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SPECIAL ARTICLE

Use of Epidemiology in Clinical Medical Publications, 1983–1999: A Citation Analysis

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Epidemiologists respond to the information needs of health professionals. Although medical professionals are routine users of epidemiologic information, use within medical specialties varies remarkably. To explore the variation in use of epidemiologic information across clinical medical specialties, the authors examined the scientific literature by analyzing patterns of citation of specific journal articles to and by the *American Journal of Epidemiology* (AJE). A total of 178,396 journal citations to and 126,478 citations by AJE were made from 1983 through 1999; citations were classified according to the subject category of the referencing or referenced journal. Clinical medical journals accounted for 50.6% of all citations combined (both referenced to and referenced by AJE); general/internal medicine (17.9%), cancer (10.4%), and cardiovascular (4.9%) journals had the highest number of citations. Few citations to and by AJE were found in publications specializing in dermatology, gastroenterology, orthopedics, allergy, anesthesiology, surgery, rheumatology, and other areas. Trend patterns of citations between clinical and epidemiologic literature indicated that citations to the fields of cardiovascular disease and cancer are increasing, whereas citations regarding pediatrics have remained stable. This analysis suggests an increasing interchange of information between epidemiologists and clinicians specializing in certain fields, uncovering potential research opportunities for epidemiologists.

clinical medicine; epidemiology; public health; publishing

Abbreviations: AIDS, acquired immunodeficiency syndrome; AJE, *American Journal of Epidemiology*; JCR, *Journal Citation Reports*.

Epidemiologists identify, collect, analyze, and ultimately disseminate information for practical application by a wide range of health care professionals and organizations. During the past two decades, there has been a progressive interest in applying epidemiologic methods in clinical medicine. This increased interest is reflected in the growing use of epidemiologic methods in clinical research, a shift in the focus of epidemiology courses for medical students and practicing physicians toward more clinically oriented topics, and the growing opportunities for advanced training in epidemiology for medical students and clinicians (1). However, the extent to which epidemiologic information is used by clinicians is often difficult to quantify, in part because defining "use of information" between fields is complex. Information must first be exchanged, understood, and then applied. Tracking the path from the communication of facts or

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knowledge to the actual application or use of that information is not a straightforward process. Furthermore, this interaction between epidemiology and clinical medicine can vary remarkably across clinical specialties (2).

One method that may be used to explore the interface between fields, including epidemiology and clinical medicine, is citation analysis. This method is commonly used in the information sciences to quantify the frequency with which defined user populations access information as it is circulated through the published literature. Citation analysis assesses the interaction between disciplines as represented by citation patterns (3). Put simply, citation analysis is a method for counting the number of times articles in a specific journal (i.e., index journal) cite (i.e., reference) articles published in journals that focus on different medical specialties. In addition, the number of times that articles from these journals cite the index journal can also be counted. Citation analysis attempts to answer the questions: "How often has a journal been cited? What journals have cited it? Is it the old or the newer material that is being cited?"

Although citation analysis can determine whether information has been exchanged between two fields, this methodology has limitations, even when used as an indirect measure of use of epidemiologic information by clinical specialties. For example, how and why information is cited is not revealed through these analyses; neither quality nor significance of usage can be measured; and citations may refer to full papers, technical communications, letters, and editorials, among others. Nonetheless, the process of systematically analyzing and mapping citation patterns within and between fields can shed light on whether a certain body of literature (e.g., epidemiology) is being used, via information transfer, by another area of science (e.g., clinical medicine).

This study uses citation analysis to examine citation activity between the epidemiologic literature and clinical science journals for the publication years 1983–1999. Specifically, we identify which clinical medical specialties use epidemiologic literature most and which specialties have only minimal use. We also examined citation trends over the 17-year period. This study builds upon an earlier citation analysis study that examined interactions and trends in the use of epidemiologic information by clinical medicine for the publication years 1976–1982 (2).

MATERIALS AND METHODS

Data source

This study used data from the *Journal Citation Reports* (JCR), a database composed of information about the number of times each year a journal is cited and the name of the citing journal. The JCR have been published by the Institute for Scientific Information since 1975 and represent the most comprehensive citation index to the scientific literature, covering 5,600 journals across more than 150 scientific disciplines (4). We used two "packages" from the JCR for each year examined. The *cited* package tabulates the number of times that published articles have cited articles published in the index journal. The *citing* package tabulates the number of times articles published in other journals were cited by the index journal.

Selection of journals

Given our interest in the exchange of information between epidemiology and clinical medicine, we chose the *American Journal of Epidemiology* (AJE) as our epidemiologic journal of reference. Selection of AJE facilitated comparison with the earlier citation analysis (2), because AJE was used as the index journal for that study as well. In previous and the current analyses, AJE was chosen because it had the highest citation ratio (e.g., citations per citable items published) for articles published in epidemiology and public health journals for the years spanning the study period (5).

To select the clinical medicine journals, we reviewed information from both the JCR *cited* and *citing* packages to compile a list of journals that cited information from AJE and a list of those that were cited by AJE. Although the information contained in the *cited* and *citing* packages is based on individual journal articles, the citation counts are attributed to the journal in which the article appears. Information provided in the JCR, therefore, summarizes data as journal citations rather than individual article citations. For each year of our 17-year study period, we identified the 100 journals that most often cited articles from AJE. We also determined the top 100 journals cited by articles published in AJE. After obtaining these lists for each individual year, we then combined them to create two lists (i.e., the "cited" and "citing" lists) for the entire 17-year period. Because many of the same journals accounted for high numbers of citations for each individual year, the combined lists for the entire study period contained fewer than 500 journals for each list. For this study, we chose to limit our more detailed analysis to the top 200 journals found on each of the combined lists. This cutoff captured approximately 60 percent of the citation data for each list (figure 1) and was similar to the proportion of citations used for the more detailed analysis in the earlier study (2).

Assignment of journals to specialty category

Once the journals for the analysis were selected, we assigned them to one of 52 specific specialty areas, which assignment was also done in the earlier citation analysis study (2). This assignment was based on information contained in the JCR, which categorize journals by subject (6). Journals falling into more than one category were assigned to the subspecialty category rather than to the general specialty area. For example, the *Pediatric Infectious Disease Journal* was assigned to the category of infectious disease (a subspecialty) rather than to pediatrics (a general specialty). Journals not categorized by the JCR were evaluated and assigned to categories based on the title of the journal, information contained in "Instructions to Authors," and the table of contents in a sample issue. Decisions about how to assign these journals were reached by consensus of all study investigators.

Once journals were assigned to one of the 52 categories, we collapsed these groups into the following three general

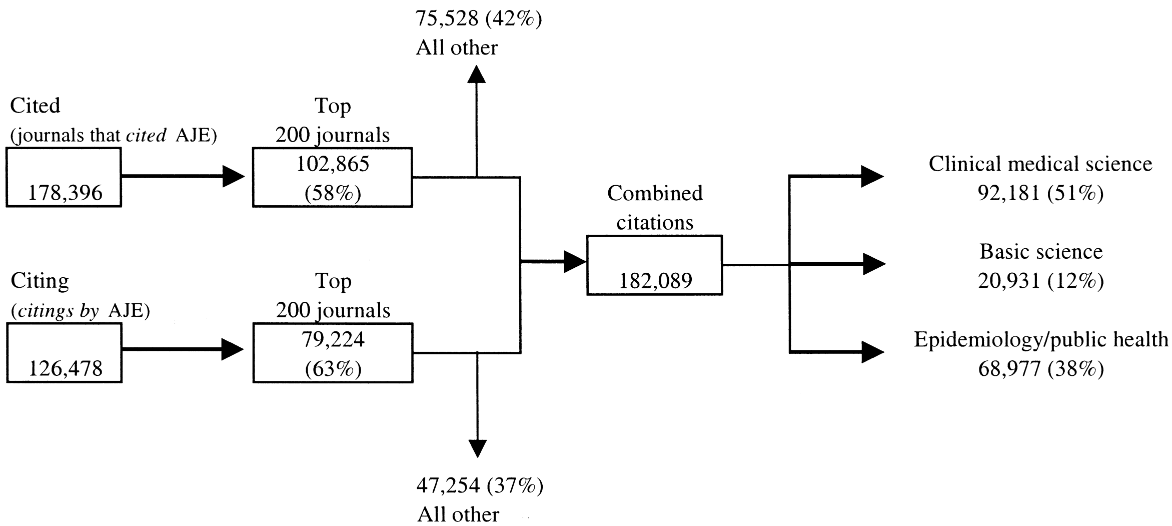

FIGURE 1. Algorithm used for citation analysis, *American Journal of Epidemiology* (AJE), 1983–1999.

fields: clinical medical sciences (n = 28), basic science (n = 22), and epidemiology/public health (n = 2). Decisions about journal placement into one of these three general fields were reached by consensus of the study investigators and were based largely on journal content.

Measures and analysis

Our initial analysis included all citations from both lists, citations to AJE, and citations by AJE for the years 1983–1999. Citations were rank ordered by journal title for the 25 most frequently cited journals on both lists. The citations for the next 175 journal items were collapsed into a single category, and the remaining citations were collapsed into the "all other" category.

A more detailed analysis using only the information from the top 200 journals from each list (i.e., the "cited" and "citing" lists) was performed. For each clinical medical science category, the number of journal titles in the list of journals by subject categories in the JCR (6) was tabulated. We then tabulated the number and proportion of citations to AJE, by AJE, and combined (i.e., both the cited and the citing lists). We used these counts as very rough estimates of the interchange between epidemiologic literature and each of these specialties. Moreover, these counts were used to answer the questions, "Does a given medical specialty cite the epidemiologic literature as often as the converse?" and "Has the directionality of citations between various medical specialties and AJE changed since the previous citation analysis (2)?"

The number of citations between AJE and the three general categories of journals (i.e., clinical medical science, basic science, and epidemiology/public health) was tabulated for each year of the study. Trend lines representing the total combined citation activity between epidemiology and each of these three general areas were used to compare the extent of epidemiologic knowledge being exchanged across fields over time. Using the combined citation totals reveals the interactivity between epidemiology and the other fields and attempts to answer the question, "How much interchange is occurring between epidemiology and these general fields via the literature?" We also examined similar trends for the combined citation interaction between AJE and selected clinical specialty journals (i.e., general internal medicine, cancer, cardiovascular disease, infectious disease, and pediatrics) to compare exchange of information across these specialties.

To identify the most useful journals for delivering epidemiologic results to clinical medical professionals, we calculated the "epidemiologic impact factor" for the clinical journals that had the highest number of citations within AJE. The epidemiology impact factor for a journal takes into account two measures: 1) its proportion of all citations with AJE and 2) its "impact factor," the ratio between citations to articles in a journal and the number of citable articles published in that journal. The "impact factor" also suggests the relative importance of a journal in a given field (7). For example, a journal with an impact factor of 2.0 has its articles cited twice, on average, by other journals. In addition, the use of the impact factor eliminates some of the bias that favors journals by size and frequency (7), thereby making it possible to compare larger, more frequently published journals with small obscure journals. The epidemiologic impact factor for a journal was calculated as the product of its impact factor in 1999 (8) and the proportion of all citations with AJE attributable to that journal over the study period. We used this calculation to measure the relative importance of a journal for interchanging information with the epidemiologic literature.

TABLE 1. Number of times that articles published between 1983 and 1999 cited articles published in the *American Journal of Epidemiology* (cited package)

Rank	Journal name	No. of citations	Cumulative %
1	*American Journal of Epidemiology*	14,334	8.0
2	*International Journal of Epidemiology*	3,529	
3	*American Journal of Public Health*	2,935	
4	*Journal of Clinical Epidemiology*	2,664	
5	*Journal of the American Medical Association*	2,573	14.6
6	*American Journal of Clinical Nutrition*	2,251	
7	*Journal of the National Cancer Institute*	2,040	
8	*New England Journal of Medicine*	1,800	
9	*International Journal of Cancer*	1,747	
10	*Lancet*	1,557	20.0
11	*Cancer*	1,504	
12	*Journal of Infectious Disease*	1,461	
13	*American Journal of Industrial Medicine*	1,424	
14	*British Medical Journal*	1,419	
15	*Circulation*	1,418	24
16	*Epidemiologic Reviews*	1,404	
17	*Social Science & Medicine*	1,396	
18	*Diabetes Care*	1,387	
19	*Cancer Epidemiology, Biomarkers & Prevention*	1,327	
20	*Preventive Medicine*	1,244	27.7
21	*Journal of Epidemiology and Community Health*	1,222	
22	*Environmental Health Perspectives*	1,196	
23	*Archives of Internal Medicine*	1,189	
24	*Cancer Causes & Control*	1,171	
25	*Epidemiology*	1,136	31.0
Subtotal		55,328	31.0
Next 175 journals		47,540	57.7
All other journals (n = 260)		75,528	100.0
Total		178,396	100.0

RESULTS

Journal articles citing AJE

A total of 178,396 citations from 460 journals cited articles published in AJE during 1983–1999 (table 1). Twenty-five journals accounted for nearly one third (31.0 percent) of all citations to AJE. The top 200 journals (i.e., these 25 plus the next 175 journals) we selected for our more detailed analysis accounted for 57.7 percent (n = 102,865) of all citations. Of all citations, 14,3343 (8 percent) were self-citations; that is, both the cited and the citing articles were published in AJE (5). Four of the five leading journals citing AJE were epidemiology/public health journals.

Journal articles cited by AJE

A total of 126,478 articles from 360 journals were cited by AJE during the study period. Of these, 14,334 (11.3 percent) were citations to other articles published in AJE (table 2). However, four of the five leading journals cited by AJE were clinical medical science journals (*New England Journal of Medicine, Lancet, Journal of the American Medical Association* (*JAMA*), and the *Journal of the National Cancer Institute*). The top 200 journals cited by AJE accounted for 79,224 (62.6 percent) of all references.

Specialty journals

Of the 277 specialty journals classified, 165 were clinical medical science journals. These journals accounted for approximately half (50.6 percent) of all combined citations to and by AJE (table 3). The proportion of clinical medical science journals that cited articles in AJE (49.5 percent) was similar to the proportion of articles published in AJE that cited the clinical medicine literature (52.1 percent).

Among the clinical medical specialty journals, those focusing on general/internal medicine (17.9 percent), cancer (10.4 percent), and cardiovascular disease (4.9 percent) had

TABLE 2. Number of times that articles published in the journals below were referenced by the *American Journal of Epidemiology* between 1983 and 1999 (citing package)

Rank	Journal name	No. of citations	Cumulative %
1	*American Journal of Epidemiology*	14,334	11.3
2	*New England Journal of Medicine*	4,293	
3	*Lancet*	3,956	
4	*Journal of the American Medical Association*	3,403	
5	*Journal of the National Cancer Institute*	2,799	22.8
6	*American Journal of Public Health*	2,496	
7	*British Medical Journal*	2,301	
8	*American Journal of Clinical Nutrition*	1,697	
9	*International Journal of Epidemiology*	1,680	
10	*Journal of Chronic Diseases*	1,661	30.5
11	*Circulation*	1,447	
12	*Annals of Internal Medicine*	1,190	
13	*Cancer*	1,124	
14	*International Journal of Cancer*	1,049	
15	*Journal of Infectious Diseases*	976	35.1
16	*Cancer Research*	911	
17	*Biometrics*	881	
18	*British Journal of Cancer*	816	
19	*American Journal of Obstetrics and Gynecology*	795	
20	*Journal of Clinical Epidemiology*	738	38.4
21	*Morbidity and Mortality Weekly Report*	733	
22	*Science*	707	
23	*Epidemiologic Reviews*	664	
24	*American Review of Respiratory Diseases*	655	
25	*Epidemiology*	655	41.1
Subtotal		51,961	41.1
Next 175 journals		27,263	62.6
All other journals (*n* = 160)		47,254	100.0
Total		126,478	100.0

the greatest number of combined citations within AJE; reference to infectious disease and endocrinology/metabolism publications each accounted for an additional 3.8 percent of all combined citations. Journals focusing on these five specialties accounted for more than 80 percent of the clinical medical science citations (74,693/92,283). Obstetrics/gynecology (2.2 percent) and pediatrics (1.8 percent) journals accounted for the next largest proportion of citations. Several journals of clinical specialties had fewer than 300 combined citations and accounted for less than 0.2 percent of all combined citations. These specialties included allergy, anesthesiology, dermatology, drugs/addiction, gastroenterology, orthopedics, otorhinolaryngology, pharmacology/pharmacy, radiology/nuclear medicine, rheumatology, surgery, urology/nephrology, and veterinary medicine.

Time trends

Based on the citation patterns, interactions between AJE and all three general fields show steady increases from 1983 to 1999 (figure 2). The trend line for the clinical medical science journals is similar to that for epidemiology/public health journals. Combined citations for clinical medical science journals increased by 158 percent during the study period, from 3,009 in 1983 to 7,751 in 1999. For epidemiology/public health journals, the number of citations increased by 220 percent, from 1,793 in 1983 to 5,735 citations in 1999. For publications concerned with the field of basic science, the number of citations increased by 312 percent, from 502 to 2,066 during the same period.

Figure 3 presents the trends for selected clinical medicine specialties. Among these, citations to cardiovascular and cancer journals had the sharpest upward trends. From 1983 through 1999, the number of combined citations for cardiovascular and cancer specialty journals increased by 355 percent and by 288 percent, respectively. Smaller increases were seen for publications representing other specialties. Citations increased by 235 percent for infectious disease journals and by 97 percent for those focusing on general/internal medicine. The number of citations for pediatrics,

TABLE 3. Citations to and by the *American Journal of Epidemiology by clinical medical science specialty category for 1983–1999**

Category	No.	Cited AJE†		Citings by AJE		Combined	
		No.	%	No.	%	No.	%
Allergy	0		0.0		0.0		0.0
Anesthesiology	0		0.0		0.0		0.0
Cancer	20	11,027	10.7	7,983	10.1	19,010	10.4
Cardiovascular	15	5,509	5.4	3,467	4.4	8,986	4.9
Dentistry/odontology	0		0.0		0.0		
Dermatology	0		0.0		0.0		
Drugs/addiction	3	246	0.2	42	0.1	288	0.2
Endocrinology/metabolism	14	4,602	4.5	2,370	3.0	6,980	3.8
Gastroenterology	3		0.0	301	0.4	301	0.2
Geriatrics/gerontology	3	992	1.0	489	0.6	1,483	0.8
Hematology	3	490	0.5	202	0.3	693	0.4
Infectious disease	11	5,274	5.1	1,721	2.2	7,002	3.8
Medicine, general/internal	27	13,936	13.5	18,742	23.7	32,715	17.9
Neurosciences	6	1,300	1.3	420	0.5	1,722	0.9
Obstetrics/gynecology	12	2,407	2.3	1,531	1.9	3,942	2.2
Ophthalmology	12	388	0.4	716	0.9	1,105	0.6
Orthopedics	3		0.0	106	0.1	106	0.1
Otorhinolaryngology	0		0.0		0.0		0.0
Pediatrics	9	1,831	1.8	1,436	1.8	3,271	1.8
Pharmacology/pharmacy	2	65	0.1	16	0.0	81	0.0
Psychiatry/psychology	7	457	0.4	528	0.7	986	0.5
Radiology/nuclear medicine	2	119	0.1	89	0.1	208	0.1
Respiratory system	4	1,184	1.2	707	0.9	1,893	1.0
Rheumatology	2	183	0.2	63	0.1	246	0.1
Surgery	1		0.0	23	0.0	23	0.0
Tropical medicine	2	700	0.7	258	0.3	959	0.5
Urology/nephrology	1		0.0	41	0.1	41	0.0
Veterinary medicine	3	220	0.2			220	0.1
Subtotal	165	50,930	49.5	41,251	52.1	92,283	50.6
All journals	277	102,865	100.0	79,224	100.0	182,089	100.0

* For the top 200 subentries for "cited" and "citings" under the *American Journal of Epidemiology* in the *Journal Citation Reports*. See text for details.
† AJE, *American Journal of Epidemiology*.

however, remained relatively stable throughout the study period, increasing by only 16 percent, from 159 in 1983 to 184 in 1999.

Adjusting for epidemiology impact quotient

The 20 clinical medical science journals that most frequently referenced or were referenced by AJE (table 4) accounted for an annual average of 17 percent of all citations between clinical medical science journals and AJE. The journals with the highest citation frequency were the *New England Journal of Medicine* and the *Journal of the American Medical Association*. Each averaged more than 350 combined citations per year over the 17-year study period. The rankings for these two journals based solely on frequency of citations were unchanged after adjusting for their epidemiology impact quotient. However, the rank order for many other journals did change after adjustment. The journals *Cancer Research* and *Diabetes*, which were ranked 13th and 19th, respectively, on the basis of their average number of citations per year, each rose by six places in the rankings after adjusting for their epidemiology impact quotient. The *International Journal of Cancer*, which ranked seventh with an average of 165 citations per year, fell to a rank of 11th after adjusting for its epidemiology impact quotient. Its relatively low journal impact factor caused its decline in rank.

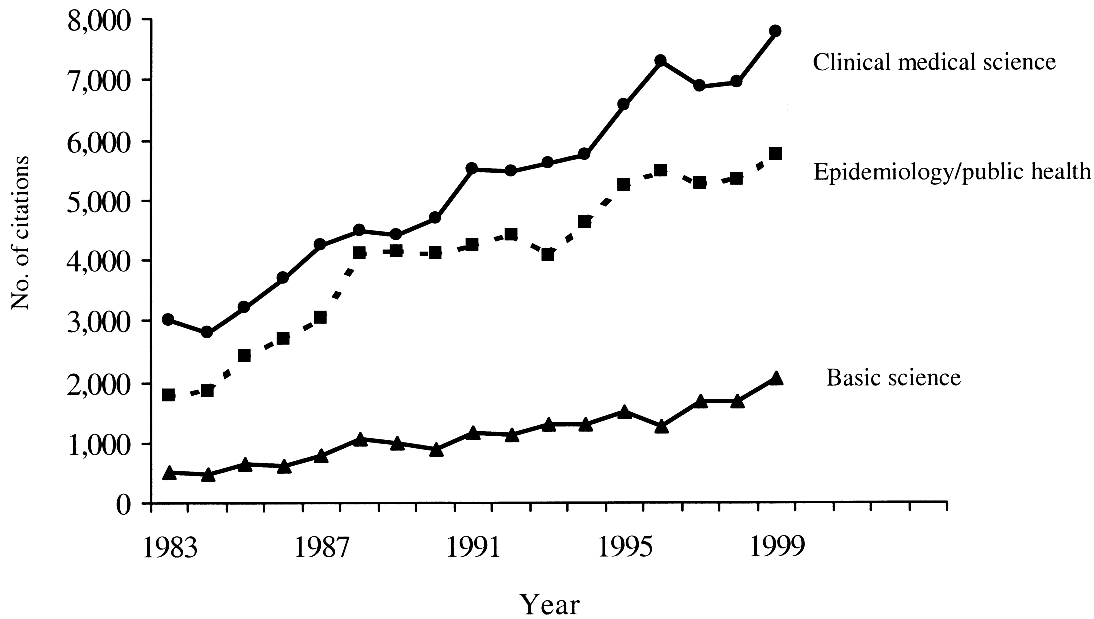

FIGURE 2. Time trends for combined citations to and from the *American Journal of Epidemiology* by general field, 1983–1999.

DISCUSSION

Consistent with the findings of the earlier study (2), the largest number of citations to and by AJE in this study were self-citations. Journals typically have self-citation rates of approximately 13 percent (4), which is expected because a field builds on work that is circulated in its own journals.

We found that four of the top five journals that cited articles in AJE were epidemiology/public health journals. This finding is also a reflection of journals supporting the development of their given field. We found that the journals most often cited by AJE were clinical medical science journals. Three of the top five were in the specialty category of

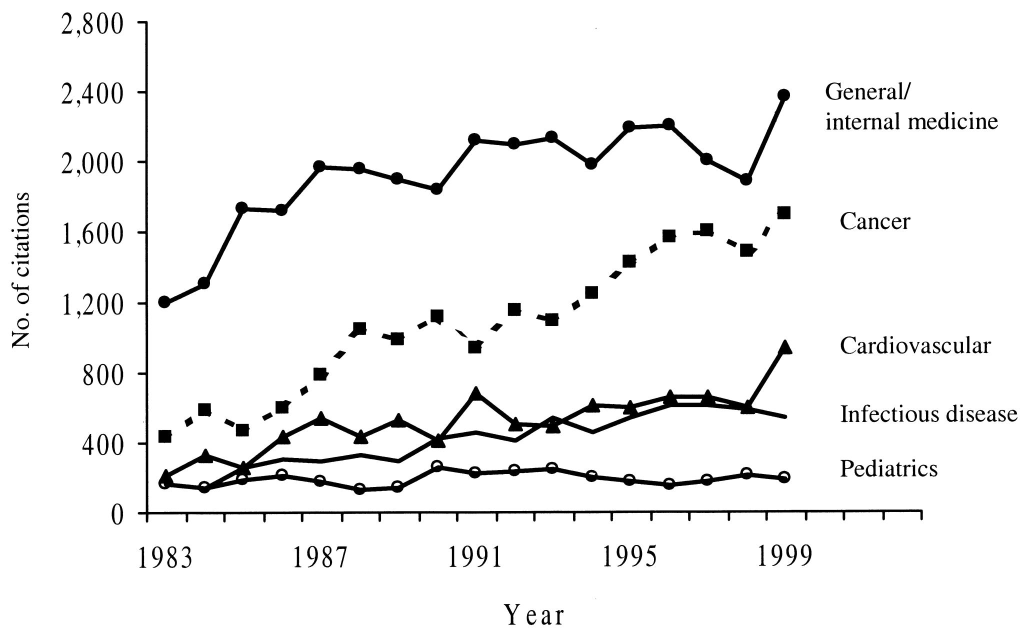

FIGURE 3. Time trends for combined citations to and from the *American Journal of Epidemiology* by selected clinical medical science specialty categories, 1983–1999.

TABLE 4. Leading clinical medical science journals cross-referencing with the *American Journal of Epidemiology* from 1983 to 1999 by rank order and epidemiology impact quotient

Journal name	Average annual no. of citations	% of all citations	Rank	Impact factor*	Epidemiology impact quotient†	Adjusted rank	% of change
New England Journal of Medicine	358.4	2.0	1	28.86	57.72	1	
Journal of the American Medical Association	351.5	2.0	2	11.44	22.88	2	
Lancet	324.3	1.8	3	10.20	18.36	4	–1
Journal of the National Cancer Institute	284.6	1.6	4	12.95	20.75	3	1
British Medical Journal	218.8	1.2	5	5.14	6.17	6	–1
Circulation	168.5	0.9	6	9.90	8.91	5	1
International Journal of Cancer	164.5	0.9	7	3.55	3.20	11	–4
Cancer	154.6	0.9	8	3.63	3.27	10	–2
Journal of Infectious Disease	143.4	0.8	9	4.84	3.87	9	
Archives of Internal Medicine	107.6	0.6	10	6.71	4.03	8	2
Diabetes Care	105.7	0.6	11	5.08	3.05	12	–1
British Journal of Cancer	105.3	0.6	12	3.28	1.97	14	–2
Cancer Research	101.5	0.6	13	8.61	5.17	7	6
Pediatrics	90.9	0.5	14	3.49	1.75	16	–2
American Journal of Obstetrics and Gynecology	86.6	0.5	15	2.40	1.20	17	–2
Hypertension	64.8	0.4	16	4.91	1.96	15	1
American Review of Respiratory Diseases‡	62.0	0.4	17				
American Journal of Medicine	55.1	0.3	18	4.98	0.60	18	
Diabetes	50.3	0.3	19	9.02	2.71	13	6
American Journal of Tropical Medicine & Hygiene	50.3	0.3	20	1.93	0.58	19	–1

* Measure of the frequency with which the “average article” in a journal was cited in 1999. See text for details.
† Product of the journal impact factor and the percentage of all citations attributable to that journal. See text for details.
‡ Impact factor not reported for 1999.

general/internal medicine. A cancer journal ranked fifth. These findings suggest that the work being done in clinical medicine is highly relevant to epidemiologic research.

The frequency of citations, both by AJE and to AJE, among the three general fields has remained unchanged from the previous study (2). Clinical medical science continued to account for half of the total combined citations. However, our study demonstrated a greater balance in the direction of citations. In the earlier study, citings by AJE to clinical medical science journal articles represented 53 percent of all combined citations to other works, and citings by clinical medical science journals to AJE accounted for 43 percent of all journals that cited AJE in 1976–1982. In the present study, the citation rates for clinical medical literature’s citing epidemiologic literature were equal to the citation rates for epidemiologic literature’s citing clinical medical literature.

Overall, the medical specialties that demonstrated the highest combined citation rates with epidemiology over the entire 17-year study period have remained unchanged compared with the earlier study (2). Most fields identified by the previous study as having low rates also had low rates in our study. However, we found that certain specialties increased their interchange with the epidemiologic literature. Publications concerning endocrinology, which were found to have low citation rates with AJE (<1 percent) in the previous study (1976–1982), accounted for nearly 4.0 percent of total combined citations during 1983–1999. Geriatrics/gerontology, neuroscience, and ophthalmology journals were others showing increased citation rates with AJE since the early 1980s. Other specialty journals (e.g., those specializing in pediatrics and the respiratory system) increased only slightly or decreased in citation rates compared with the previous study period.

The infectious disease specialty category accounted for about 4 percent of total combined citations. Because the earlier study did not categorize infectious disease as a medical specialty (it was instead represented through the tropical medicine and dermatology/venereal diseases specialty categories), no cross-study comparisons can be made. In this study, we found an imbalance in citations between infectious disease journals and AJE (table 3). Infectious disease journals were more than twice as likely to cite articles from the epidemiologic literature (e.g., cited AJE) than the converse (e.g., citings by AJE). This pattern reinforces the fact that the epidemiologic information is highly relevant to infectious disease research.

Examination of trends showed upward slopes in combined citation rates among all three general fields over the study period, suggesting that the use of epidemiology has steadily increased across both basic and clinical sciences. Trends of selected clinical specialties suggest that cardiovascular and cancer specialties had the greatest growth in citation activity over the study period, whereas rates between infectious disease and epidemiology grew steadily only to level off in the late 1990s (figure 3).

The epidemiology impact quotient was used to identify individual clinical medical journals that have demonstrated high use of epidemiologic information. This measure reveals more about a journal's level of contribution to the literature that links clinical medicine and epidemiology by accounting for factors such as size, frequency of publication, and circulation. Our results indicate that the best publishing venues for circulating epidemiologic findings and ideas that are relevant to clinical medicine might not be those journals that have the highest citation rates with AJE. Journals with the highest citation rates with AJE may not be as important as those with high citation rates and high journal impact factors. Adjusting for the epidemiology impact quotient, which takes both characteristics into account, resulted in substantial shifts in the rankings (table 4). The journals with the highest epidemiology impact quotient were in the general/internal medicine category and include the *New England Journal of Medicine*, the *Journal of the American Medical Association*, and *The Lancet*. Given their higher visibility and demonstrated support for epidemiology, these interdisciplinary journals are highly desirable venues for publishing epidemiologic research.

The improved balance in citation patterns compared with the previous study (2) illustrates an increased use of the epidemiologic literature by medical specialties. As epidemiology continues to become more useful and relevant to the field of clinical medicine, the fields become increasingly mutually dependent. This increasing interdependence has been described as creating a health climate in which "medical organizations' and physicians' economic viability is becoming dependent on population-based data, epidemiologic analysis, and public health strategies" (9, p. 36).

Shifts in citation patterns among specific specialties and epidemiology can be attributed to several factors. Shifting patterns could represent changes in the availability and accessibility of resources for research, which subsequently affect what and where research is published. The specialties that underutilized epidemiology, as well as those that show signs of decreasing use, may be accessing and publishing epidemiologic research within their own literature or within the general/internal medicine literature. In either case, in our analysis the use of epidemiologic research would be underestimated. In addition, the specialties that demonstrate low citation rates with the epidemiologic literature might not lend themselves to epidemiologic methods. For example, a hospital-based specialty (e.g., anesthesiology) may have less need for population-based data than an acute-care specialty (e.g., infectious disease), which has an established dependence on epidemiologic methods. Answers to these questions require in-depth study on the specialty level.

Examination of the number of articles indexed per publication year in Medline showed a 1.5-fold increase over the study period, from 287,777 in 1983 to 426,143 in 1999. The 2.5-fold increase in citation rates between clinical medical journals and AJE outpaced the growth of published materials, lending further evidence to the growing interdependence between the two fields. A sharp increase in the slopes in both the clinical medicine and epidemiology/public health citation curves beginning in 1993 could be attributed to several significant technical developments that occurred about this time. In the early 1990s, the Internet/World Wide Web became more prevalent in academic and research communities, thereby improving, increasing, and expediting access to published materials. In 1992, AJE switched from a monthly publication to a biweekly publication, potentially increasing the number of articles in circulation per publication year and subsequently increasing the number of expected citations to it (10). However, a Medline review of the number of indexed articles by AJE from 1992 to 1999 remained relatively constant. The increased frequency and improved access to AJE, coupled with the parallel upward sloping of the clinical medical science and the epidemiology/public health curves, suggest that the fields are growing in tandem. Epidemiology likely has been successful in identifying and meeting the needs of the clinical medical communities.

Shifts in citation patterns can be attributed to shifts in mortality trends and research priorities, as well as to the effective use of epidemiology in disease detection and prevention by infectious disease researchers. As the chronic disease-related health burden increased over time, so did the use of epidemiologic methods by chronic-disease researchers and the subsequent number of published epidemiologic studies addressing chronic-disease issues (11). The epidemiologic approach in application to chronic disease research continues to expand, as does the body of research linking many chronic diseases to infectious agents (12, 13).

Steady increases in citation rates to AJE by infectious disease journals from 1983 to 1995 may be attributed to the concurrent growth in acquired immunodeficiency syndrome (AIDS) research. AIDS-related journals (e.g., *AIDS* and the *Journal of Acquired Immune Deficiency Syndrome*) provide additional publishing opportunities for infectious disease researchers. These journals may be responsible for the dramatic decrease in the number of infectious disease-related articles published in AJE in the recent past (14). The leveling off in citation activity between epidemiology and infectious disease literature from 1996 through 1999 does not necessarily point to a slowing of the use of epidemiologic information among infectious disease researchers. The number of indexed articles by Medline for the journal *AIDS*, for example, has increased annually since its inception in 1988, indicating that AIDS researchers are seeking specific specialty journals in which to publish.

Our findings are subject to several limitations. The citation indexing system used to tabulate and analyze citation patterns does not comprehensively maintain citation information for literature from every country in the world. Journals indexed by the system are subject to inclusion criteria, which necessarily limit the pool of information from which results are drawn (15). For example, few non-English language and low circulation journals are indexed. The JCR, however, is the most comprehensive resource available, and the effect that these limitations have on our general findings is likely negligible.

Many variables can influence the impact factor of a journal and its ranking in journal lists. Title changes will have short-lived effects on the impact factor of a journal. The inclusion of review articles, which are generally cited more often than typical research articles, could result in a disproportionate number of citations, thereby elevating the title in rank and impact. The inclusion of letters could affect a journal's rank and impact. However, most journals publish primarily substantive research or review articles, and statistical discrepancies are only rarely significant (16). Variations in the ranges of peak impact factor can occur between different disciplines; therefore, viewing journals in the context of their specific specialty field (e.g., cancer) may be more useful than viewing them within general fields (e.g., clinical medicine) (6). Notwithstanding these limitations, the journals with high impact factors are among the most prestigious and most selective (16, 17), which validates our use of the journal impact factor and citation counts in the construction of the epidemiology impact quotient.

Generalizing findings based on citation trends with a single journal is risky, because epidemiologic studies are published in a variety of journals. Although AJE has been identified as being the premier journal in the field and arguably the best platform for circulating epidemiologic research in and between fields, how and why information is cited are not revealed through these analyses. Citation analysis can measure neither the quality nor the significance of usage. High citation rates and high impact factors do not necessarily reveal the relevance or value of articles published in a particular journal. Nonetheless, the prestige garnered from a high profile journal with a widespread circulation is indisputable.

Our objective was to evaluate the exchange of epidemiologic information within the field of clinical medicine. The success of any information science is related to its relevancy and accessibility to a defined group of users. Citation analysis, in spite of its limitations, provides a useful means by which to measure these performance attributes. Steady upward trends in citation activity between epidemiology and the clinical medical sciences indicate that epidemiologists continue to generate highly relevant information products. These increases also suggest that epidemiologists are not merely becoming more prolific but are improving access to their work by publishing more frequently in journals with high impact factors. Apparent gaps and declines in the use of epidemiologic information could be interpreted in numerous ways but must be considered as opportunities for growth in the field of epidemiology. For example, the various clinical medical specialties identified in this study as having low citation activity with the epidemiologic literature (e.g., allergy, anesthesiology, and dermatology) may represent fields ripe for new epidemiologic studies. The results of this study suggest that, although epidemiologists appear to be effectively recognizing, responding to, and anticipating the information needs of the field's users working in clinical medicine, broadening their focus to include certain additional medical specialties may enhance their contributions.

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