J Surg Med. 2022;6(2):196-204.
DOI: 10.28982/josam.1068263

Journal of Surgery and Medicine
e-ISSN=2602-2079

The evolution of parenteral nutrition over the past 40 years: A bibliometric overview

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Abstract

Background/Aim: Malnutrition remains a significant problem in cancer patients, intensive care patients, and patients undergoing major surgery. Although the importance of nutritional support has been proven, the preferred route for nutrient delivery is still controversial. In recent years, the use of parenteral nutrition (PN) has been increasing, and the early use of PN has become widespread once again. However, there is still no bibliometric study in the literature about PN, which has increased the number of global studies in recent years. This study aimed to analyze the scientific articles on PN published between 1980 and 2020 with statistical methods and to evaluate the subject holistically.

Methods: Articles on PN published between 1980 and 2020 were analyzed using statistical and bibliometric methods. Spearman correlation coefficient was used for correlation studies. Nonlinear (cubic model) regression analysis was used to estimate the number of publications in the coming years. Keyword network visualization maps were used to identify trending topics and collaborations.

Results: A total of 9424 publications were found. Of these publications, 5461 (57.9%) were articles. The top 3 contributing countries to the literature were the USA (1901, 34.8%), UK (542, 10%), and France (437, 8%). The top 3 most active institutions were Harvard University (99, 1.8%), University of Toronto (98, 1.8%), and University of California, Los Angeles (84, 1.5%). The top 3 journals with the highest number of publications were Journal of Parenteral and Enteral Nutrition (894, 16.4%), Clinical Nutrition (337, 6.2%), and Nutrition (187, 3.4%). According to the average number of citations per article, the most influential journals were Annals of Surgery (88.2, 1.5%), Gastroenterology (85.8), and Gut (81.2), respectively.

Conclusion: In this comprehensive study on PN, a summary of 5461 articles were presented. The trend topics in PN research are determined and it can be said that most of them related with intensive care units and cancer patients. This article may be a valuable resource for clinicians and scientists on PN global outcomes.

Keywords: Parenteral nutrition, Nutrition support, Bibliometric analysis, Trends

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Ethics Committee Approval
This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of Interest
No conflict of interest was declared by the authors.

Financial Disclosure
The authors declared that this study has received no financial support.

Published
2022 February 15

How to cite: Özkan MB, Yıldırım MB. The evolution of parenteral nutrition over the past 40 years: A bibliometric overview. J Surg Med. 2022;6(2):196-204.

Introduction

Malnutrition continues to be an important problem, especially in cancer patients, intensive care patients, and patients undergoing major surgery. Malnourished patients are more likely to suffer from increased morbidity and mortality, hospital stay-related infections, and wound-related complications [1]. Lack of malnutrition therapy is associated with a five-fold increase in mortality in malnourished patients compared to well-nourished patients (11.7% vs. 2.4%) [1, 2]. Identifying malnutritional surgical patients and providing appropriate nutritional support has long been an important issue in surgical studies [1]. Malnutrition can adversely affect the functioning of many organ systems, such as the gastrointestinal tract, kidneys, heart, and lungs. Parallel to the weakness of muscle strength and immune function in malnourished patients, the possibility of infection may increase, wound healing may deteriorate, and postoperative recovery time may be prolonged. All these factors can lead to longer hospital stays and increased healthcare costs [1-4].

Nutritional support can be given safely with oral, enteral, or parenteral nutrition (PN), which provides fluid, calories, carbohydrates, and essential nutrients [5]. PN is a medical nutrition therapy provided by intravenous administration of nutrients such as amino acids, glucose, lipids, electrolytes, vitamins, and trace elements [3, 4]. PN has been in use for over 50 years and is an essential and often life-saving therapy to provide nutritional support to patients who cannot tolerate adequate enteral nutrition. [3-5]. PN is the intravenous administration of necessary nutrients if the nutrients can be partially or not wholly taken enterally. It significantly reduces morbidity and mortality when given to patients in need, especially in major surgical procedures, severe burns, severe head trauma, severe malnutrition, and sepsis. However, PN is not without risk. Although the importance of nutritional support has been proven, the preferred route for nutrient delivery is still controversial. Both diets have advantages and disadvantages. PN has been associated with more infectious complications from meta-analysis studies [6, 7], but calorie targets are more easily achieved using this method. Alternatively, enteral feeding (EN) preserves gastrointestinal function as it is a more physiological route but also is associated with higher stomach and intestinal intolerance rates such as vomiting, reflux, aspiration, and even ischemic bowel syndrome [6].

Due to the lack of well-designed, sufficiently powerful randomized control studies on the efficacy of PN in hospital settings, the current use of PN is based mainly on international guidelines from professional communities [3, 4, 8].

Studies based on statistical and bibliometric analyses have been carried out on many key medical subjects in synchronization with the increasing number of publications in the literature, especially in recent years [9-13]. Bibliometrics is the analysis of scientific outputs in the literature using various statistical methods [9]. Bibliometric studies revealed using comprehensive statistical methods also offer researchers ideas about new studies that they can design by showing past and current trends [12, 13]. Researchers who read bibliometric studies created by analyzing the findings obtained as a result of many scientific studies carried out by different researchers on a subject can dominate the literature in a short time [10, 11]. In addition, international cooperation analyzes in bibliometric studies can also show the general research trend of a subject in the world [9-13]. PN use has shown a steady increase in recent years, and the early use of PN has become widespread once again [6, 14]. Despite the fact that the number of global studies on PN has expanded in recent years, no bibliometric study has been published. The goal of this study was to use bibliometric and statistical tools to assess scientific articles on PN published between 1980 and 2020. As a result of the analyses, it was aimed to identify the most influential studies, journals, authors, institutions, and countries on PN, reveal cooperation between countries, reveal past and current trend issues, and summarize the PN issue holistically.

Materials and methods

Web of Science (WoS) database (by Clarivate Analytics) was used for literature review. “Parenteral nutrition”, “parenteral feeding”, “parenteral nutrition” were used as search keywords in WoS. The publication search was done only in the "title" section of the studies. All articles with *parenteral nutrition*, *parenteral feeding*, and *parenteral nutritional* in the title were obtained by this search method and downloaded from the WoS database. The dates of the search process were determined as 1980-2020 (access date: 01.09.2021). Reproducibility codes for researchers to access similar documents (search findings may vary depending on different access dates): (title: ("parenteral nutrition") or title: ("parenteral feeding") or title: ("parenteral nutritional") Timespan: 1980-2020. Indexes: SCI-Expanded, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI). VOSviewer (Version 1.6.17, Leiden University's Center for Science and Technology Studies) package program was used for bibliometric network visualizations [15]. The website (https://app.datawrapper.de) was used for world map drawing.

Statistical analysis

Statistical analyzes were performed with the SPSS (Version 22.0, SPSS Inc., Chicago, IL, USA) package program. The normal distribution of data was tested with the Kolmogorov-Smirnov test. Spearman's correlation coefficient was used in accordance with the data distribution for the analysis of the correlations between the number of articles produced by the world countries and some economic development indicators of the world countries ((Gross Domestic Product (GDP), Gross Domestic Product per capita (GDP per capita), data obtained from the world bank, [16]) to determine whether there is an effect of economic power on the productivity of publications on PN. Non-linear regression analysis (cubic model) was used to estimate the number of publications in the coming years. R square (R^2) value was used to evaluate the model's success in the regression analysis. The limit of statistically significant difference was accepted as $P<0.05$.

Results

As a result of the literature review, 9424 publications about PN published between 1980 and 2020 were found in the Web of Science database. The distribution of these publications is Article (5461, 57.9%), Meeting Abstract (2299, 24.3%), Letter

(518, 5.4%), Review (468, 4.9%), Proceedings Paper (366, 3.8%) and 312 (3.7%) of the rest were in other publication types (Editorial Material, Note, Book Chapter, Correction, News Item, Book Review, Correction Addition, Early Access, Discussion, Reprint, Book, Retracted Publication, Biographical Item and Software Review). Bibliometric analyzes were carried out with 5461 articles from a total of 9424 publications. 89.8% (4908) of these articles were English, 3.9% (214) German, 2.4% (134) Spanish, 2.3% (130) French, 0.7% (41) Russian, and the rest were published in other languages (Portuguese (9), Turkish (8), Italian (5), Polish (5), Japanese (3), Chinese (1), Dutch (1), Hungarian (1), Serbian (1). The h-index of 5461 articles was 131, average citations per article 22.03, the sum of citations 120312 (without self-citations: 94671).

Active research areas

The top 10 research areas with the most studies about PN are Nutrition Dietetics (2396, 43.8%), Surgery (735, 13.4%), Pediatrics (640, 11.7%), Gastroenterology Hepatology (518, 9.4%), Medicine General Internal (426, 7.8%), Pharmacology Pharmacy (246, 4.5%), Endocrinology Metabolism (180, 3.2%), Oncology (139, 2.5%), Critical Care Medicine (132, 2.4%), Immunology (112, 2.1%).

Development and future trend of publications

The distribution of the number of published articles by year is shown in Figure 1. The non-linear cubic model regression analysis results used to predict the number of papers that can be produced in 2021 and beyond are also shown in Figure 1. The agreement of the Cubic model with the data (R^2=0.717) was 71.7%. Therefore, due to this model results, it was predicted that 236 (Confidence Interval %: 207-265) articles would be printed in 2021, and 332 (CI%: 290-379) articles will be produced in 2025 (Figure 1).

Active countries

The world map showing the distribution of the number of articles according to the countries and the column chart of the top 20 countries that produce the most publications are shown in Figure 2. Top 20 countries that have published the most articles about PN; USA (1901, 34.8%), UK (542, 10%), France (437, 8%), Germany (387, 7%), Canada (313, 5.7%), Spain (306, 5.6%), Japan (281, 5.1%), Italy (270, 4.9%), China (210, 3.8%), Sweden (148, 2.7%), Belgium (138, 2.5%), Netherlands (135) , 2.4%), Switzerland (105, 1.9), Australia (101, 1.8%), Denmark (95, 1.7%), Poland (91, 1.6%), Israel (72, 1.3%), Brazil (71, 1.3%)), Taiwan (60, 1.1%), and Turkey (54, 0.9%).

Total link strength scores of 41 countries that wrote at least 10 articles from 88 countries producing publications on PN and had international collaboration among their authors were calculated. The collaboration clustering network map created according to these scores is shown in Figure 3.a. According to the results, 5 different clusters related to international collaboration were formed (Cluster 1: Austria, Canada, Chile, England, Germany, Greece, Ireland, Netherlands, Switzerland, Cluster 2: Argentina, Australia, Brazil, India, Malaysia, Mexico, New Zealand, Singapore, Wales, 3: Croatia, Czech Republic, Hungary, Israel, Norway, China Slovenia, Sweden, Cluster 4: Finland, Iran, Japan, South Africa, South Korea, Taiwan, Turkey, USA, Cluster 5: Belgium, Denmark, France, Italy, Poland, Scotland, Spain). International collaboration density map is shown in Figure 3.b.

Correlation analysis

The amount of articles generated by countries on PN and their Gross Domestic Product (GDP) and GDP per capita had a statistically significant association (r=0.743, P<0.001; r=0.717, P<0.001).

Active authors

The top 10 most active and productive authors who have written the most articles on PN are Goulet O (64), Messing B (55), Ament ME (53), Kudsk KA (53), Ricour C (51), Bistrian BR (47), Jeejeebhoy KN. (43), Pironi L (42), Steiger E (41), Teitelbaum DH (39).

Active institutions

Top 15 institutions that produce the most articles about PN; Harvard University (99), University of Toronto (98), University of California Los Angeles (84), University of Michigan (70), University of Tennessee (69), University of Pennsylvania (67), University of Alberta (59), Rigshospitalet (affiliated with University of Copenhagen) (56), Necker-Enfants Malades Hospital (affiliated with University of Paris Descartes) (55), Osaka University (53), University of Wisconsin (53), Veterans Admin Medical Ctr (52), University of Texas (51), The Hospital for Sick Children (SickKids, affiliated with University of Toronto) (49), Baylor College of Medicine (48).

Active journals

In 967 different journals, 5461 articles about PN were published. Table 1 lists the first 56 most active journals that publish 15 or more papers, as well as the total number of citations obtained by the journals and the average number of citations per article. The citation network visualization map between these journals is illustrated in Figure 4.

Figure 1: Distribution of publications on parenteral nutrition by years and prediction of articles in the coming years with the non-linear cubic model

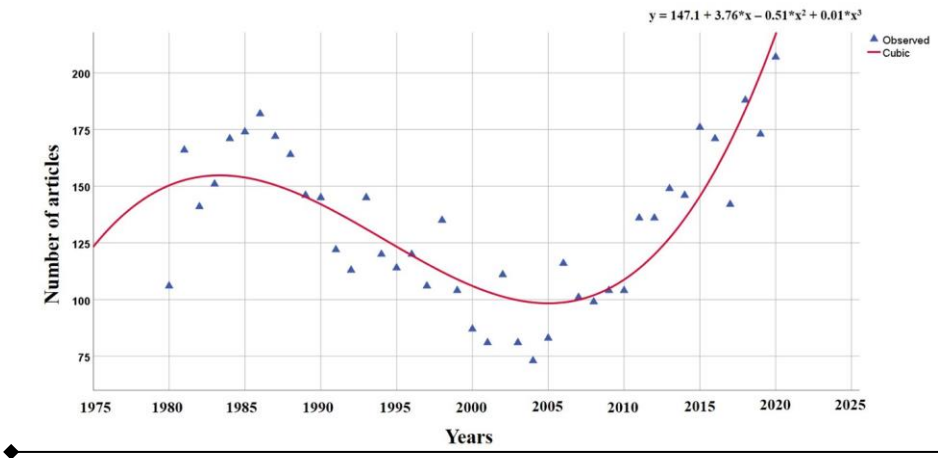


Figure 2: Distribution of publications on parenteral nutrition by world countries and column chart of the top 20 most productive countries (*productivity increases from light colors to dark colors)

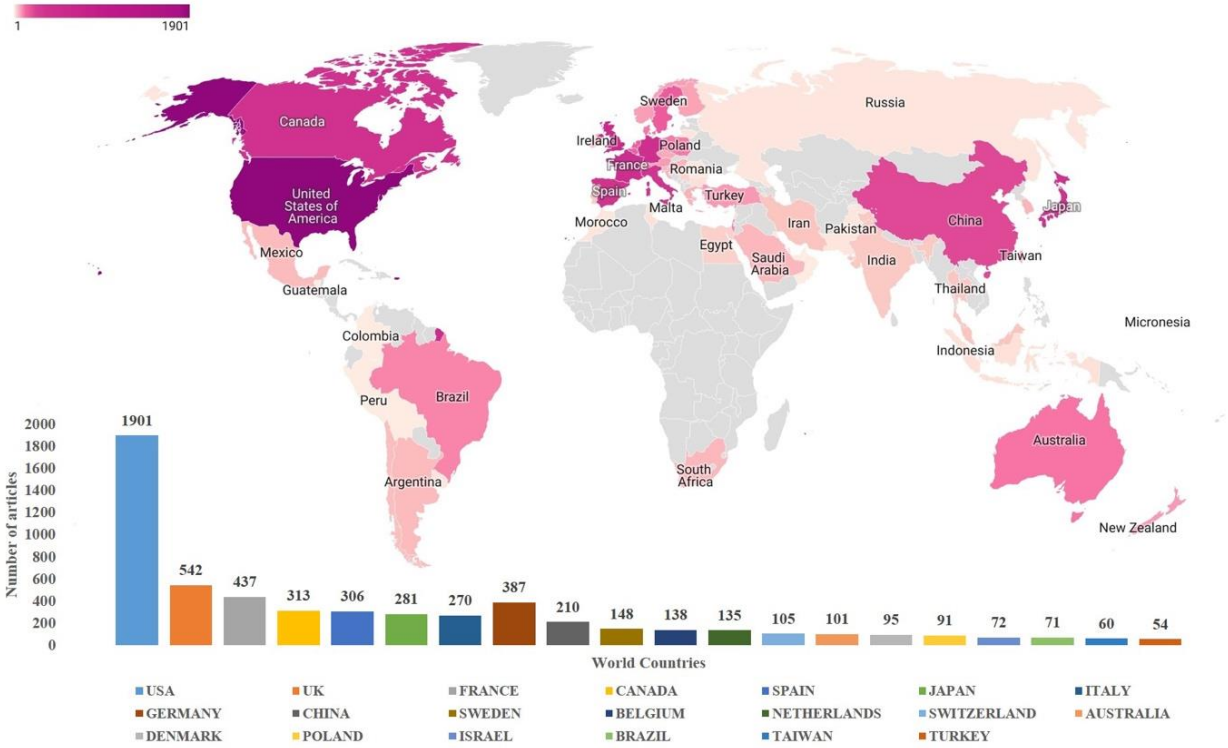


Figure 3: a. Network visualization map of cluster analysis on international collaboration on parenteral nutrition (*Colors show clustering. The size of the circles shows the number of articles.), b. Density map for international collaboration of worldwide countries on parenteral nutrition. (*The strength of ICS increases from blue to red (blue-green-yellow-red) (ICS: international collaboration score))

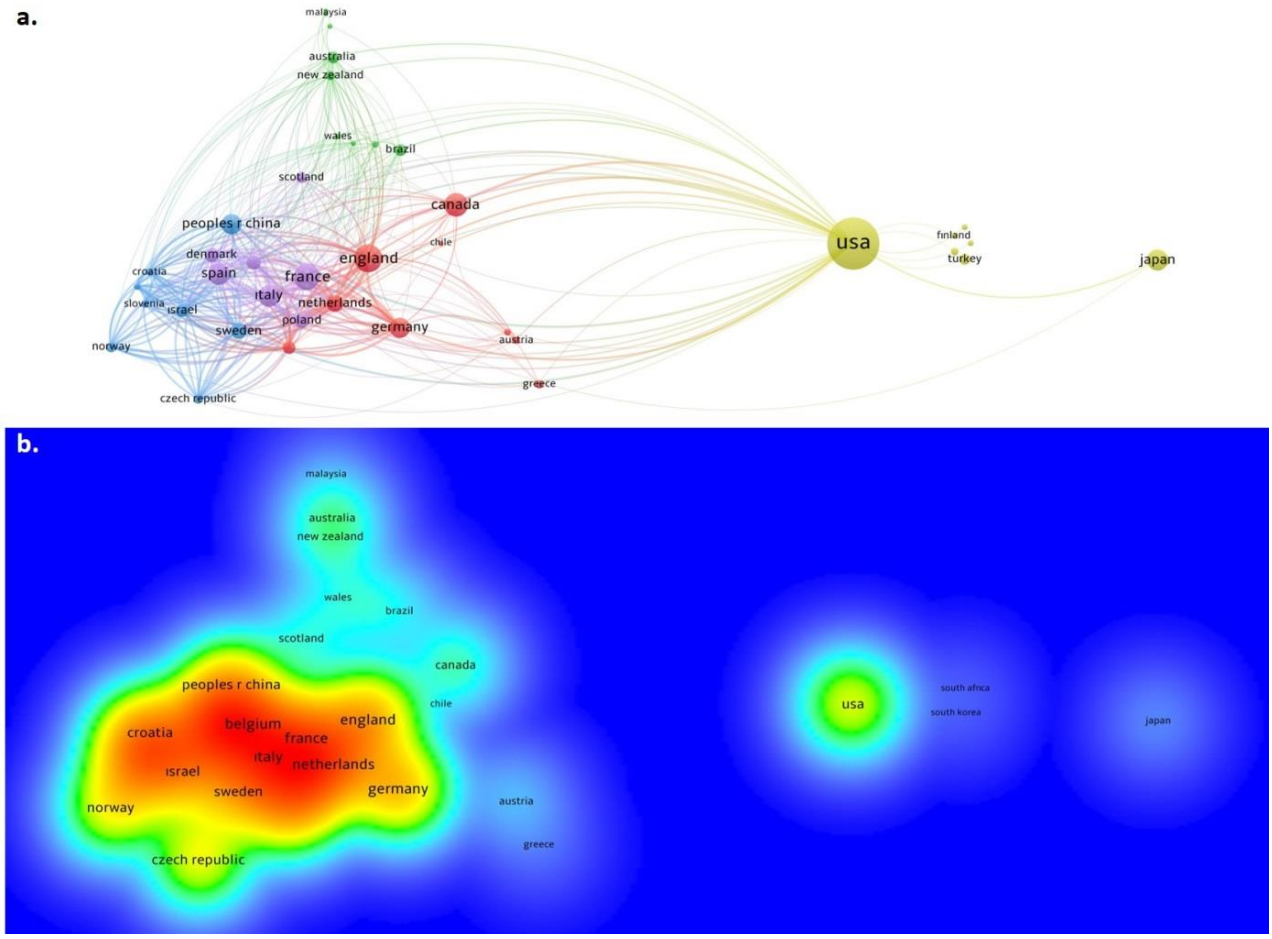


Table 1: 56 most active journals with more than 15 articles on PN

Journals	RC	C	AC	Journals	RC	C	AC
Journal of Parenteral and Enteral Nutrition	894	20068	22.4	Home Parenteral Nutrition, 2nd Edition	25	15	0.6
Clinical Nutrition	337	6678	19.8	Journal of The American College of Nutrition	25	444	17.8
Nutrition	187	4052	21.7	American Journal of Surgery	24	1037	43.2
American Journal of Clinical Nutrition	133	5664	42.6	Archives of Surgery	24	1220	50.8
Nutricion Hospitalaria	116	596	5.1	Metabolism-Clinical and Experimental	24	661	27.5
Nutrition in Clinical Practice	105	841	8.0	Surgery Gynecology & Obstetrics	24	940	39.2
Journal of Pediatric Gastroenterology and Nutrition	104	2217	21.3	American Journal of Physiology-Gastrointestinal and Liver Physiology	21	949	45.2
Journal of Pediatric Surgery	90	2692	29.9	Current Opinion in Clinical Nutrition and Metabolic Care	21	472	22.5
Annals of Surgery	70	6173	88.2	Journal of The American Dietetic Association	20	281	14.1
Gastroenterology	61	5235	85.8	Intensive Care Medicine	20	524	26.2
Journal of Pediatrics	60	3042	50.7	Archives of Disease in Childhood-Fetal and Neonatal Edition	18	385	21.4
Infusionstherapie UND Klinische Ernahrung	55	230	4.2	Asia Pacific Journal of Clinical Nutrition	18	106	5.9
Surgery	45	2373	52.7	Aktuelle Ernahrungsmedizin	17	44	2.6
Transplantation Proceedings	43	484	11.3	American Surgeon	17	187	11.0
Critical Care Medicine	39	1712	43.9	Gastroenterologie Clinique et Biologique	17	190	11.2
Journal of Surgical Research	38	1223	32.2	Gut	17	1380	81.2
Nutrients	35	137	3.9	Proceedings of hhe Nutrition Society	17	338	19.9
Nutrition Clinique et Metabolisme	35	37	1.1	World Journal of Surgery	17	365	21.5
Acta Chirurgica Scandinavica	34	279	8.2	American Journal of Gastroenterology	16	771	48.2
Journal of Nutrition	34	794	23.4	American Journal of Health-System Pharmacy	16	190	11.9
Pediatric Research	34	874	25.7	Current Opinion in Gastroenterology	16	18	1.1
European Journal of Clinical Nutrition	32	504	15.8	Nutrition Research	16	83	5.2
Clinical Nutrition Espen	29	139	4.8	Scandinavian Journal of Gastroenterology	16	521	32.6
Infusionstherapie UND Transfusionsmedizin	29	86	3.0	British Journal of Nutrition	15	534	35.6
British Journal of Surgery	28	1544	55.1	Home Parenteral Nutrition	15	19	1.3
Pediatrics	28	1565	55.9	Pediatric Surgery International	15	177	11.8
Digestive Diseases and Sciences	27	838	31.0	Plos One	15	206	13.7
Cancer	26	1075	41.3	World Journal of Gastroenterology	15	421	28.1

RC: Record Count, C: Number of Citation, AC: Average Citation Per Document

Citation analysis

Among the 5461 articles published between 1980 and 2020, the first 25 articles with the highest number of citations according to the total number of citations are presented in Table 2. Then, the average number of citations per year is shown in the last column of Table 2.

Table 2: Top 25 most cited articles according to total citations on PN

No	Article	Author Journal	PY	TC	AC
1	Early versus late parenteral nutrition in critically ill adults	Casaer, MP.et al. New England Journal of Medicine	2011	884	80.36
2	Enteral versus parenteral-feeding - effects on septic morbidity after blunt and penetrating abdominal-trauma	Kudsk, KA. et al. Annals of Surgery	1992	844	28.13
3	Perioperative total parenteral-nutrition in surgical patients	Williford, WO. New England Journal of Medicine	1991	705	22.74
4	Total parenteral-nutrition promotes bacterial translocation from the gut	Alverdy, JC. et al. Surgery	1988	604	17.76
5	Clinical and metabolic efficacy of glutamine-supplemented parenteral-nutrition after bone-marrow transplantation - a randomized, double-blind, controlled-study	Ziegler, TR. et al. Annals of Internal Medicine	1992	554	18.47
6	Optimisation of energy provision with supplemental parenteral nutrition in critically ill patients: a randomised controlled clinical trial	Heidegger, CP. et al. Lancet	2013	436	48.44
7	Compared with parenteral nutrition, enteral feeding attenuates the acute phase response and improves disease severity in acute pancreatitis	Windsor, ACJ. et al. Gut	1998	425	17.71
8	Prevalence of liver disease and contributing factors in patients receiving home parenteral nutrition for permanent intestinal failure	Cavicchi, M. et al. Annals of Internal Medicine	2000	422	19.18
9	Enteral nutrition is superior to parenteral nutrition in severe acute pancreatitis: results of a randomized prospective trial	Kalfarentzos, F. et al. British Journal of Surgery	1997	398	15.92
10	Influence of total parenteral-nutrition on fuel utilization in injury and sepsis	Askanazi, J. et al. Annals of Surgery	1980	396	9.43
11	Six-month outcome of critically ill patients given glutamine-supplemented parenteral nutrition	Griffiths, RD. et al. Nutrition	1997	391	15.64
12	Enteral compared with parenteral nutrition: a meta-analysis	Braunschweig, CL. et al. American Journal of Clinical Nutrition	2001	379	18.05
13	Long-term survival and parenteral nutrition dependence in adult patients with the short bowel syndrome	Messing, B. et al. Gastroenterology	1999	375	16.3
14	Preoperative parenteral-feeding in patients with gastrointestinal carcinoma	Muller, JM. et al. Lancet	1982	363	9.08
15	Espen guidelines on parenteral nutrition: central venous catheters (access, care, diagnosis and therapy of complications)	Pittiruti, M. et al. Clinical Nutrition	2009	360	27.69
16	Total parenteral nutrition in the critically ill patient	Heyland, DK. et al. Jama-Journal of the American Medical Association	1998	360	15
17	Does total parenteral-nutrition induce gallbladder sludge formation and lithiasis	Messing, B. et al. Gastroenterology	1983	358	9.18
18	Respiratory changes induced by the large glucose loads of total parenteral-nutrition	Askanazi, J. et al. Jama-Journal of the American Medical Association	1980	343	8.17
19	Addition of glutamine to total parenteral-nutrition after elective abdominal-surgery spares free glutamine in muscle, counteracts the fall in muscle protein-synthesis, and improves nitrogen-balance	Hammarqvist, F. et al. Annals of Surgery	1989	332	10.06
20	Postoperative enteral versus parenteral nutrition in malnourished patients with gastrointestinal cancer: a randomised multicentre trial	Bozzetti, F. et al. Lancet	2001	320	15.24
21	Early parenteral nutrition in critically ıll patients with short-term relative contraindications to early enteral nutrition a randomized controlled trial	Doig, GS. et al. Jama-Journal of the American Medical Association	2013	312	34.67
22	Safety and efficacy of a fish-oil-based fat emulsion in the treatment of parenteral nutrition-associated liver disease	Gura, KM. et al. Pediatrics	2008	305	21.79
23	The effect of parenteral-nutrition on gastrointestinal immunity - the importance of enteral stimulation	Alverdy, J. et al. Annals of Surgery	1985	281	7.59
24	Comparison of the safety of early enteral vs parenteral nutrition in mild acute pancreatitis	McClave, SA. et al. Journal of Parenteral And Enteral Nutrition	1997	279	11.16
25	Meta-analysis of parenteral nutrition versus enteral nutrition in patients with acute pancreatitis	Marik, PE. et al. BMJ-British Medical Journal	2004	277	15.39

PY: Publication year, TC: Total citation, AC: Average citations per year

Co-citation analysis

The references sections of all 5461 papers studied contained a total of 67911 studies. The first 11 papers with the greatest co-citations (over 100 citations) were respectively; Alverdy (1988) (Number of co-citations (NC): 132), Cavicchi (2000) (NC: 146), Dudrick (1968) (NC: 175), Jeejeebhoy (1976) (NC: 101), Koletzko (2005) (NC:178), Kudsk (1992) (NC:132), Mirtallo (2004) (NC:116), Moore (1992) (NC:118), Sheldon (1978) (NC:119), Singer (2009) (NC:100), Staun (2009) (NC:110) [17-27].

Trending topics

In all of the 5461 articles published about PN, 4535 different keywords were used. Among these keywords, 102 different keywords used in at least 13 separate articles are shown in Table 3. The cluster network visualization map between these keywords is shown in Figure 5. Trend visualization network map is presented in Figure 6, and citation network visualization map is illustrated in Figure 7.

Table 3: The most frequently used keywords on PN

Keywords	Number of uses	Keywords	Number of uses	Keywords	Number of uses
parenteral nutrition	1166	compounding	34	olive oil	17
total parenteral nutrition	402	newborn	30	outcomes research	17
home parenteral nutrition	267	surgery	28	cytokines	16
intestinal failure	151	home nutrition support	25	meta-analysis	16
nutrition	127	critical care	24	nutritional status	16
enteral nutrition	115	glucose	24	artificial nutrition	15
cholestasis	113	nutrition support	24	growth hormone	15
short bowel syndrome	106	child	23	hypophosphatemia	15
neonate (s)	94	liver	23	prematurity	15
nutritional support	73	manganese	23	preterm infants	15
glutamine	70	parenteral formulas	23	refeeding syndrome	15
pediatric (s)	69	growth	22	short-bowel syndrome	15
lipid emulsion (s)	68	omega-3 fatty acids	22	administration	14
sepsis	63	parenteral	22	gastric cancer	14
malnutrition	61	preterm	22	glutathione	14
children	56	safety	22	medication errors	14
complications	52	insulin	21	minerals	14
lipid (s)	51	quality	21	palliative care	14
TPN	51	survival	21	parenteral nutrition solutions	14
central venous catheter	49	aluminum	20	parenteral nutrition-associated cholestasis	14
quality of life	47	life cycle	20	patient safety	14
critical illness	45	nutrition support practice	20	randomized controlled trial	14
fish oil	44	bacterial translocation	19	apoptosis	13
trace elements	42	body composition	19	copper	13
infection	40	adult	18	crohn's disease	13
amino acids	37	oxidative stress	18	lipid peroxidation	13
liver disease	37	risk factors	18	mortality	13
cancer	36	stability	18	research and diseases	13
hyperglycemia	36	total parenteral nutrition (tpn)	18	selenium	13
parenteral nutrition-associated liver disease	36	catheter	17	steatosis	13
rat (s)	36	catheter-related bloodstream infection	17		

Figure 4: Network visualization map for citation analysis of active journals on Parenteral nutrition. (*The average number of citations per article by journals increases from blue to red. The size of the circles shows the number of articles.)

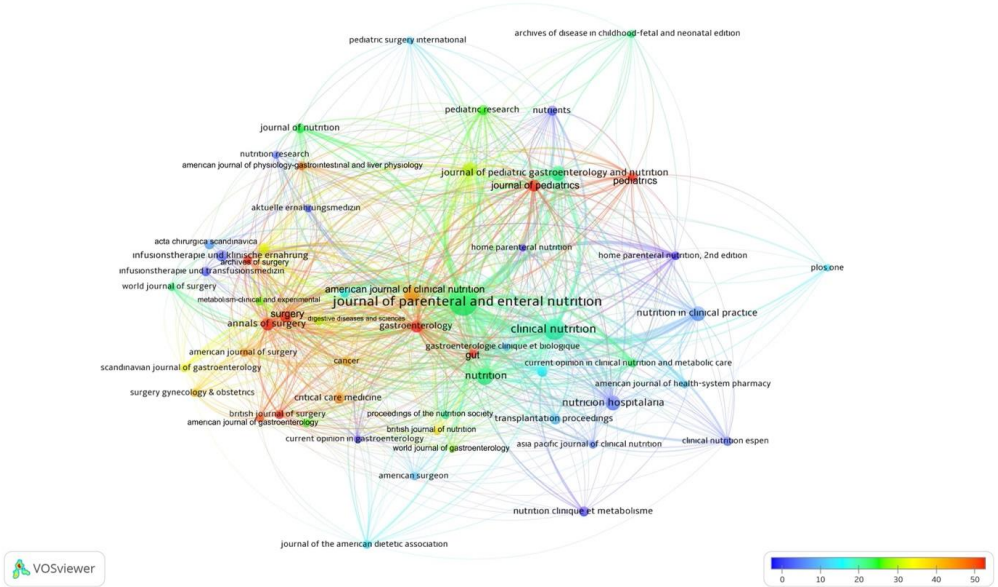


Figure 5: Network visualization map for cluster analysis based on keyword analysis on Parenteral nutrition. (* Clustering is shown by colors. The color of keywords in the same cluster is the same. The size of the circle represents the number of times the keyword has been used.)

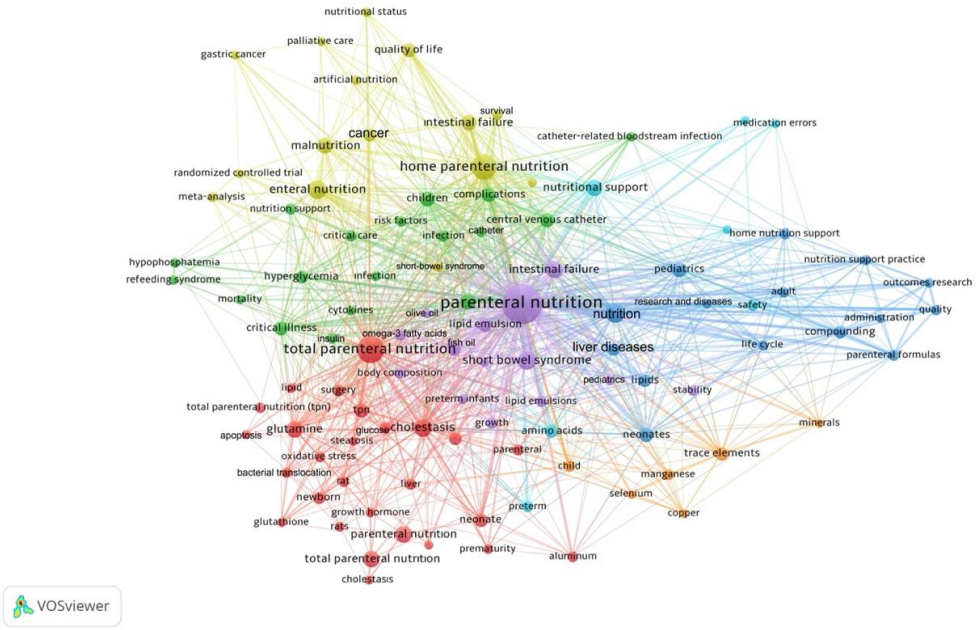


Figure 6: Network visualization map for trends on Parenteral nutrition. (* The article's topicality grows from blue to red as indicated by the indication in the upper left corner of the figure (blue-green-yellow-red). The size of the circle represents the number of times the keyword has been used.)

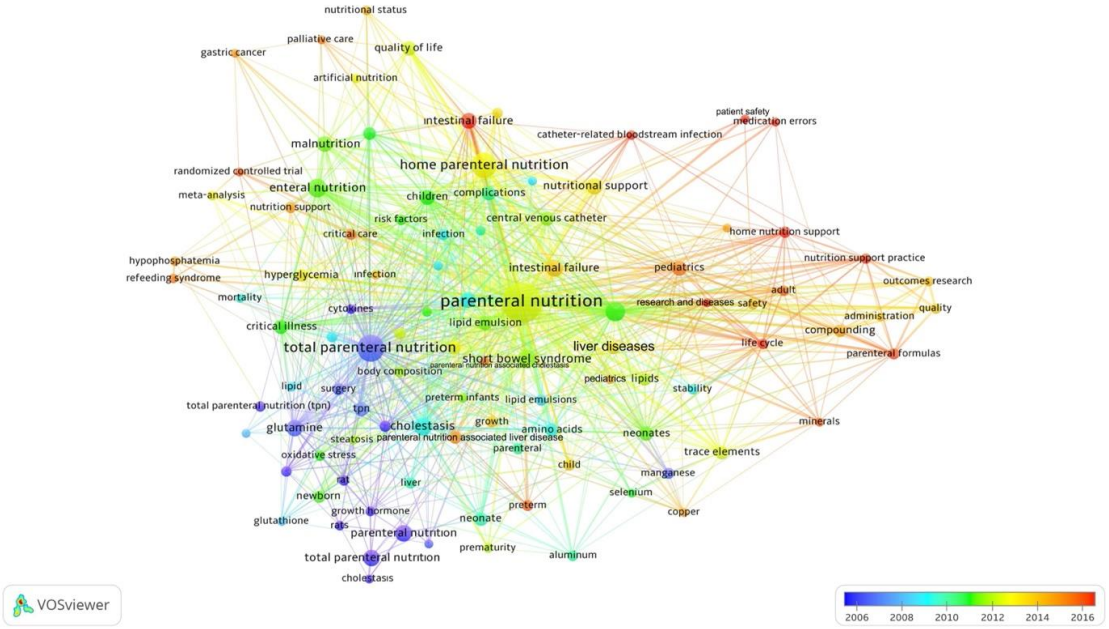
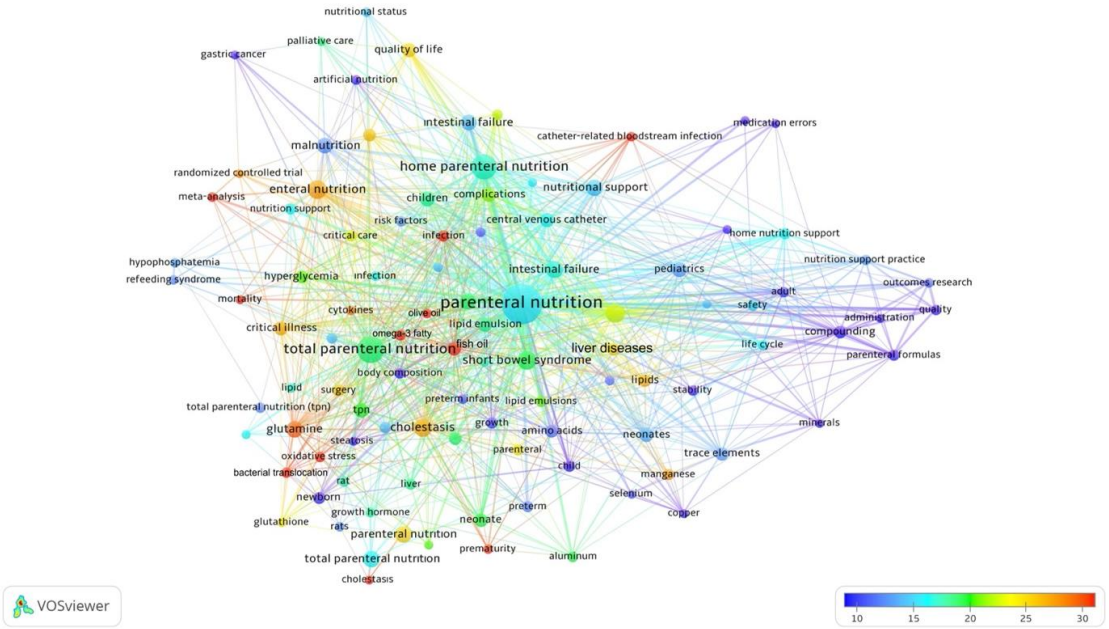


Figure 7: The most commonly mentioned subjects on parenteral nutrition are visualized in a network map. (* The amount of citations increases as the color changes from blue to red. The size of the circle represents the number of times the keyword has been used.)



Discussion

According to our findings, although there was an increasing trend in the number of articles on PN between 1980 and 1986, it showed a decreasing trend from 1987 to 2004. As of 2005, the number of articles on PN showed an increasing trend again until 2020, and the number of articles reached 207 in 2020. When the non-linear regression analysis results are evaluated, it is seen that the number of papers will continue with an increasing exponential trend.

When looking at the distribution of publications by world countries, 17 of the first 20 countries with the highest article productivity on PN were developed, while the other three (Brazil, China, and Turkey) were developing. However, although these three were developing countries, they were nations with relatively bigger economies. According to the findings of our study's correlation analysis, the high level of significant correlation between article productivity and metrics of economic development shows that the economic development level of countries is effective in the productivity of publications on PN. Furthermore, in the literature, bibliometric studies on many different medical subjects have been shown to be effective in publication productivity [10-12]. When the density map was developed based on the total score of cooperation between the countries, the countries with the most intensive cooperation were France, England, Italy, Belgium, Germany, Netherlands, Poland, Spain, Denmark, Sweden, and Switzerland, respectively. When the co-authorship cooperation of countries on PN is examined, it seems that collaboration based on geographical location is effective in the production of articles (Denmark, Spain, France, Italy, Poland), (England, Netherlands, Germany, Austria, Greece), (Croatia, Slovenia, Czech Republic), (Norway, Sweden), countries that are in the same cluster but not geographically close (USA, Turkey, Finland, Japan), (Canada, Chile), (Brazil, Australia, Wales) were working together. In some studies in the literature, it has been stated that geographical proximity is effective in the production of publications [10-12].

The journals that published the most articles on PN were determined as Journal of Parenteral and Enteral Nutrition, Clinical Nutrition, Nutrition, American Journal of Clinical Nutrition, Nutricion Hospitalaria, Nutrition in Clinical Practice, Journal of Pediatric Gastroenterology and Nutrition, Journal of Pediatric Surgery, Annals of Surgery, Gastroenterology, and Journal of Pediatrics, respectively. We recommend that authors who want to publish on PN look into these journals first. When journal citation analyses are compared, the most effective journals are determined based on the average number of citations per article they publish are Annals of Surgery, Gastroenterology, Gut, Pediatrics, British Journal of Surgery, Surgery, Archives of Surgery, Journal of Pediatrics, American Journal of Gastroenterology, American Journal of Physiology-Gastrointestinal and Liver Physiology, Critical Care Medicine, American Journal of Surgery, American Journal of Clinical Nutrition, and Cancer, respectively. Therefore, we recommend that researchers who want their articles to be cited more consider these journals first.

The most cited study was, determined by evaluating the assessed papers based on the total amount of citations they obtained, "Early versus late parenteral nutrition in critically ill adults" published in the New England Journal of Medicine by Casaer et al. [28]. The second most influential study is Kudsk et al., titled “Enteral versus parenteral-feeding - effects on septic morbidity after blunt and penetrating abdominal trauma” published in Annals of Surgery [22]. The third most influential study was Williford's (1991) article titled "Perioperative Total Parenteral-Nutrition in Surgical Patients" published in the New England Journal of Medicine [29]. The 4th and 5th most influential studies are written by Alverdy et al. and Ziegler et al. [17, 30]. When the papers are evaluated according to the number of citations per year, the most cited article belongs to Casaer et al. [28]. The second most influential article is from Heidegger et al., published in the Lancet. titled “Optimization of energy provision with supplemental parenteral nutrition in critically ill patients: a randomized controlled clinical trial” [31]. The third most influential study wrote by Fivez et al.'s article titled "Early versus late parenteral nutrition in critically ill children" was published in the New England Journal of Medicine [32]. The fourth most influential study belongs to Doig et al. article titled “Early parenteral nutrition in critically ill patients with short-term relative contraindications to early enteral nutrition a randomized controlled trial” published in the Jama-Journal of The American Medical Association [33]. The fifth most influential study did by Kudsk et al. [22]. According to the co-citation numbers of all analyzed articles, studies from Alverdy (1988), Cavicchi (2000), Dudrick (1968), Jeejeebhoy (1976), Koletzko (2005), Kudsk (1992), Mirtallo (2004), Moore (1992), Sheldon (1978), Singer (2009), Staun (2009) were identified as the most influential [17-27]. We can recommend that clinicians and researchers interested in this subject read these publications first.

When the results of the keyword analysis were assessed, it was discovered that PN topics were divided into clusters into seven different colors as a result of the clustering analysis. The most cited keywords were fish oil, infection, omega-3 fatty, olive oil, mortality, oxidative stress, catheter-related bloodstream infection, bacterial translocation, meta-analysis, prematurity, glutamine, cytokines, and cholestasis. The keywords researched in recent years, according to the findings of the analysis done to determine the trend subjects, are; intestinal failure, life cycle, catheter-related bloodstream infection, medication errors, patient safety, home nutrition support, nutritional support practice, research and diseases, parenteral formulas, preterm, minerals, adult, randomized controlled trial, pediatrics, critical care, refeeding syndrome, palliative care, parental nutrition-associated cholestasis, hypophosphatemia, nutrition support, gastric cancer.

As a result of the literature review on PN, no bibliometric study was found. Therefore, it can be said that the comprehensive research we have done on this subject is the first bibliometric research. Pubmed and Scopus indexes were not used in the literature review of our study, and only the WoS database was used. This is due to the inability to perform citation and co-citation analyses in the Pubmed database and the fact that studies with low impact levels are also included in the Scopus database [9-13]. The WoS database is preferred because it indexes the articles published in more influential journals than other databases and provides comprehensive citation analysis. In

recent years, WoS has also been chosen more in bibliometric analyzes [9-13].

Conclusion

In this comprehensive bibliometric study, we shared a summary of 5461 articles published between 1980 and 2020 on PN, which has seen an increase in the amount of articles about it published. Therefore, it can be said that trend topics in PN research in recent years: Intestinal failure, life cycle, catheter-related bloodstream infection, medication errors, patient safety, home nutrition support, nutritional support practice, study and diseases, parenteral formulas, preterm, minerals, adult, randomized controlled trial, pediatrics, critical care, refeeding syndrome, palliative care, parental nutrition-associated cholestasis, hypophosphatemia, nutrition support, and gastric cancer. We think that this article on parenteral nutrition worldwide outcomes could be useful for physicians and scientists.

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