Library Journal Use and Citation Half-Life in Medical Science

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This study investigated the in-house use half-life of journals in the Library of Veterans General Hospital, Taipei, and their citation half-life, and the difference between them. The use study employed the sweep method and the study period lasted for 6 months. The citation half-life of each journal of this study was based on the data listed in the *Science Citation Index, Journal Citation Reports, 1993.* The results of this study illustrate that publication frequency, journal age, language, and country of publication, and subject category all are related to both use and citation half-lives. In addition, the use half-life also reflects the extent of holdings of particular titles in the local library. The mean use half-life of the total 835 journals is 3.43 years, which is significantly shorter than the mean citation half-life, 6.28 years. The difference between mean use half-life and mean citation half-life is 2.85 years, and is statistically significant as revealed by the *t* test.

Introduction

Obsolescence is one of the major foci of library journal use and citation use study. The essential question to be answered by a study of obsolescence is: "How long will a publication continue to be used after it has been published?" Line and Sandison (1975, p. 286) stated that obsolescence implies a relationship between use and time, and can be investigated by synchronous and diachronous methods. Synchronous studies are made on records of use or bibliographic references made at one point in time, comparing the use against the age distribution of the material used or cited. Diachronous studies follow the use of particular items through successive observations at different dates. After the "half-life" of a particular journal has been determined, one can then establish the obsolescence rate of that journal. The "half-life" is a term borrowed from nuclear physics. Burton and Kebler (1960, pp. 18–19) are credited with first using the term "half-life" in 1960 in the subject of scientific and technical literature, and they defined the term as "that time required for the obsolescence of one-half the currently published literature" or "the time during which one-half of all the currently active literature was published." Line (1970, p. 51) pointed out that in a synchronous study, one commonly reported measure is the "median citation age"—the number of years required to encompass the more recent 50% of all references made. The rate of obsolescence is determined by median use age, theoretically.

The annual *Journal Citation Reports (JCR)* (1992), published by the Institute for Scientific Information (ISI), lists "citing" and "cited" half-life values for indexed journal titles. The first is the median citation age, the second is the diachronous measure. Todorov and Glanzel (1988) distinguish between "cited half-life" and "citing half-life" but describe both as median citation ages. Lancaster (1991, p. 25) pointed out that the "cited half life shows how far back in time one must go to account for one half of the citations a journal receives in a given year." Clearly, a cited half-life reflects different journal characteristics. A journal with long half-life might suggest that it publishes articles of more enduring value. On the contrary, a short half-life journal of rapid obsolescence contains ephemeral articles.

More librarians today must deal with the information explosion of journal literature and, therefore, have to make difficult decisions on weeding or storing less needed collections. A study of journal half-life, whether in-house use half-life or citation half-life, would help to guide the planning of library collections and information services. In the literature, there is essentially no study exploring the relationship between in-house use half-life and citation half-life, though separate studies in both are quite abundant (see Line & Sandison, 1975; Gapen & Milner, 1981; Vlachy, 1985; and Line, 1993). Perhaps, Guitard's study, in 1985, on comparing the half-lives of photocopy request in the Spanish Institute of Scientific and Technical Information with *Science Citation Index (SCI)* data of citation half-life, is the only one. Guitard (Line, 1993, p. 673) found that the citation half-life is shorter than the one for use. King, Mc-

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Donald, and Roderer, (1981, p. 172) compiled data of citation half-life for various scientific fields and half-life for all uses of physical sciences, psychology, and social sciences. The data shows that direct comparison can only be made for the field of botany, which shows that the citation half-life is much longer than use half-life. It is not clear whether such a single observation can be generalized or not. Moreover, the use half-life data compiled by King et al. are very short, from 0.2 to 0.9 years. It is not clear how these data were determined.

The objective of the present study is to investigate the in-house use half-life of journals in the Library of Veterans General Hospital, Taipei, and their citation half-life, and the difference between them. Medical science journals were selected as the basis for this study because it is a subject area of rapid change. Brookes (1970, p. 321) has cautioned people, interested in measuring obsolescence, to pick a relatively fast-developing scientific subject area, thereby, one in which a reliable constant measure of obsolescence can be obtained. The particular library was selected for this study because: (1) Veterans General Hospital is one of the two biggest hospitals, and the major educational hospital in Taiwan; and (2) it is the most productive hospital in Taiwan, in terms of the journal articles published by its researchers. Journal use should, therefore, reflect the full range of activities in medicine—education, research, and clinical practice.

Hypothesis and Methodology

It is known that the most direct comparison would have compared patterns of use in the library with citation patterns of the same uses. However, the number of articles published by a single institute in a year or two may not be significant, even compared to the number of journals in the subject. Consequently, the number of citation would not be significant, and the citation half-life, thus compiled, could be very scattering. It should also be noted that not all uses are for scholarly purposes. As a hospital library, most journals are used for clinical practice. On the other hand, the purpose of this study is to examine if there is a significant relationship between use in a local medical library and global citation use. If such a relationship does exit, it is unnecessary to conduct a use study, and citation data could be compiled easily from *JCR*. This requires much less effort than conducting citation studies from the publications of local users. Therefore, the journals covered in *JCR* and available in the Library of Veterans General Hospital, Taipei, were selected as the object of this study. The following hypothesis is made: The use half-life of journals in a particular medical library is not significantly different from the citation half-life of these journals as reflected in the *JCR*.

The use study should be simple enough to gain the most information without placing an unreasonable burden on the librarian or intruding on users. Therefore, this survey employed the sweep method. That is, it counted journals, bound and unbound, as they were reshelved after being picked up, several times each day, from tables and carts where they were left by users. The publication year of each journal was also recorded. The study period lasted for 6 months, i.e., from November 1, 1994 to April 30, 1995. After the completion of data collection, the use half-life of each journal was evaluated based on its definition: The number of years required to encompass the first 50% of the total use that title received.

This study assumed that it is possible to develop an accurate picture of in-house journal use despite the following: (1) Journals reshelved by a user are not counted. If a volume is taken from the shelf, some form of use is made of it. However, it is assumed that if a user reshelved a volume immediately after examining it, then use was negligible; (2) when patrons picked up an issue already used by someone else and placed it on a shelving cart, or when patrons photocopied more than one article of each issue, the study counted it as only one use. Although the study design did not account for journals used and reshelved by users, and those used more than once are treated as one use, this does not necessarily limit its usefulness in measuring the studied journals' relative use with respect to each other. Since the bound volume is too heavy to hold and read in the stacks, most users tend to bring it to a study area. This reading behavior reduced the possibility of journal reshelving by the user. The two procedures indicated above may yield the biggest limitation of this study: It underestimates the total use. However, such underestimation would prevail on each volume of a journal, and it is anticipated that it will not influence the journal use half-life significantly.

For journal citation studies in the sciences, the most reliable tools for citation analyses are the annual *SCI Journal Citation Reports.* The first *JCR* was published in 1975 and analyzed citations for the 1974 *SCI.* The citation half-life of each journal of this study was based on the data listed in the *Science Citation Index, Journal Citation Reports,* 1993. This study was a synchronous type comparison between journal library use and journal citation use. The data collection for the library use study was completed by April 30, 1995, while the corresponding part of the citation use can only be derived from the 1993 issue of *JCR* because of the time lag in production of *JCR.* Therefore, there was a difference in time period covered with most library use data from 1994 and 1995, and *JCR* data from 1993. Although there are somewhat different time periods—literature used in a particular year versus citations to earlier literature, there is a fair degree of stability in citation from year to year in the most cited journals, while more variability is present for the periphery. New titles would clearly be at a disadvantage, but, for established titles, the difference in half-life would change insignificantly in 2 years. Comparing the *JCR* issues from 1992 to 1995, a stability of the citation distribution can be obtained. For example, the journals with highest impact factor and their corresponding half-life in the subject area of general and internal medicine are quite similar. Therefore, this discrepancy could be acknowledged as a limitation of this study, but it should not be considered a serious limita-

TABLE 1. Distribution of journal citation half-life.

Half	>10	9.0–9.9	8.0–8.9	7.0–7.9	6.0–6.9	5.0–5.9	4.0–4.9	3.0–3.9	2.0–2.9	1.0–1.9	0–0.9
Title	74	45	73	97	145	171	127	64	27	7	5
%	8.9	5.4	8.7	11.6	17.4	20.5	15.2	7.7	3.2	.84	.6

tion. Using the data obtained in this study, a statistical test, i.e., *t* test was applied to explore the difference between use and citation half-life.

Nature of Use and Citation Half-Life Data

The journals covered in *JCR* and available in the Library of Veterans General Hospital, Taipei, were selected as the object of this study. This results in 835 titles for the investigation.

Citation Half-Life

JCR 1993 microfiche edition did not provide an exact number for journals with a citation half-life greater than 10 years, but used ≥10 to substitute. In this study, 74 titles belong to this category. The half-life of the remaining 761 journals range from 0.5 to 9.9 years. A complete list of citation half-life in descending order, and corresponding use half-life and rank is given in Tsay (1996). It should be noted that the half-life of 54 titles is not found in *JCR* 1993; it is calculated based on the definition of citation half-life, i.e., the number of years required to encompass the first 50% of all citations received. For example, the total citation number for *American Journal of Gastroenterology* is 4,727, and the 50% of all citations is 2,364. At age 5, the accumulated citation number is 2,248 which is less than 2,364; at age 6, the accumulated citation number becomes 2,684, which is greater than 2,364. Therefore, the citation half-life is: $5 + (2{,}364 - 2{,}248)/(2{,}684 - 2{,}248) = 5.27$ years. Only two significant digits, i.e., 5.2 years, were given for this journal in *JCR* 1993. In the following section, the use half-lives were also determined in the same way.

As can be seen from Table 1, 171 out of 835 (20.5%) journals have citation half-life of 5.0–5.9 years. More than half of the journals (443 out of 835) aggregate in the cluster of citation half-life from 4.0 to 6.9 years, especially from years of 5.0 to 6.9 years.

The mean citation half-life of the total 835 journals is 6.28 years. Excluding 74 journals, whose half-life is equal to, or greater than, 10 years, the mean citation half-life of 761 journals is 5.92 years.

Use Half-Life

The data of use half-life in descending order and corresponding citation half-life and rank are listed in Tsay (1996). The mean use half-life of the total 835 journals is 3.43 years, and is 3.60 years if 39 zero-use journals are omitted. Excluding 74 titles whose citation half-life is equal to, or greater than, 10, the mean use half-life of the remaining 761 titles is 3.07 years. Both are significantly shorter than those for citation. The relatively short mean use half-life indicates that new volumes of a title are generally used more often than older volumes. This agrees with Line and Sandison's (1975) assertion. They proposed that most library use patterns are updating use, and that this kind of use is concentrated on relatively recent items, published mainly in the last 2 or 3 years.

Table 2 demonstrates that more than half of the total journals (472 out of 835, 56.5%) have use half-lives ranging from 0 to 2.9 years. Among them, 186 journals (22.3%) have half-lives from 2.0 to 2.9, and 167 journals (20%) have half-lives from 1.0 to 1.9. In general, the shorter the half-life, the more the journal number is. There are 32 titles with use half-life equal to, or greater than, 10 years.

Citation Half-Life and Use Half-Life of Four Categories (All Titles)

To gain more insight about the relationship between use half-life and citation half-life, the 835 journals were divided into four subject categories and the *t* test was done for each category. *Journal Coverage of the Current Contents*, April 1992, a booklet listing all of the journals covered in the *Current Contents* database, was consulted for the determination of each journal's subject category. For those journals that would not be found there, several *Current Contents: Clinical Medicine* and *Current Contents: Life Science* issues of 1995 were checked. Category A included clinical medicine journals; category B consisted of life science journals; journals which publish both clinical medicine and life science articles were classified as category C; and category D contained the rest, which publish neither clinical medicine nor life science articles. This grouping resulted in 266 titles for category A, 328 titles for category B, 206 titles for category C, and 35 titles for category D.

As indicated earlier, the mean citation half-life of the total 835 journals is 6.28 years. Table 3 shows the distribution of mean citation half-life, and mean use half-life, for journals of categories A, B, C, and D.

The mean half-lives for journals of categories A, B, C, and D of 761 titles, excluding the 74 journals with citation half-life longer than 10 years, also shows a distribution similar to Table 3, which treats citation half-lives ≥10 years as 10 years.

In general, mean citation half-lives are greater than mean use half-lives, regardless of the basis of calculation or categorization. Journals dealing with both clinical medicine and life science, i.e., category C, have the longest mean

TABLE 2. Distribution of journal use half-life.

Half	>10	9.0–9.9	8.0–8.9	7.0–7.9	6.0–6.9	5.0–5.9	4.0–4.9	3.0–3.9	2.0–2.9	1.0–1.9	0–0.9
Title	32	10	12	20	24	36	82	147	186	167	119
%	3.8	1.2	1.4	2.0	2.0	4.3	9.8	17.6	22.3	20.0	14.3

citation half-life (6.64 years) and mean use half-life (4.0 years). The mean use half-life of the life science journals is somewhat greater than that of clinical medicine journals. Journals contributing nothing directly relevant to medical science, i.e., subject category D, have the second longest mean citation half-life (6.44 years), but have the shortest mean use half-life (1.13 years). This indicates that these journals have been cited for a much longer time universally, while their local use is with the shortest use half-life. These journals appear to become obsolete rapidly in the local library. They may be used more for current awareness and less for research. Overall, the mean half-life of use and citation for journals of each subject category is quite similar, except journals of subject category D, whose mean use half-life differs substantially.

This study shows heavy use of the most recent literature and a lower use of items more than 3 years old. Most journals receive heavy use for 1, 2, or 3 years and then settle down to a steady use over subsequent years (Tsay, 1996). The use analysis demonstrates rapid obsolescence and short half-lives.

Nature of Journals with Citation Half-Life Equal to, or Greater than, 10 Years

It would be interesting to examine journals with citation half-life equal to, or greater than, 10 years in more detail based on their initial date of publication, publication frequency, and subject category. The *Serials Directory* (1995) CD-ROM edition, produced by EBSCO, was consulted for this information.

Table 4 shows that most journals with longest citation half-lives are likely to be published monthly (37 out of 74, including one journal published 11 times a year) and bimonthly (19 out of 74, including one journal published 7 times a year). This suggests that medical journals published monthly or bimonthly may be stored longer in the library than other titles. Eight titles are published quarterly, and only one journal publishes semiannually. The shortest time interval of publication is 23 times a year. It might be equivalent to a biweekly or semimonthly publication. No journals published weekly have a half-life longer than 10 years.

TABLE 3. Citation half-life and use half-life among categories A, B, C, and D.

	A Clin Med (266 titles)	B Life Sci (328 titles)	C Life Sci/Clin Med (206 titles)	D Other (35 titles)
Citation-half-life	6.06	6.20	6.64	6.44
Use-half-life	3.02	3.64	4.00	1.13

Journals with a longer citation half-life are, in general, older than journals with shorter half-lives because a longer time span of material is available to be cited. Table 4 also indicates that *American Journal of the Medical Sciences, Brain,* and *American Journal of Ophthalmology* are all over 100 years old. Among them, the oldest one (168 years) is *American Journal of the Medical Sciences. Brain* is 117 and *American Journal of Ophthalmology* is 111, respectively. There are six, six, and seven journals aged over 90, 80, and 70 years, respectively.

The 74 less obsolescent journals are published all over the world. The United States is the source of most of these 74 journals. European countries, including Sweden, Norway, Denmark, Switzerland, Belgium, the Netherlands, and Italy, also contribute some journals that were cited for relatively longer time. While most of them are published in English, multiple language journals still play significant roles. As can be seen from Table 4, titles with the word "Acta," or "Scandinavica" are all journals typically published by the Northern European countries. And some of them are multiple language publications with English, French, and German. Two Italian journals cover articles or summaries written in English, French, German, or in Italian, French, and Spanish. There are two Asian journals, one is published in Japan and the other in India.

Journals of clinical medicine, the largest subject category with various branches, dominate journals with longest citation half-lives. Among them, ophthalmology is the most significant subject that contains six titles. Dentistry and surgery come next, and each include five journals. Pharmacy, otorhinolaryngology, orthopedics, neurology, and pathology each include three journals. The diseases of the eye have been studied and treated from the very beginnings of medicine. The modern literature of dentistry has developed since the mid-19th century. Otorhinolaryngology developed over the last 100 or so years as ear, nose, and throat surgery (Morton & Godbolt, 1992). Evidently, ophthalmology, dentistry, and otorhinolaryngology are all well developed subjects with stable methods of clinical treatment. Therefore, most of their journals contain active literature that would last for a long time. It is speculated that researchers in these long established specialties would tend to cite older articles which are pertinent to their research. Surgery, orthopedics, and neurology are rapidly changing fields. However, it is not clear why these journals ranked high in the list of citation half-life $\geq$10 years. Further study is needed.

There are nine general medical science journals whose citation half-lives are equal to, or greater than, 10 years. Most of them are obviously nationally oriented. For examples, *Acta Medica Scandinavica and Scandinavian Journal of Rehabilitation Medicine* are Swedish publications. *Indian Journal of Medical Research* publishes the results of work, mainly from authors of India. *Bulletin of the New York Academy of Medicine, New York State Journal of Medicine,* as well as *American Journal of the Medical Sciences* are all American publications. *Proceedings of the Royal Society of Medicine—London* is obviously a British periodical.

Nature of Journals with Use Half-Life Equal to, or Greater than, 10 Years

There are 32 journals with use half-lives equal to, or greater than, 10 years. Ten of them have a half-life greater than 22 years. The journal with the longest half-life is *Journal of Pharmacology and Experimental Therapeutics.* The holdings for this journal dated from 1951 to 1978. Its total use frequency is 25 only, but most (17 times) of its use aggregate in the issues published from 1960 to 1975. Consequently, it has a very long half-life. *Helvetica Chimica Acta,* the second longest half-life (23.5 years) journal, is another case with a similar situation. It was used only three times for issues dated from 1966 to 1975.

Most of the journals with a use half-life greater than 10 years were used quite infrequently. Some of them were used only once, twice, or three times. In the meantime, their holdings are usually limited to a short period and are before mid-1970. Therefore, with a 20 years or so use age, it is very likely to obtain a half-life greater than 10 years. This phenomenon and the previous two longest half-life journals reflect that a journal with a long half-life may not be equivalent to slow use obsolescence. A journal use half-life must be confined to what the library has and is subject to internal biases determined by the library stock.

Three of the journals with a use half-life greater than 10 years, namely, *Archives of Dermatology, Journal of Bone and Joint Surgery—American Volume,* and *Medicine,* however, fit the usual perspective on journals with a long half-life. These three journals were used heavily, and their use frequency distributed quite uniformly since the beginning date of their holdings.

To investigate in more detail the nature of journals with longer half-lives, Table 5 illustrates the holding period, publication frequency, and subject field of journals with use half-life equal to, or greater than, 10 years. The following provides more in-depth discussion.

It is interesting to note from Table 5 that three-fourths of the journals (24 out of 32) with use half-life $\geq$10 years have holdings that are closed, i.e., their holdings began with a particular year and ended with another one, or were for a single year. Thirteen titles out of these 24 have holdings closed by 1980. Two reasons can be ascribed to this phenomenon: One is discontinued subscription by the library, the other is the variation of journal titles, such as name changed to a new one, old title split into two titles, or ceased publication. There are eight journals with open holdings.

As observed for journals with citation half-life equal to, or greater than, 10 years, most journals that were used with a longer half-life ($\geq$10 years) are published monthly (20 out of 32, including one journal published 11 times a year, and another published 13 times a year) or bimonthly (6 out of 32, including one journal published 8 times a year). Two journals are published semimonthly and three are published quarterly. *Nature—New Biology* is the only weekly journal.

As indicated in Table 5, most journals whose use half-life is greater than 10 years deal with clinical medicine or biology. Two subject fields and associated titles that are not pertinent to medical science include chemistry and nutrition. There is one general science journal.

Journals in clinical medicine disperse widely among various specialties. Each specialty contains one to two journals. Pharmacy and pharmacology is another main discipline with significant relationship to clinical medicine. It includes three journals.

In summary, the holding period of journals is one of the major factors that dominates the longer use half-life, at least by users of the Veterans General Hospital Library. However, the longer half-life of use patterns of this study fit Line and Sandison's (1975, p. 314) assertion that "the date concerned is linked to the availability to individual readers [and] implies substantial differences between one title and another."

Statistical Tests between Use and Citation Half-Lives

This section conducts a *t* test between use and citation half-lives to explore their difference, if any. The tests are performed for all titles and for the four subject categories. In-depth discussions are provided.

General Comparison

As presented in the previous section, citation half-lives for the medical journals vary from 0.5 to longer than 10 years. The mean citation half-life of the total 835 journals is 6.28 years. Excluding 74 journals whose half-life is 10 or more years, the mean citation half-life of the total 761 journals is 5.92 years. Of the 74 titles whose citation half-life is equal to, or longer than, 10, 18 also have a use half-life of 10 or more years. All of these 18 journals have run for quite a long time. This seems to be accommodated for journals to be cited for many years, in other words, to have a longer citation half-life. However, these 18 titles were subscribed to by the library for only a short period, and most of them are publications before 1980. In the meantime, most of them were used a few times only. For journals with a bound use frequency and uniform distribution, whose holdings began in an earlier year, say, the 1950s, and are still open, the older the journal is, the lower rate it was used.

TABLE 4. Publication date, publication frequency, and subject field of journals with citation half-life ≥10 years.

No.	Title	Publication date	Publication frequency	Subject
1	Am J of the Medical Sciences	1827–	Monthly	Medical science
2	Archives of Neurology pre: AMA Archives of Neurology	1960–(v.3–)	Monthly	Neurology
3	Annals Otology Rhinology Laryngology pre: Annals of Ophthalmology & Otology	1897–(v.6–)	Monthly	Otorhinolaryngology
4	Am J Orthodontics Dentofacial Orthoped pre: Am J Orthodontics	1986–(v.90–)	Monthly	Dentistry
5	Annals of Ophthalmology	1969–	Bimonthly	Ophthalmology
6	Acta Radiologica pre: Acta Radiologic Diagnosis	1987–(v.28–)	Bimonthly	Radiology
7	Acta Oto-Laryngologica	1918–	Bimonthly	Otorhinolaryngology
8	Acta Odontologica Scandinavica	1939–	Bimonthly	Dentistry
9	Acta Physiologica Scandinavica	1940–	Monthly	Biology–physiology
10	Analytical Biochemistry	1960–	18/yr	Biology–biochemistry
11	Archives of Oral Biology	1959–	Monthly	Dentistry
12	Archives of Dermatology pre: AMA Archives of Dermatology	1960–(v.82–)	Monthly	Dermatology
13	Annals Tropical Medicine Parasitology	1907–	Bimonthly	Tropical medicine
14	Anatomical Record	1906–	Monthly	Anatomy
15	Annals of Human Genetics	1954–(v.19–)	Quarterly	Biology–genetics
16	Biochemical Genetics	1967–	Monthly	Biology—genetics; biology—biochemistry
17	Biometrika	1901–	Quarterly	Biology
18	Acta Orthopaedica Scandinavica	1930–	Bimonthly	Orthopedics
19	Am J Ophthalmology	1884–	Monthly	Ophthalmology
20	Am J Anatomy suc: Developmental Dynamics	1901–1991 (v.1–v.192)	Monthly	Anatomy
21	Arch Otolaryngology—Head Neck Surgery pre: Archives of Otolaryngology	1986–(v.112–)	Monthly	Otorhinolaryngology
22	Acta Medica Scandinavica pre: Nordiskt Medicinskt Arkiv suc: J of Internal Medicine	1919–1988 (v.52–v.224)	Monthly	Medical science
23	Arch Intl Pharmacodynamie Therapie pre: Archives Internationales de Pharmacodynamie Therapie	1899–(v.6–)	Bimonthly	Pharmacy/pharmacology
24	Acta Ophthalmologica	1923–	Bimonthly	Ophthalmology
25	Bacteriological Reviews suc: Microbiological Reviews	1960–1977	Quarterly	Biology–microbiology
26	British J Ophthalmology	1917–	Monthly	Ophthalmology
27	Cancer Treatment Reports suc: J National Cancer Institute	1976–1987	Monthly	Neoplasma/neoplastic
28	British J Nutrition	1947–	Monthly	Nutrition & dietetics
29	Canadian J Biochemistry pre: Can J Biochemistry and Physiol suc: Can J Biochemistry and Cell Biol	1964–1982 (v.42–v.60)	Monthly	Biology–biochemistry
30	Canadian J Ophthalmology	1966–	7/yr	Ophthalmology
31	British J Diseases of the Chest pre: Br J Tuberculosis Disease Chest suc: Respiratory Medicine	1959–1988 (v.53–v.82)	Quarterly	Respiratory system
32	Brain: A Journal of Neurology	1878–	Bimonthly	Neurology
33	Bull the New York Academy Medicine	1925–	Semiannually	Medical science
34	Clinical Allergy suc: Clinical & Experimental Allergy	1971–1988 (v.1–v.18)	Bimonthly	Allergy/immunology
35	Clinica Chimica Acta	1956–	20/yr	Chemistry; pathology
36	Cleft Palate—Craniofacial Journal pre: Cleft Palate Journal	1991–(v.28–)	Bimonthly	Surgery
37	Electronics	1985–(v.58–)	Semimonthly (23/yr)	Electricity; electronics; electrical engineering
38	Japanese Heart Journal	1960–	Bimonthly	Cardiology
39	Indian Journal of Medical Research pre: Paludism suc: Indian J of Medical Res Sec. A & B	1913–1988	Monthly	Medical science
40	Cortex	1964–	Quarterly	Neurology

TABLE 4. (continued).

No.	Title	Publication date	Publication frequency	Subject
41	Helvectica Chimica Acta	1918–	8/yr	Chemistry
42	Experientia	1945–	Monthly	General science
43	Computer Methods & Programs in Biomedicine	1985–(v.20–)	9/yr	Biotechnology; computers
44	J Am Dental Association	1929–(v.26–)	Monthly	Dentistry
45	Computer Journal	1958–	Irregular (10 issues)	Computers
46	Experimental and Molecular Pathology	1962–	Bimonthly	Pathology
47	Electronic Engineering	1928–	Monthly	Electricity; electronics; electrical engineering
48	J Acoustical Society of America	1929–	Monthly	Physics–sound
49	Journal of Pharmaceutical Sciences	1961–(v.50–)	Monthly	Pharmacy/pharmacology
50	J Laboratory and Clinical Medicine	1915–	Monthly	Medical science
51	Medicine	1922–	Bimonthly	Internal medicine
52	J Bone Joint Surgery—British Volume	1948–(v.30–)	9/yr	Surgery; orthopedics
53	J Pharmacokinetics Biopharmaceutics	1973–	Bimonthly	Pharmacy/pharmacology
54	J Bone Joint Surgery—American Volume pre: J Bone Joint Surgery	1948–(v.30–)	Monthly	Surgery; orthopedics
55	J Histochemistry & Cytochemistry	1953–	Monthly	Biology–cytology, & histology
56	Journal of Comparative Pathology pre: J Comparative Pathology	1965–(v.75–)	8/yr	Pathology; veterinary sciences
57	Journal of Morphology pre: J of Morphology & Physiology	1931–(v.52–)	Monthly	Biology–physiology
58	J Sports Medicine Physical Fitness	1961–	Quarterly	Sports medicine
59	Steroids	1963–	Monthly	Biology; chemistry
60	New York State Journal of Medicine	1901–1993	Monthly	Medical science
61	Scand J Plastic Reconstructive Surgery	1967–	Quarterly	Surgery
62	Scand J Rehabilitation Medicine	1969–	Quarterly	Medical science
63	Ophthalmologica pre: Zeitschrift fuer Augenheilkunde	1938–(v.96–)	Bimonthly	Ophthalmology
64	Respiration Physiology	1966–	Monthly	Biology–physiology
65	Psychosomatic Medicine	1939–	Bimonthly	Psychiatry
66	Proc Royal Society Medicine—London	1907–	Monthly	Medical science
67	Scand J Clinical & Laboratory Invest	1949–	8/yr	Biology–physiology
68	Proceedings Society Experiment Biology Medicine	1903–	11/yr	Medical science; biology
69	Oral Surgery Oral Med Oral Pathology	1995–	Monthly	Dentistry
70	Paraplegia	1963–	Monthly	Physically impaired
71	Surgery Gynecology & Obstetrics suc: J American College of Surgeons	1905–1993	Monthly	Surgery; gynecology, & obstetrics
72	Am J Digestive Diseases	1934–1979 (v.24–)	Monthly	Gastroenterology
73	Cancer Chemotherapy Reports, pt. 1–3 suc: Cancer Treatment Reports	1959–1966	Monthly	Neoplasma/neoplastic
74	Journal of Parasitology	1914–	Bimonthly	Parasitology

Journals with a long citation half-life may have a very short use half-life. Eight out of 74 journals with a long citation half-life have a use half-life less than 2 years. Five journals with a citation half-life of 10 or more years were never used and result in zero-use half-life. The reason is that those journals' subjects are irrelevant to medical or life science and, therefore, are of less interest to local users, while the citation activities of these journals are spread globally. Therefore, although they have a very short or zero-use half-life, they are still used widely in the world for a long time.

By careful examination of the ranked list of citation half-life and use half-life in Tsay (1996), it can be found that, in general, journals with shorter citation half-lives also have shorter use half-lives. All except three journals with a use half-life of 9.5, 6.5, and 4.5 years, 39 of the titles whose citation half-lives are less than 3 years also have use half-lives ranging from 0 to 2.9 years. And, normally, the citation half-life is greater than the use half-life. The difference between them is about 1 to 2 years.

T *Test for All the Journals*

In general, for all 835 titles, the mean citation half-life was greater than the mean use half-life. The *t* test showed that the difference is 2.85 years. The *t* test for the paired

TABLE 5. Holding period, publication frequency, and subject field of journals with use half-life ≥10 years.

No.	Title	Holding period	Publication frequency	Subject
1	J Pharmacology Experiment Therapeutics	1951–1978	Monthly	Pharmacy/pharmacology
2	Helvetica Chimica Acta	1966–1978	8/yr	Chemistry
3	Journal of Nutrition	1951–1981	Monthly	Nutrition
4	Cancer Chemotherapy Reports suc: Cancer Treatment Reports	1970–1976	Monthly	Neoplasma/neoplastic
5	Am J Digestive Diseases suc: Digestive Diseases & Sciences	1956–1978	Monthly	Gastroenterology
6	Archives Internationales de Pharmacodynamie et de Therapie	1967–1978	Bimonthly	Pharmacy/pharmacology
7	Archives of Oral Biology	1967–1976	Monthly	Dentistry
8	Nature—New Biology	1971–1973	Weekly	Biology
9	Proceedings Royal Soc Medicine—London suc: J of Royal Society of Medicine	1910–1977	Monthly	Medical science
10	J Labelled Compounds Radiopharmaceut	1976–	13/yr	Chemistry
11	Experientia: Monthly J of Pure & Applied Science	1966–1979	Monthly	General science
12	Bacteriological Reviews suc: Microbiological Reviews	1960–1977	Quarterly	Biology–microbiology
13	Am J Anatomy suc: Developmental Dynamics	1951–1991	Monthly	Anatomy
14	J of Neurophysiology	1970–1980	Monthly	Neurology; biology–physiology
15	Australian Dental Journal	1968–1987	Bimonthly	Dentistry
16	International Surgery pre: J Intl College Surgeon Intl Surgery	1966–1980	Quarterly	Surgery
17	Anatomical Record	1946–	Monthly	Anatomy
18	Nutrition	1961–1974	Bimonthly	Nutrition
19	Clinical Allergy suc: Clinical & Experimental Allergy	1971–1988	Bimonthly	Allergy/immunology
20	Acta Medica Scandinavica suc: J of Internal Medicine	1961–1988	Monthly	Medical science
21	J Liquid Chromatography	1982	Semimonthly	Chemistry
22	Archives of Dermatology pre: AMA Archives of Dermatology	1952–	Monthly	Dermatology
23	Canadian J Biochemistry & Cell Biology	1966–1986	Monthly	Biology–biochemistry
24	International J of Biochemistry	1974–1987	Monthly	Biology–biochemistry
25	Developmental Biology	1984	Monthly	Biology
26	Proceedings Society of Experimental Biology & Medicine	1949–	11/yr	Medical science; biology
27	J Cardiovascular Pharmacology	1979–1988	Monthly	Pharmacy; cardiology
28	Am J Tropical Medicine & Hygiene	1952–	Monthly	Tropical medicine
29	J Bone Joint Surgery—American Volume Pre: J Bone & Joint Surgery	1951–	Monthly	Surgery; orthopedics
30	J Physiology—London	1901–	Semimonthly	Biology–physiology
31	Medicine	1922–	Bimonthly	Internal medicine
32	British J Disease of the Chest pre: British J Tuberculosis Disease Chest suc: Respiratory Medicine	1981–1988	Quarterly	Respiratory system

differences between these two kinds of half-lives are computed by SAS. The paired *t* test also determined the probability that the absolute value of the mean difference was greater than zero by chance alone. The probability of the difference occurring by chance is 0.0001. Therefore, it can be concluded that the mean differences are highly significant ($t = 25.7$, $P < 0.05$). In order to obtain a more accurate result, 74 journals with citation half-life of 10 or more years were excluded in another *t* test. Again, with *p*-value of 0.0001, the result also shows a significant difference of 2.84 years between citation half-life and use half-life. Both approaches reject the null hypothesis that there is no significant difference between citation half-life and use half-life.

The fact that the use half-life is significantly shorter than the citation half-life is opposed to the point proposed by Line (1993, p. 673), who indicated that "it seems likely that citations show faster perhaps substantially faster decay than uses." The phenomenon of longer citation half-life might result from the fact that "nothing can be cited until an author has read it and no such citation can be pursued until the reference has been published" (Line & Sandison, 1975, p.

TABLE 6 Mean difference of citation half-life and use half-life for journals of categories A, B, C, and D.

Category	A Clin Med	B Life Sci	C Life Sci/Clin Med	D Other
Difference (835 titles)	3.04	2.56	2.64	5.32
Difference (761 titles)	2.86	2.71	2.68	4.88

312). It should be noted that there must be a delay between a given item being read by an author and its citation appearing in print. Garvey et al. (1970, p. 63) have shown that, on average, work reported in journal articles was begun 28 months prior, was completed 15 months prior, and was written up and submitted 8 months prior to publication. Subramanyam (1981, p. 38) also pointed out that the time lag between the "submission of the first manuscript and the eventual publication of the paper in a journal may range from six months to a couple of years."

T *Test for Journals of Four Categories*

The mean differences for categories A, B, C, and D obtained from the *t* test of each group are listed in Table 6. The mean difference between citation half-life and use half-life of clinical medicine journals (category A) is 3.04 years for all titles, or 2.86 years for 761 titles, excluding 74 journals with a half-life equal to, or longer than, 10 years. For journals of life science (category B) and journals dealing with both clinical medicine and life science (category C), the mean differences are 2.56 or 2.71 years and 2.64 or 2.68 years, respectively. The mean difference of journals whose subjects are relevant to neither clinical medicine nor life science (category D) is 5.32 or 4.88 years, respectively, which are much longer than the other three categories. The paired *t* test computes that all *p*-values for journals of these four categories is 0.0001. Therefore, they are all statistically significant. So, it can be concluded that the mean of citation half-life and use half-life for journals of each category are not equal.

Furthermore, an ANOVA was used to test the hypothesis that the means for journals of the four categories are all equal to each other, against the alternative hypothesis that they are not all equal. Since the *F* (with 3 and 831 degrees of freedom) is 8.65 and the *p*-value is 0.0001, therefore, it might be concluded that the mean differences for the four groups of journals are not all equivalent. The mean differences for journals of category A, B, and C are so close that it cannot be considered that they are different. Therefore, Duncan's multiple-range test, a post-hoc test was conducted to investigate differences between levels of the independent variable. As the output from the Duncan procedure shows, journals of category A, B, and C are not significantly different (at the 0.05 level). Journals of category D are significantly different ($p < 0.05$) from journals of subject A, B, and C. From this Duncan's test, it can be concluded that journals concerning neither clinical medicine nor life science do have a larger mean difference between citation half-life and use half-life than journals of the other three categories. And the mean differences for journals of category A, B, and C are not significantly different. This can be understood that, as discussed in the previous section, category D has approximately the same mean citation half-life as the other three categories, while it has a much shorter mean use half-life due to its lack of relevance to either clinical medicine or life science.

The ANOVA and Duncan's multiple-range test also yields the same conclusion for 761 journals excluding 74 titles with citation half-life equal to, or greater than, 10 years.

Summary and Conclusions

This study explores the nature of the citation half-life and use half-life and the difference between the mean of them. The following conclusions can be drawn:

(1) There were fewer uses of the older items than of more recent stocks. Journal use decline is not uniform. There appear to be great variations among journal titles. Accessibility can also affect use substantially, and, therefore, the journal's use half-life. Most journals with a long half-life have decayed slowly because they were never used heavily.

(2) Publication frequency, journal age, language and country of publication, and subject category all are related to citation half-life. Use half-life is also influenced by those factors affecting citation half-life. In addition, the use half-life also reflects the extent of holdings of particular titles in the local library.

(3) The four subject categories in this study have approximately the same citation half-life. This uniform distribution among different subject categories does not appear for the use half-life. The category of neither clinical medicine nor life science (D) has the shortest mean half-life, while the other three categories have a half-life close to each other.

(4) The mean use half-life of the total 835 journals is 3.43 years, which is significantly shorter than the citation half-life, 6.28 years. The mean citation half-life is 5.92 years if 74 journals with a half-life equal to, or longer than, 10 years are excluded. There is also a significant difference between the mean citation half-life and the mean use half-life for journals of each category. The journals irrelevant to either clinical medicine or life science have the largest difference in mean citation half-life and mean use half-life.

(5) Journals with a long citation half-life, equal to, or longer than, 10 years, can have diverse use half-lives. Many of them also have a very long use half-life,

though their uses were generally quite few and limited to earlier volumes only. In general, journals with shorter citation half-lives also have shorter use half-lives.

(6) The *t* test showed the difference between mean use half-life and mean citation half-life is 2.85 years. Such a degree of difference prevails for journals in all categories except category D, which has a difference as large as 5.31 years (or 4.87 years if 74 journals with a citation half-life equal to, or greater than, 10 years are excluded). The journals in category D deal with neither clinical medicine nor life science. Therefore, they are not core journals for the subject of the present study. Thus, for journals in medical science, use half-life may be approximated by citation half-life by subtracting the 2.8 years that is the difference between mean use and citation half-life.

The results of this study clarify the difference between the half-life of journal use in a particular medical library and their citation use all over the world, and help to establish a base for librarians making decisions about journal subscriptions, discarding, and binding in that area for the institution under study. It may also help information system designers to select journals to be included or removed in the databases of indexing and abstracting services. Journals with a long half-life usually contain articles of more enduring value and, therefore, subscription to such journals in the institute would be worthwhile, and longer storage of such long half-life journals would also be required. Inclusion of these journals in indexing and abstracting services would be justified scientifically. On the other hand, binding of old journals with a very short half-life would be unnecessary and these types of journals could be discarded. However, it should be noted that the present study also reveals that a number of long half-life journals do not receive heavy uses but receive quite few uses, and their uses are limited to earlier volumes only. This study has found a mean difference between the half-life of journal library use and citation half-life. If such a difference can be generalized for other types of libraries, then collection managers may use citation half-life as an objective basis to predict journal use half-life. Data for citation half-life may be drawn from *JCR*. Therefore, conducting a more labor-intensive in-house use study would be unnecessary. This is believed to be valuable for today's libraries, many of which are facing budget cuts.

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