Publication trends of vegetarian nutrition articles in biomedical literature, 1966–1995[1–3]

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ABSTRACT We documented publication trends of vegetarian nutrition articles in biomedical literature between 1966 and 1995 using the National Institutes of Health MEDLINE bibliographic database. The publication rate of vegetarian articles increased steadily during the 3 decades, from an average of <10/y in the late 1960s to 76/y in the early 1990s. After adjusting for the total number of articles indexed in MEDLINE annually, we found that publication of vegetarian nutrition articles increased dramatically, by 4-fold, during the 1970s and reached an oscillating plateau during the 1980s. In the early 1990s, the proportion of vegetarian nutrition articles 8 articles per 1000 vegetarian nutrition articles and ≈20 per 100 000 articles indexed by MEDLINE. Non-nutrition journals have progressively published a larger share of all vegetarian articles in the biomedical literature during the period studied. The nature and study design of published vegetarian research has changed over the years as well. The proportion of original research and review articles increased whereas case series and letters to the editor decreased. Reports of epidemiologic studies of vegetarians with longitudinal designs have superseded cross-sectional designs in number and proportion. In 40% of all publications, preventive and therapeutic applications of vegetarian diets constituted the major themes of vegetarian articles in the decade of 1986–1995. However, 20 y earlier the main focus was on the nutritional adequacy of vegetarian diets. The progressive change in the themes of vegetarian nutrition publications is interpreted as a shift in the role of vegetarian diets in human nutrition. *Am J Clin Nutr* 1999;70(suppl):601S–7S.

KEY WORDS Vegetarian, vegetarian diets, vegetarianism, MEDLINE, publication trends, bibliometric study, nutritional adequacy

INTRODUCTION

The number and proportion of the total articles published on a particular topic in peer-reviewed journals reflects the interest of professionals in the subject at any particular time. Funding agencies, researchers, reviewers, and editors do not live in an aseptic social environment, and their preferences and decisions to fund, perform, review, and publish research on a particular topic vary over time and are influenced by many factors. On the other side of the equation, scientists and health professionals, who are the major consumers of biomedical literature, tend to form views on particular topics on the basis of results of published research articles and the quality and frequency at which these articles appear in the literature.

Professional interest in vegetarian nutrition has reached unprecedented levels. This is only partly explained by the growing numbers of vegetarians and the increased popularity of vegetarian diets (1). The growing evidence of the health benefits of certain vegetarian diets as presented in biomedical literature has certainly increased the professional and scientific interest in the subject (2–4). A historical survey and thematic analysis of biomedical literature on vegetarian nutrition may provide an appropriate indicator of changes in attitude toward vegetarian nutrition and vegetarian diets among health professionals and scientists. Therefore, this study was undertaken to assess publication trends of vegetarian nutrition articles in biomedical literature during the past 30 y. Specifically, we determined the annual number and proportion of vegetarian nutrition articles published in biomedical and nutrition literature. Also, we aimed to assess whether the nature and type of published vegetarian nutrition articles have changed over time.

METHODS

We used the MEDLINE database in CD-ROM version (SilverPlatter International, Norwood, MA) as a source of bibliographic information. The years included in the analysis were 1966, when MEDLINE was initiated, through 1995, the last year for which complete information was available at the time of the search. For each of those 30 y we identified the number of records that satisfied the following criteria: any record indexed by MEDLINE; any record that contained the key term vegetarianism, vegetarian, or vegetarians; any record in a journal that was indexed by MEDLINE as a nutrition journal; or any record that contained the vegetarian key terms and was found in a nutrition journal.

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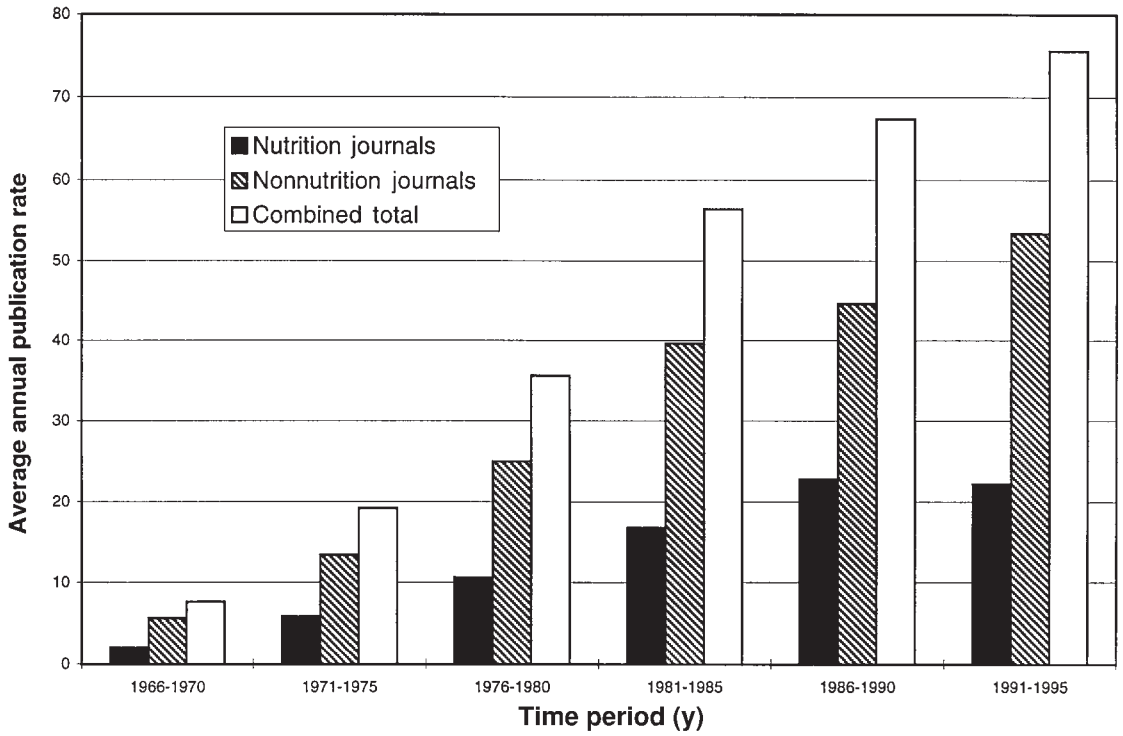

FIGURE 1. Annual average publication rate of vegetarian nutrition articles in nutrition journals, non-nutrition journals, and their combined total, 1966–1995.

Nutrition journals were identified as follows: *1*) nutrition journal titles were identified in the subject index of all MEDLINE journals in 1994 (5); *2*) the abbreviated title of each journal was entered as a search string; *3*) a search history was performed for each title in every year from 1966 to 1995; *4*) journal titles that yielded zero records in any year were referenced in Ulrich's index (6) to check for possible former titles; *5*) the journal list was appended to include the former titles found; and *6*) the search protocol was repeated. The absolute and relative (ie, to the total in its category) numbers of records were noted and plotted against time by using an EXCEL data management program (Microsoft, Redmond, WA).

This process yielded a total of 1309 records. To characterize vegetarian publications during this period, a systematic random sample of the 1309 MEDLINE citations and abstracts records in which the term vegetarianism, vegetarian, or vegetarians appeared anywhere in the record were reviewed. The search was done only in even-numbered years from 1966 to 1995, producing a total of 652 records. Citations of all indexed journal articles, including original research, case histories, case series, review articles, letters, editorials, and opinions, were included in the study sample. Retrieved records were displayed and then printed. The printed records were assessed for the following information: year of publication, type of journal, language of publication, country of address of the author for articles published after 1985 (when MEDLINE records began including the authors' addresses), type of article or publication, study design, country of origin of the study population, and main theme. Because abstracts were not included in MEDLINE records before 1975, extracting information required that the original article be referenced manually. Of the 652 records retrieved, 17 were not available in bound form at the Loma Linda University library. In addition, 48 articles were excluded for the following reasons: MEDLINE records did not contain sufficient information, the article dealt with entomology, zoology, or anthropology, the studies were in animals and had no direct application to human diets, or mention of the word *vegetarian* was coincidental. Thus, a total of 587 relevant records were used in the analysis. Data were entered and analyzed by using SPSS for Windows (version 7.0; SPSS Inc, Chicago, 1995). Chi-square for linear trends analysis was used to test for progressive temporal changes (7).

RESULTS

In 1966–1995, the total number of vegetarian nutrition articles indexed in MEDLINE was 1309. Of those, 401 were published in nutrition journals and the remaining 908 were published in nonnutrition, mainly medical and basic sciences journals. Thus, the ratio of the total number of vegetarian articles in nonnutrition to nutrition journals during this period was 2.3:1.

The average number of vegetarian nutrition articles published per year in nutrition journals, nonnutrition journals, and all journals indexed by MEDLINE from 1966 to 1995, by 5-y time periods, are shown in **Figure 1**. The publication rate of vegetarian articles increased steadily during these 3 decades in both journal categories and in the combined total. Among nutrition journals, the publication rate increased from 2 to 22/y over the 30-y span of this study, representing an 11-fold increase. A similar proportional increase was observed among nonnutrition journals, from an average of 5 to 54/y during the period studied. Thus, the total number of published articles on this topic in the biomedical literature increased from an average of 8 to 76/y.

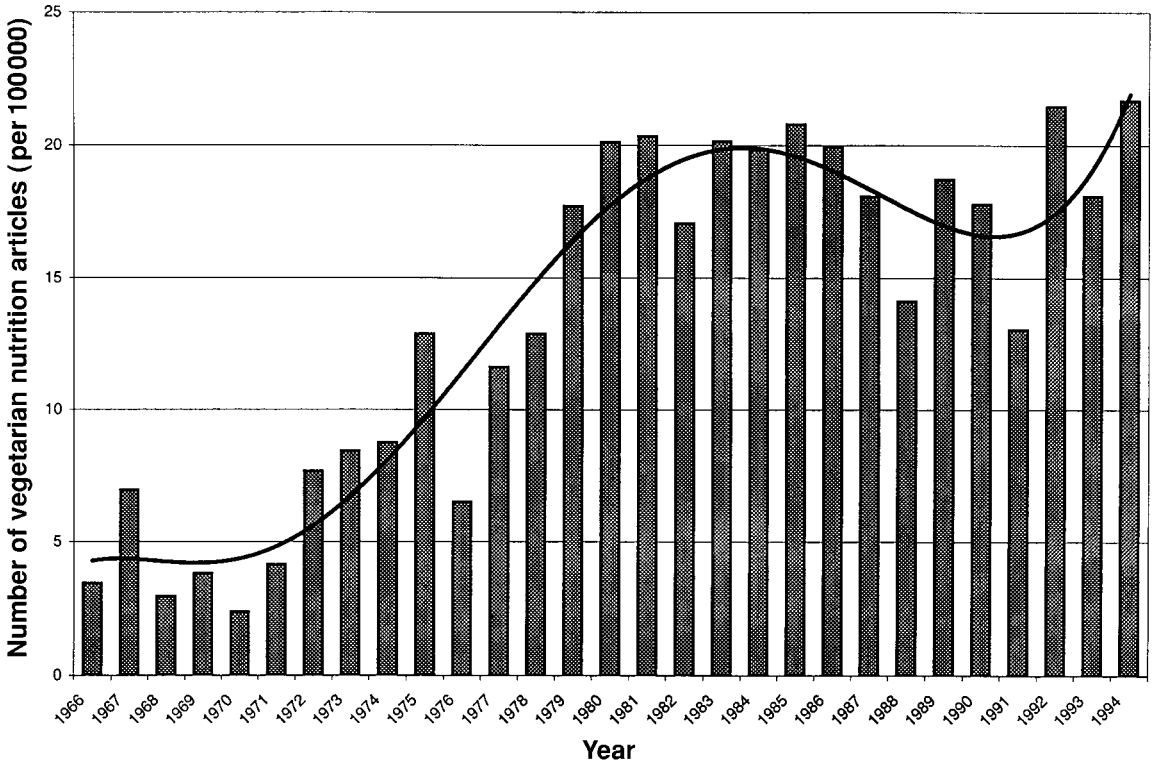

FIGURE 2. Ratio of vegetarian nutrition articles to the total number of articles indexed by MEDLINE annually between 1966 and 1995.

A point to consider is the relevance of these increases in light of secular increases in the number of articles indexed, both in nutrition and nonnutrition journals, by MEDLINE during this period. From 1966 to 1995, there was a steady, almost linear increase in the total number of articles indexed in MEDLINE annually. A total of 174 553 articles were indexed in 1966, and 382 700 were indexed in 1994; thus, the total number of MEDLINE entries doubled during that time. By contrast, the number of articles published in nutrition journals increased 3.5-fold during the same period, from 836 to 2868/y.

The proportion of vegetarian nutrition articles relative to all articles indexed by MEDLINE in each year from 1966 to 1994 (expressed per 100 000) is shown in **Figure 2**. After adjusting for the number of articles indexed in MEDLINE each year, we observed a dramatic increase in the vegetarian literature during the 1970s that reached an oscillating plateau during the 1980s with a possible new surge in the early 1990s. The growth rate during the 1970s was ≈400%, from < 5 to 20 vegetarian nutrition articles per 100 000 articles in the biomedical literature.

The number of vegetarian nutrition articles in nutrition journals by 5-y time periods is shown in **Figure 3**. The proportion of vegetarian nutrition articles published in nutrition journals increased during every 5-y period except for the period of 1991–1995. If the articles published as proceedings of the first (8) and second (9) International Congress on Vegetarian Nutrition in *The American Journal of Clinical Nutrition* in 1988 and 1994 are excluded from the computations, the proportion of vegetarian nutrition articles in nutrition journals experienced negative growth in the later 1980s and the early 1990s, from the highest point in the early 1980s (data not shown).

It is informative to compare changes over time in the absolute number of vegetarian nutrition articles in nutrition and nonnutrition journals. Since the mid-1970s, the proportion of the total

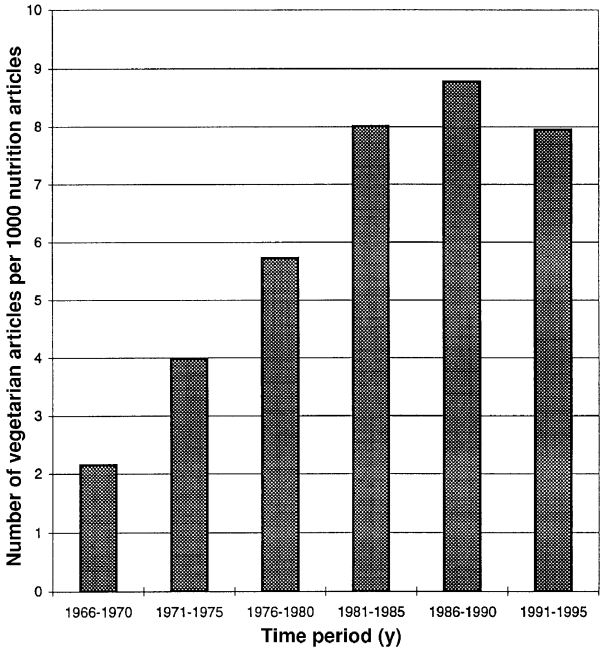

FIGURE 3. Number of vegetarian nutrition articles per 1000 articles in nutrition journals indexed by MEDLINE between 1966 and 1995.

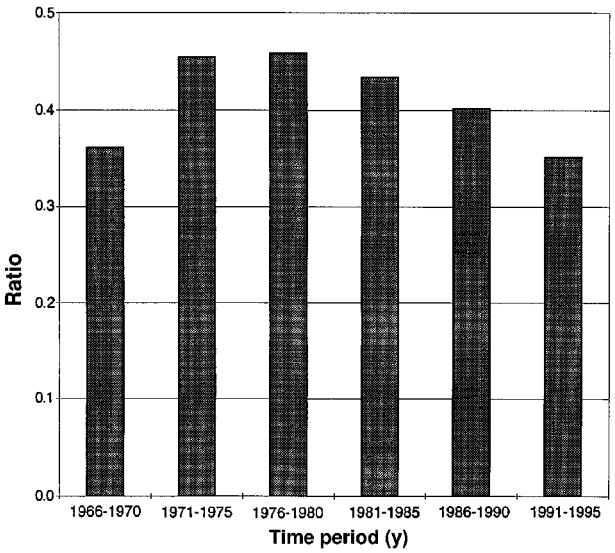

FIGURE 4. Ratio of the 5-y annual average of the total number of vegetarian nutrition articles published in nutrition journals to those published in nonnutrition journals.

number of vegetarian nutrition articles published in nutrition journals compared with nonnutrition journals has decreased steadily (**Figure 4**). Nonnutrition journals have been progressively publishing a larger share of all the vegetarian nutrition articles in the biomedical literature during that period.

The ratio of vegetarian nutrition articles published in nutrition journals to those published in nonnutrition journals is shown in **Figure 5**. The ratio showed a decreasing trend throughout the period studied, dropping from 72:1 during 1966–70 to 47:1 during 1991–95. Excluded from this analysis were the articles published as proceedings of the first (8) and second (9) International Congress on Vegetarian Nutrition. Similar results were observed when these articles were included (not shown).

Several characteristics of a random sample of the vegetarian nutrition articles published from 1966 to 1995 are summarized by decade in **Table 1**. Over 90% of the vegetarian nutrition literature indexed by MEDLINE was written in English, with no changes in this proportion over time. The origins of the study populations have changed over the years. Studies in vegetarians in Asia have proportionally decreased whereas studies on European vegetarians have increased greatly. Immigrants from the Indian subcontinent to the United Kingdom were studied steadily for the last 3 decades. MEDLINE records did not include authors' addresses until 1986. Among the 250 publications for which the address of the author was listed, 111 (44.4%) were in Europe, 92 (36.8%) were in North America, mainly the United States, and 22 (8.8%) were in Asia (not shown).

Of all the publications, 52% were original research and 16% were review articles, with clear increasing trends for both types of articles. Letters represented about one-fourth of all types of vegetarian nutrition publications between 1966 and 1975 but their frequency swiftly decreased over the years to <4% in the past decade. The study design was determined for 342 of the articles. Of those, one-third compared groups of vegetarians with nonvegetarians. One-fifth were clinical trials or therapeutic interventions; this design proportionally increased over the years. Case histories or series (reports of one or a few patients) were common during the first decade (30%); however, they decreased significantly over the years to 9%. Epidemiologic designs (cross-sectional and longitudinal) contributed an overall total of 23%. Whereas cross-sectional studies proportionally decreased over the years, cohort and case-control (longitudinal) studies increased.

The main themes of the vegetarian nutrition articles published are shown in **Table 2**. Articles dealing with nutritional adequacy issues, such as nutritional status, deficiency diseases, adequacy of vegetarian diets, and growth or anthropometric indexes, comprised 30% of all articles published. These themes prevailed (48%) in the first decade studied, but their overall frequency swiftly decreased over the years with a significant linear trend. Articles on preventive or therapeutic applications of vegetarian diets, such as the ones dealing with risk factors, chronic diseases, and other medical conditions, have increased over the years. Articles with multiple themes (any combination of the above) also increased over time, representing 9% of the total in the last decade. Thus, the proportion of vegetarian nutrition articles devoted to certain themes changed throughout the period studied.

DISCUSSION

To our knowledge, the present study represents the first published work using bibliometric techniques to quantify and assess scientific activity in the field of vegetarian nutrition. In this evaluation, we covered only the years for which the electronic MEDLINE database was available. Obtaining data from before 1966 would require performing manual searches of earlier years. However, those years were for the most part covered by Hardinge and Crooks' (10) evaluation of the scientific vegetarian literature. For that review article, the authors identified <100 reports on the subject published in the English language from earlier literature up to 1962.

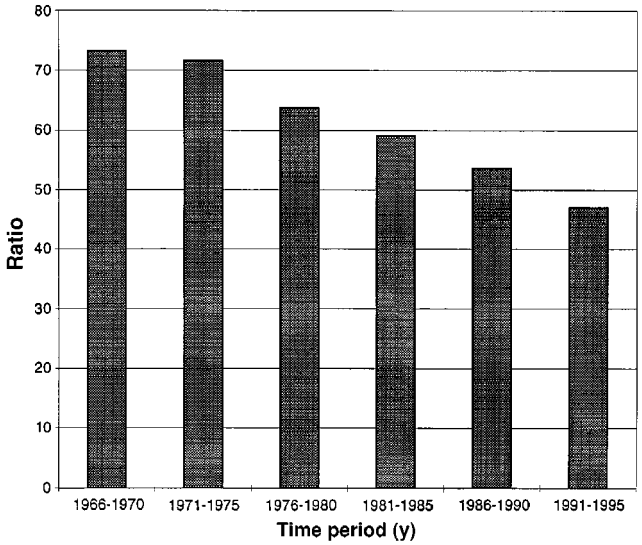

FIGURE 5. Proportion of vegetarian nutrition articles in nutrition journals to those in nonnutrition journals, excluding proceedings of the first (8) and second (9) International Congress on Vegetarian Nutrition.

TABLE 1
Characteristics of published vegetarian nutrition articles in biomedical literature, 1966–1995

Characteristic	Total	1966–1975	1976–1985	1986–1995	P^1
			n (%)		
Total	587 (100)	41 (7)	187 (31.9)	359 (61.2)	
Language					
English	541 (92.2)	37 (90.2)	172 (92)	332 (92.5)	
Non-English	46 (7.8)	4 (9.8)	15 (8)	27 (7.5)	0.636
Total	587 (100)	41 (100)	187 (100)	359 (100)	
Origin of study population					
Europe	75 (34.7)	0 (0)	3 (7.9)	72 (42.3)	<0.001
North America	57 (26.4)	2 (25)	16 (42.1)	39 (23)	0.083
Asia	36 (16.6)	4 (50)	9 (23.7)	23 (13.5)	0.004
Immigrant (Indians to United Kingdom)	28 (13)	1 (12.5)	6 (15.8)	21 (12.4)	0.693
Other (Australia and New Zealand)	20 (9.3)	1 (12.5)	4 (10.5)	15 (8.8)	0.647
Total	216 (100)	8 (100)	38 (100)	170 (100)	
Type of article					
Original research	299 (51.8)	13 (32.5)	98 (53.8)	188 (53)	0.115
Review or position paper	94 (16.3)	4 (10)	20 (11)	70 (19.7)	0.008
Editorial or commentary	63 (10.9)	5 (12.5)	22 (12.1)	36 (10.1)	0.467
Letter	42 (7.3)	9 (22.5)	19 (10.4)	14 (3.9)	<0.001
Application or instructional	22 (3.8)	2 (5)	6 (3.3)	14 (3.9)	0.997
Other	57 (9.9)	7 (17.5)	17 (9.3)	33 (9.3)	0.251
Total	577 (100)	40 (100)	182 (100)	355 (100)	
Study design					
Comparison of groups	115 (33.6)	6 (30)	44 (38.6)	65 (31.3)	0.425
Clinical trials and therapeutic intervention	70 (20.5)	1 (5)	17 (14.9)	52 (25)	0.006
Case series	39 (11.4)	6 (30)	15 (13.2)	18 (8.7)	0.008
Cross-sectional or survey	47 (13.7)	6 (30)	19 (16.7)	22 (10.6)	0.011
Cohort or case-control	32 (9.4)	0 (0)	4 (3.5)	28 (13.5)	0.001
Other	39 (11.4)	1 (5)	15 (13.2)	23 (11.1)	0.874
Total	342 (100)	20 (100)	114 (100)	208 (100)	

[1] Chi-square for linear trends (7).

The present study documented a sharp increase of vegetarian nutrition publications in biomedical literature during the past 30 y. This increase occurred in both absolute and relative numbers and has been experienced in nutrition as well as nonnutrition journals. In absolute numbers, nonnutrition journals as a whole have always published more vegetarian nutrition articles than have nutrition journals. In relative numbers, however, the proportion of articles devoted to vegetarian nutrition has always been much greater in nutrition journals than in nonnutrition journals. It is worth noting that *The American Journal of Clinical Nutrition* has been the major contributor of vegetarian nutrition articles to biomedical literature (11), and that is above and

TABLE 2
Main themes of published vegetarian nutrition articles in biomedical literature, 1966–1995

	Total	1966–1975	1976–1985	1986–1995	P^1
			n (%)		
Nutritional adequacy issues	162 (29.7)	14 (48.2)	66 (37.2)	82 (24.2)	0.001
Nutritional status	78 (14.3)	9 (31)	29 (16.4)	40 (11.8)	0.006
Deficiency diseases	32 (5.9)	2 (6.9)	16 (9)	14 (4.1)	0.058
Adequacy of vegetarian diets	41 (7.5)	3 (10.3)	16 (9)	22 (6.5)	0.241
Growth and anthropometry	11 (2)	0 (0)	5 (2.8)	6 (1.8)	0.899
Preventive and therapeutic applications	210 (38.6)	7 (24.1)	68 (38.5)	135 (40.0)	0.196
Risk factors	123 (22.6)	3 (10.3)	47 (26.6)	73 (21.6)	0.982
Chronic diseases	38 (7)	2 (6.9)	9 (5.1)	27 (8)	0.333
Medical conditions	49 (9)	2 (6.9)	12 (6.8)	35 (10.4)	0.575
Multiple themes[2]	40 (7.4)	0 (0)	10 (5.6)	30 (8.9)	0.044
Guidelines and recommendations	45 (8.3)	2 (6.9)	12 (6.8)	31 (9.2)	0.193
Other	87 (16)	6 (20.7)	21 (11.9)	60 (17.8)	0.367
Total	544 (100)	29 (100)	177 (100)	338 (100)	

[1] Chi-square test for linear trends (7).
[2] Any combination of ≥2 of the above listed themes.

beyond those published in the previous proceedings of vegetarian congresses (8, 9).

Results of the present study show that whereas the number of vegetarian nutrition articles increased steadily in both the nutrition and nonnutrition literature for the past 30 y (Figure 1), the proportion of those articles followed a more irregular pattern of growth. In biomedical literature as a whole, we observed dramatic growth during the 1970s, a plateau during the 1980s, and a possible new surge in the early 1990s. In the nutrition literature, the proportion of vegetarian nutrition articles grew until the mid-1980s and has declined since then. Note that for the last 25 y the number and proportion of vegetarian nutrition articles in nutritional journals relative to nonnutrition journals also followed a downward trend (Figures 4 and 5). Nonnutrition journals are progressively publishing a larger share of all vegetarian nutrition articles in the biomedical literature. The publication rate increase of vegetarian nutrition articles in scientific literature undoubtedly reflects the increased professional interest in this subject for the past 30 y. Most recently, however, the noted shift in publication trends can be interpreted as a growing interest in vegetarian nutrition issues among scientists and professionals of disciplines other than nutrition, a tendency for nutrition scientists to also publish in nonnutrition journals, or both.

It is important to take into consideration the advantages and limitations of MEDLINE (12, 13). Its chief advantages are that *1*) it has most of the leading journals in the biomedical and health science fields indexed, *2*) it is easily accessible in CD-ROM and online formats, and *3*) key words can be used to search and retrieve information (5). However, key words may have changed over time in definition and application. Finally, this bibliographic database has some limitations such as a bias in favor of medical science journals and those coming from the United States, Canada, and the United Kingdom relative to other health science journals and non-English journals (5, 13). Thus, the total number and proportion of vegetarian nutrition articles is probably underestimated; however, the bias of the bibliographic database does not invalidate the trends observed in the present analysis.

The task of quantifying and assessing scientific activity is complex. Bibliometric studies are especially useful when dealing with subjects that are studied often or general topics such as the one studied here (12, 14), presupposing that scientific literature has good indicators of scientific activity. Through bibliometric analyses it is possible to derive several indicators that assess trends over time. Comparing the scientific activity of particular disciplines by quantitative indexes, particularly by numbers of centers and geographic diversity of research endeavors (15), can be useful in getting a global picture of scientific activity occurring over large geographic areas during long periods (16, 17). However, it sheds little light on the economic and human resources devoted to a discipline or the quality of research. Yet it is important to assess both quantitative and qualitative indicators (15).

In the present study we attempted to evaluate the quality and tendencies of research on vegetarian nutrition on the basis of assessments of selected characteristics of the articles. Several trends emerged from these analyses. First, over the years hard research data have replaced soft data in that original research articles, the backbone of peer-reviewed professional journals, now constitute the largest type of vegetarian nutrition publication; letters to the editor, a less rigorous type of publication, only constitute a minority. Second, stronger study designs have superseded weaker ones. Clinical trials on vegetarian diets are proliferating whereas case series reports of vegetarians are declining. Similarly, reports of epidemiologic studies with longitudinal designs have superseded in number and proportion the weaker cross-sectional designs. Finally, the main focus of vegetarian nutrition research is changing. In 40% of all vegetarian nutrition articles published in 1986–1995, the major theme was preventive and therapeutic applications of vegetarian diets. Twenty years earlier, the nutritional adequacy of vegetarian diets was the major theme.

Thus, the types of vegetarian nutrition articles have evolved over the years from more observational to more analytic, paralleling similar trends in other areas of scientific endeavor. The observed progressive change in the main themes of vegetarian nutrition articles is interpreted as a shift in the role of vegetarian diets in human nutrition. In the past 30 y, scientific endeavors in the area of vegetarian nutrition seem to have progressively shifted from investigating concerns held by nutritionists and other health professionals to a fertile area of investigation in which creative solutions for various medical conditions and preventive approaches to chronic diseases may be found.

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