04.022
CrossRef
British Food Journal
Probiotic therapy for gastro-intestinal allergenic infants - A preliminary review
Sarkar, S
British Food Journal, 109(6): 481-492.
10.1108/00070700710753535
CrossRef
Expert Review of Anti-Infective Therapy
Probiotics: overview of microbiological immunological and characteristics
Blandino, G; Fazio, D; Di Marco, R
Expert Review of Anti-Infective Therapy, 6(4): 497-508.

American Journal of Clinical Nutrition
Protection from gastrointestinal diseases with the use of probiotics
Marteau, PR; de Vrese, M; Cellier, CJ; Schrezenmeir, J
American Journal of Clinical Nutrition, 73(2): 430S-436S.

Inflammation
Induction of nitric oxide synthesis by probiotic Lactobacillus rhamnosus GG in J774 macrophages and human T84 intestinal epithelial cells
Korhonen, R; Korpela, R; Saxelin, M; Maki, M; Kankaanranta, H; Moilanen, E
Inflammation, 25(4): 223-232.

International Dairy Journal
Effect of milk supplementation and culture composition on acidification, textural properties and microbiological stability of fermented milks containing probiotic bacteria
Oliveira, MN; Sodini, I; Remeuf, F; Corrieu, G
International Dairy Journal, 11(): 935-942.

Current Pharmaceutical Design
The importance of guidelines in the development and application of probiotics
Reid, G
Current Pharmaceutical Design, 11(1): 11-16.

European Journal of Pediatrics
Probiotics in infectious diarrhoea in children: are they indicated?
Vandenplas, Y; Salvatore, S; Viera, M; Devreker, T; Hauser, B
European Journal of Pediatrics, 166(): 1211-1218.
10.1007/s00431-007-0497-9
CrossRef
Critical Reviews in Food Science and Nutrition
Probiotic spectra of lactic acid bacteria (LAB)
Naidu, AS; Bidlack, WR; Clemens, RA
Critical Reviews in Food Science and Nutrition, 39(1): 13-126.

Current Pharmaceutical Design
Probiotics in intestinal and non-intestinal infectious diseases - Clinical evidence
Hatakka, K; Saxelin, M

Current Pharmaceutical Design, 14(): 1351-1367.

Clinical Pediatrics
Growth and Tolerance of Healthy Term Infants Receiving Hydrolyzed Infant Formulas Supplemented With Lactobacillus rhamnosus GG: Randomized, Double-Blind, Controlled Trial
Scalabrin, DM; Johnston, WH; Hoffman, DR; P'Pool, VL; Harris, CL; Mitmesser, SH
Clinical Pediatrics, 48(7): 734-744.
10.1177/0009922809332682
CrossRef
Rivista Italiana Di Pediatria-Italian Journal of Pediatrics
Immunization against rotavirus - A valuable option at the end of the era of obligatory immunizations
Guarino, A
Rivista Italiana Di Pediatria-Italian Journal of Pediatrics, 24(6): 1035-1038.

American Journal of Gastroenterology
Probiotics and infectious diarrhea
Saavedra, J
American Journal of Gastroenterology, 95(1): S16-S18.

International Journal of Clinical Practice
Multicentric study of the effect of milk fermented by Lactobacillus casei on the incidence of diarrhoea
Pedone, CA; Arnaud, CC; Postaire, ER; Bouley, CF; Reinert, P
International Journal of Clinical Practice, 54(9): 568-571.

Journal of Nutrition
Food supplementation with milk fermented by Lactobacillus casei DN-114 001 protects suckling rats from rotavirus-associated diarrhea
Guerin-Danan, C; Meslin, JC; Chambard, A; Charpilienne, A; Relano, P; Bouley, C; Cohen, J; Andrieux, C
Journal of Nutrition, 131(1): 111-117.

Journal of Animal Physiology and Animal Nutrition
Effects of a probiotic Enterococcus faecium strain supplemented from birth to weaning on diarrhoea patterns and performance of piglets
Zeyner, A; Boldt, E
Journal of Animal Physiology and Animal Nutrition, 90(): 25-31.
10.1111/j.1439-0396.2005.00615.x
CrossRef
Clinical Reviews in Allergy & Immunology
Probiotics in clinical conditions
Marteau, PR
Clinical Reviews in Allergy & Immunology, 22(3): 255-273.

Annual Review of Nutrition
Nutritional impact of pre- and probiotics as protective gastrointestinal organisms
Teitelbaum, JE; Walker, WA
Annual Review of Nutrition, 22(): 107-138.

10.1146/annurev.nutr.22.110901.145412
CrossRef
Lancet
Gut flora in health and disease
Guarner, F; Malagelada, JR
Lancet, 361(): 512-519.

Journal of Pediatric Gastroenterology and Nutrition
Probiotics in the treatment and prevention of acute infectious diarrhea in infants and children: A systematic review of published randomized, double-blind, placebo-controlled trials
Szajewska, H; Mrukowicz, JZ
Journal of Pediatric Gastroenterology and Nutrition, 33(): S17-S25.

Pediatric Research
Immune responses in rhesus rotavirus-challenged balb/c mice treated with bifidobacteria and prebiotic supplements
Qiao, HP; Duffy, LC; Griffiths, E; Dryja, D; Leavens, A; Rossman, J; Rich, G; Riepenhoff-Talty, M; Locniskar, M
Pediatric Research, 51(6): 750-755.
10.1023/01.PDR.0000017481.64723.1F
CrossRef
Lancet Infectious Diseases
Rotavirus infection in adults
Anderson, EJ; Weber, SG
Lancet Infectious Diseases, 4(2): 91-99.

Journal of Alternative and Complementary Medicine
Probiotics in the prevention and treatment of diarrhea
Fox, CH
Journal of Alternative and Complementary Medicine, 10(4): 601-603.

Digestion
Probiotics as a treatment strategy for gastrointestinal diseases?
Bergonzelli, GE; Blum, S; Brussow, H; Corthesy-Theulaz, I
Digestion, 72(1): 57-68.
10.1159/000087638
CrossRef
Allergic Diseases and the Environment
Protective nutrients and gastrointestinal allergies
Duggan, C
Allergic Diseases and the Environment, 53(): 217-249.

Journal of Clinical Gastroenterology
Effects of Feeding an Infant Formula Containing Lactobacillus GG on the Colonization of the Intestine: A Dose-Response Study in Healthy Infants
Petschow, BW; Figueroa, R; Harris, CL; Beck, LB; Ziegler, E; Goldin, B
Journal of Clinical Gastroenterology, 39(9): 786-790.

PDF (150)

Journal of Pediatric Gastroenterology and Nutrition
Acidified Milk Formula Supplemented With Bifidobacterium lactis: Impact on Infant Diarrhea in Residential Care Settings
Chouraqui, J; Van Egroo, L; Fichot, M
Journal of Pediatric Gastroenterology and Nutrition, 38(3): 288-292.

PDF (257)
The Pediatric Infectious Disease Journal
Effect of probiotic Lactobacillus strains in young children hospitalized with acute diarrhea
ROSENFELDT, V; MICHAELSEN, KF; JAKOBSEN, M; LARSEN, CN; MØLLER, PL; PEDERSEN, P; TVEDE, M; WEYREHTER, H; VALERIUS, NH; PÆRREGAARD, A
The Pediatric Infectious Disease Journal, 21(5): 411-416.

PDF (187)
Journal of Pediatric Gastroenterology and Nutrition
Effect of Lactobacillus GG and Breast-feeding in the Prevention of Rotavirus Nosocomial Infection
Mastretta, E; Longo, P; Laccisaglia, A; Balbo, L; Russo, R; Mazzaccara, A; Gianino, P
Journal of Pediatric Gastroenterology and Nutrition, 35(4): 527-531.

PDF (242)
The Pediatric Infectious Disease Journal
Nosocomial Rotavirus Infection in European Countries: A Review of the Epidemiology, Severity and Economic Burden of Hospital-Acquired Rotavirus Disease
Gleizes, O; Desselberger, U; Tatochenko, V; Rodrigo, C; Salman, N; Mezner, Z; Giaquinto, C; Grimprel, E
The Pediatric Infectious Disease Journal, 25(1): S12-S21.

PDF (749)
Journal of Clinical Gastroenterology
Probiotics Used in Human Studies
Montrose, DC; Floch, MH
Journal of Clinical Gastroenterology, 39(6): 469-484.

PDF (150)
Journal of Pediatric Gastroenterology and Nutrition
Lactobacillus GG Administered in Oral Rehydration Solution to Children with Acute Diarrhea: A Multicenter European Trial
Guandalini, S; Pensabene, L; Zikri, MA; Dias, JA; Casali, LG; Hoekstra, H; Kolacek, S; Massar, K; Micetic-Turk, D; Papadopoulou, A; de Sousa, JS; Sandhu, B; Szajewska, H; Weizman, Z
Journal of Pediatric Gastroenterology and Nutrition, 30(1): 54-60.

PDF (0)
Journal of Pediatric Gastroenterology and Nutrition
Effect of Feeding Yogurt Versus Milk in Children With Acute Diarrhea and Carbohydrate Malabsorption
Boudraa, G; Benbouabdellah, M; Hachelaf, W; Boisset, M; Desjeux, J; Touhami, M
Journal of Pediatric Gastroenterology and Nutrition, 33(3): 307-313.

PDF (154)
Journal of Pediatric Gastroenterology and Nutrition
Are Medications Useful as Adjunctive Therapy for Oral Rehydration Solutions?
Rhoads, JM
Journal of Pediatric Gastroenterology and Nutrition, 32(1): 1.

PDF (0)
Current Opinion in Pulmonary Medicine
Probiotics for the prevention of nosocomial pneumonia: current evidence and opinions
McNabb, B; Isakow, W
Current Opinion in Pulmonary Medicine, 14(3): 168-175.
10.1097/MCP.0b013e3282f76443
PDF (117) | CrossRef
Journal of Pediatric Gastroenterology and Nutrition
Smectite in the Treatment of Acute Diarrhea: A Nationwide Randomized Controlled Study of the Italian Society of Pediatric Gastroenterology and Hepatology (SIGEP) in Collaboration With Primary Care Pediatricians
Guarino, A; Bisceglia, M; Castellucci, G; Iacono, G; Casali, LG; Bruzzese, E; Musetta, A; Greco, L; SIGEP Study Group for Smectite in Acute Diarrhea.,
Journal of Pediatric Gastroenterology and Nutrition, 32(1): 71-75.

PDF (113)
Journal of Clinical Gastroenterology
Probiotics for the Developing World
Reid, G; Anand, S; Bingham, MO; Mbugua, G; Wadstrom, T; Fuller, R; Anukam, K; Katsivo, M
Journal of Clinical Gastroenterology, 39(6): 485-488.

PDF (80)
Journal of Clinical Gastroenterology
Probiotics for Children: Use in Diarrhea
Guandalini, S
Journal of Clinical Gastroenterology, 40(3): 244-248.

PDF (107)
The Pediatric Infectious Disease Journal
Effect of probiotic Lactobacillus strains on acute diarrhea in a cohort of nonhospitalized children attending day-care centers
ROSENFELDT, V; MICHAELSEN, KF; JAKOBSEN, M; LARSEN, CN; MØLLER, PL; TVEDE, M; WEYREHTER, H; VALERIUS, NH; PÆRREGAARD, A
The Pediatric Infectious Disease Journal, 21(5): 417-419.

PDF (52)
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