

Purpose: The research assesses the impact of online journals on citation patterns by examining whether researchers were more likely to limit the resources they cited to those journals available online rather than those only in print.

Setting: Publications from a large urban university with a medical college at an urban location and at a smaller regional location were examined. The number of online journals available to authors on either campus was the same. The number of print journals available on the large campus was much greater than the print journals available at the small campus.

Methodology: Searches by author affiliation from 1996 to 2005 were performed in the Web of Science to find all articles written by affiliated members in the college of medicine at the selected institution. Cited references from randomly selected articles were recorded, and the cited journals were coded into five categories based on their availability at the study institution: print only, print and online, online only,

not owned, and dropped. Results were analyzed using SPSS. The age of articles cited for selected years as well as for 2006 and 2007 was also examined.

Results: The number of journals cited each year continued to increase. On the large urban campus, researchers were not more likely to cite journals available online or less likely to cite journals only in print. At the regional location, at which the number of print-only journals was minimal, use of print-only journals significantly decreased.

Conclusion/Discussion: The citation of print-only journals by researchers with access to a library with a large print and electronic collection appeared to continue, despite the availability of potential alternatives in the online collection. Journals available in electronic format were cited more frequently in publications from the campus whose library had a small print collection, and the citation of journals available in both print and electronic formats generally increased over the years studied.

INTRODUCTION

Studies have continued to provide evidence of the impact of online journals on scholarly activity and library usage. Several studies have documented that the provision of online journals has decreased the use of the print journal collection [1–6]. Libraries have reduced their print journal collections due to decreased print use and increased access to online journals [7, 8]. Boyce et al. found that by 2001/02, the majority of articles read by faculty were found online [9]. However, the impact of online journals has not been seen in all areas. In a previous study, the author examined whether the citation patterns of faculty publications would be impacted by the large increase in the availability of online journals [10]. Web of Science author affiliation searches for the years 1993, 1996, 1999, and 2002 were performed to examine citation patterns before online journals were available (1993, 1996, 1999) and after (2002). None of the results of the study suggested that researchers were citing journals available online more and/or citing journals available only in print less [10].

Because this previous study did not find that online journals had an impact on the citation patterns of medical faculty, the present paper reports an examination of the citation patterns of more recent publications to determine if there was evidence of changes in more current years. Journal citation

Highlights

- The number of articles cited each year increased from 1996 to 2007.
- Journals available only in print were cited on average more than the journals in other formats.
- Researchers continued to cite journals available only in the library's print collection, including older issues; however, mode of access to these print-only materials was not studied.
- Thirty percent of a journal issue's usage for publication occurred within the first three years of publication.

Implications

- Though this study did not assess how authors were accessing cited materials, materials that were available only in print at the study institution were still cited in examined publications. Thus, libraries may wish to examine retention policies given local patterns of use: a larger print collection may not see a significant reduction in use for citation and research purposes.
- In libraries with small print collections, new models for facilitating access to print-only material need to be investigated.

patterns before and after the introduction of online journals were examined to determine whether researchers were more likely to limit the journal articles they cited to those journals available online rather than those available only in print. In addition, this study examined if faculty and staff were less likely to cite older issues of a journal, the majority of which had been accessible only in print, given the availability of online journals.

METHODOLOGY

To examine the impact of online journals on the citation patterns of university authors, a retrospective, longitudinal study of publications from 1996 through 2005 was conducted. Two different techniques were used: one to examine use of more current journal issues and one to examine the citation patterns of older journal issues. While the author's 2005 study was used as the basis for the methodology described below, several aspects were changed. The 2005 study examined data from 1993, 1996, 1999, and 2002. The current study focused on the years (1996 and 1997) prior to the introduction of full text in 1999 and additional following years (2000, 2001, 2004, 2005) to determine if there was a change in citation patterns. Two adjacent years were examined in the current study followed by a two-year break to decrease the potential of an atypical year skewing results.

This study examined citation data from a large, urban university, University of Illinois at Chicago (UIC). UIC has a College of Medicine (COM) on the large urban campus in Chicago and several COM regional campuses (Peoria, Rockford, and Urbana). The UIC COM, Chicago (urban campus), and the UIC COM, Peoria (regional campus), were used in this study. Both COM locations have their own local health sciences libraries providing access to a print journal collection. Choosing these locations provided the chance to contrast two locations that have equal access to online journals but very different access to the number of journals available in the print journal collection. At the time of this study, the urban campus health sciences library had approximately 1,115 print journal subscriptions, 329 (30%) of which were available only in print; the regional campus had approximately 230 print journal subscriptions, 38 (16.5%) of which were available only in print.

In 1998, only 15 online biomedical journals were available to faculty, staff, and students at both locations. By the end of 2000, more than 3,000 online journals were available and more than 20,000 online journals by 2006. Over 5,000 of the online journals were related to health or biomedical sciences. The majority of the journals made available online between 1999 and 2005 included retrospective access to 1995/96. By 2004, Serials Solutions Open URL links had been made available in the majority of the online databases at the study institution, providing direct links to online versions of journal articles when available.

Identification of citation patterns

To identify changing citation patterns related to the use of "current" journals, articles published by researchers from each of the study locations were identified and the cited references from these articles were examined. Separate searches of key terms identifying each campus (e.g., Univ Illinois and coll med) in the author affiliation field were performed in the Web of Science database to find all articles published by authors at each of the locations. The years 1996 and 1997 were examined to establish a pattern of journal citing prior to the introduction of online journals, and 2000, 2001, 2004, and 2005 were examined to see if any change in citing journals occurred after the introduction of the online journals.

Journal and citation inclusion criteria

Cited references from each affiliate-authored article were recorded for each of the selected years. Only articles for which the first or second institutional addresses were affiliated with the study institution were included in the study as previous research has indicated that first authors contribute more than their coauthors to their publications [11]. Second authors were included to ensure an adequate sample size of journals articles. It was possible that authors from both locations may have contributed to an article, but this occurrence is anecdotally known to have been rare. In addition, included articles had to have at least ten cited references to help exclude letters to editors and conference abstracts and ensure that a robust number of references were included.

To ensure a more equitable comparison between years, only cited references with a publication date within ten years of the year being examined were included in the analysis. Without this limitation, an article published in 2005 would have had nine additional years of "citable" articles compared to an article from 1996. Because the purpose of this article was to study the impact online journals had on the use of the print journal collection, only print journals for which the studied libraries maintained continual subscription from 1985 through 2007 were included. Journals that ceased or began publication during the years studied were also excluded.

All eligible articles were identified for each study location and for each year studied. To ensure that an equal number of articles were compared each year, 175 articles from the urban location and 32 articles from the regional medical campus were randomly selected for each year under study from the pool of published articles for each year using a web-based random number generator program. The study populations of 175 and 32 articles were selected using the smallest number of articles published in the years under consideration at each study location. Though the Peoria campus produced fewer than 32 articles in 1 year, 32 was selected as the cut-off point as it was the next lowest number of articles published and allowed for meaningful data sets across the years

Table 1

Total number of cited references in articles (published by first and second authors containing at least 10 references) from each campus during each year examined

	1996	1997	2000	2001	2004	2005
Urban campus (175 articles/year)						
Total articles published	198	197	202	203	228	203
Total # of citations all years	6,323	6,176	7,420	7,583	7,763	8,674
Total # of citations from last 10 years	4,205	4,445	5,570	5,754	5,713	6,208
Regional campus (32 articles/year)						
Total articles published	36	26	42	32	33	40
Total # of citations all years	1,584	N/A	1,751	1,094	1,900	1,489
Total # of citations from last 10 years	922	N/A	1,140	843	1,302	1,085

Note: Data could not be collected for 1997 for the regional campus as too few articles were published.

studied. Analyzing a subset of randomly selected articles helped to control for potential temporal trends such as an exceptional number of articles published in a given year.

Cited journals were separated into five categories based on their availability at each of the study locations. The online catalog was used to determine print and online holdings and the time period in which an online journal was acquired. Categories were:

1. "Print only" included those journals that were available only in print format from 1985 to 2005 at the study institution.
2. "Online only" included those journals that became available online between 1999 and 2002 at the study institution, were still available online in 2005, and were not available in print from 1985 to 2005. Prior to 1999, the majority of these journals articles would need to have been requested through interlibrary loan (ILL) for authors to obtain a copy.
3. "Online and print" included journals that were available in print from 1985 to 2005 at the study institution, in addition to becoming available online at the study institution between 1999 to 2002.
4. "Not owned" included those journals that were not available in print or online during the study period at the study institution.
5. "Dropped" included journals excluded from the analysis if the journal title became available in an online format at the study institution after 2002. A journal was also excluded if its status changed during the study period (e.g., if a journal ceased publication or if a journal began publication after the start of the study period).

The number of times a journal was cited in each of the years studied was entered into separate spreadsheets for the urban and regional medical campuses. The library continued to acquire additional online journals in 2006 and 2007; therefore, 2005 was chosen as the cut off date for this study. Otherwise, several of the print-only journals would have become ineligible as a result of the selection criteria, thus limiting the journals remaining in the study. Results from categories 1, 2, and 3 were analyzed using SPSS.

Use of older journal issues

This study also examined the use of older journal issues. Many of the online journal collections at the

study institution did not include online volumes before 1995/96; thus authors could have accessed older articles through the library's print collection. Using the sets of randomly selected articles as described above, all cited references, regardless of the age of the cited reference, in the years 1996, 1997, 2000, 2001, and 2005 were analyzed to determine the age of the journals cited (e.g., if a cited article was published in 1997 and cited by a paper published in 2000, the age of the issue was recorded as three years).

In addition, data from 175 randomly selected articles from the urban campus published in 2006 and 2007 and 32 randomly selected articles from the regional campus published in 2006 and 2007 were included in the analysis of the age of journals cited. Utilizing data from 2005–2007 provided a pool of very recent citations. The age of articles cited (in years) was recorded in addition to the year the cited article was used in a publication. Results were analyzed using SPSS.

RESULTS

Examination of citation patterns

Table 1 depicts the number of cited references from the randomly selected articles published by first and second authors from each campus during each year examined. The number of articles cited each year on the urban campus increased, while the number of articles cited on the regional campus also increased, but more sporadically.

Urban campus. A total of 1,479 distinct journals were cited by authors at the urban campus. Eight hundred thirty-eight journals cited by urban authors were excluded from the analysis because they did not meet the study criteria (e.g., ceased publication, incomplete journal series, journal not owned, etc.). Of the 641 cited journals that remained in the study, 147 journals were available only in print, 35 journals were available only online, and 459 journals were available in both online and in print. The total and mean number of times journal articles were cited each year by authors at this location are presented in Table 2. The mean use of the print-only, print-and-online, and online-only journals increased over the years. Overall, the mean number of times the journals remaining in this study were cited

Table 2
Number of cited articles by journal status, urban campus

	Urban campus					
	1996	1997	2000	2001	2004	2005
All journals						
Print only (n=147)						
Mean	5.10	6.03	7.65	7.66	6.85	7.04
Total times cited	750	886	1,124	1,126	1,007	1,035
Online only (n=35)						
Mean	0.40	0.89	0.91	1.14	1.03	1.40
Total times cited	14	31	32	40	36	49
Print and online (n=459)						
Mean	5.44	5.54	7.02	7.07	6.75	6.92
Total times cited	2,496	2,545	3,222	3,244	3,097	3,174
Total (n=641)						
Mean	5.09	5.40	6.83	6.88	6.46	6.64
Total times cited	3,260	3,462	4,378	4,410	4,140	4,258
Abridged Index Medicus (AIM) only journals*						
Print only (n=15)						
Mean	9.20	9.47	19.13	14.40	13.80	16.33
Total times cited	138	142	287	216	207	245
Print and online (n=70)						
Mean	6.46	7.34	7.61	6.77	7.90	8.40
Total times cited	452	514	533	474	553	588
Total (n=85)						
Mean	6.94	7.72	9.65	8.12	8.94	9.80
Total times cited	590	656	820	690	760	833

* The urban campus had no online only subscriptions to AIM journals.

increased in 2000 and 2001 compared to 1996, although the numbers slightly decreased in 2004 and 2005. Interestingly, journals available only in print were cited on average more than the journals available in print and online formats.

A repeated measures analysis of variance (ANOVA) test was performed to examine the effects of online journals on the citation patterns of urban authors. The analysis did not find a statistically significant interaction between year of citation and print status. In other words, the findings suggested that over time, journals in print were not less likely to be cited and journals available online were not more likely to be cited, when compared to journals cited prior to the introduction of online journals. An additional ANOVA test was run on a subset (journals in the MEDLINE Abridged Index Medicus [AIM] subset) of the above journals with similar results (Table 2).

Regional campus. A total of 760 journals were cited by authors at this campus, of which 564 journals cited were excluded from the statistical analysis because they did not meet the study criteria. Of the 196 cited journals that remained in the study, 13 journals were available in print only, 122 journals were available online only, and 61 journals were available in both online and print. The total and mean number of cited articles by the regional authors are presented in Table 3. In general, the number of journal articles cited increased from 1996 to 2005.

The ANOVA test was performed to examine the effects of online journals on the citation patterns of authors at this location. In general, the print-only

journals remained the most cited during all the years studied. There was a statistically significant interaction between the year of citation and the print status ($F=5.256$, $P<0.001$). In general, the number of cited references decreased during the study years for the print-only journals, while the cited references of the online-and-print journals increased. Cited references for the online-only journals also increased over the study period, with the exception of a decrease in 2005. Of note was the decrease overall in the number of articles cited in 2005. As also noted at the urban setting, journals available in print were cited on average more than the other journals.

An ANOVA test of the AIM journals also showed an increase in citing the online-and-print journals and a decrease in citing the print-only journals ($F=2.194$, $P<0.038$). These findings suggested that online journals have had an impact on the citation patterns of authors on the regional campus, where only a small print journal collection was available. Researchers were citing the journals available online more and citing the journals available only in print less.

Use of older journals

Table 4 (online) shows the average use of journals based on their age for both the urban and regional medical campuses. Thirty percent of a journal issue's usage occurred within the first three years of an issue being published. As journal issues became older, their use decreased. Figures 1 and 2 show the percentage of use by year and the age of the journal issue cited. In the urban setting, the average use of journal issues by

Table 3
Number of cited articles by journal status, regional campus

	Regional campus					
	1996	1997	2000	2001	2004	2005
All journals						
Print only (n=13)						
Mean	8.25	N/A	6.85	9.23	6.69	5.77
Total times cited	99	N/A	89	120	87	75
Online only (n=122)						
Mean	1.28	N/A	1.34	1.36	2.23	1.10
Total times cited	156	N/A	164	166	272	134
Print and online (n=61)						
Mean	3.61	N/A	4.08	1.57	4.48	4.39
Total times cited	220	N/A	249	96	273	268
Total (n=196)						
Mean	2.44	N/A	2.56	1.95	3.22	2.43
Total times cited	475	N/A	502	382	632	477
AIM only journals						
Print only (n=6)						
Mean	3.00	N/A	2.00	5.83	4.00	2.50
Total times cited	18	N/A	12	35	24	15
Online only (n=3)						
Mean	0.33	N/A	0.67	0.33	0.67	0.33
Total times cited	1	N/A	2	1	2	1
Print and online (n=34)						
Mean	2.79	N/A	3.41	1.56	4.88	4.88
Total times cited	95	N/A	116	53	166	166
Total (n=43)						
Mean	2.65	N/A	3.02	2.07	4.47	4.23
Total times cited	114	N/A	130	89	192	182

age did not vary greatly between years. This suggests that medical faculty (and other university authors) continued to access older issues in print as the majority would not have been available online.

Because no significant change in the citation patterns of authors on the urban campus was found during the 1996-to-2005 study period, an additional analysis of the online and print journals was performed. These journals represented a stable sample of journals that were available in print during the entire study and

became available online sometime between 1999 to 2002 (Figure 3). No decrease in citing older issues of journals for scholarly research, even in 2007, was apparent, suggesting that researchers continued to access older issues of journals, as the majority of older issues would have been available only in print.

At the regional setting, the percentage of use generally increased over the years for journal issues eight years old or younger, and the percentage of use decreased over the years for journal issues sixteen

Figure 1
Percentage of use of journal issues by year and age of journal, urban campus

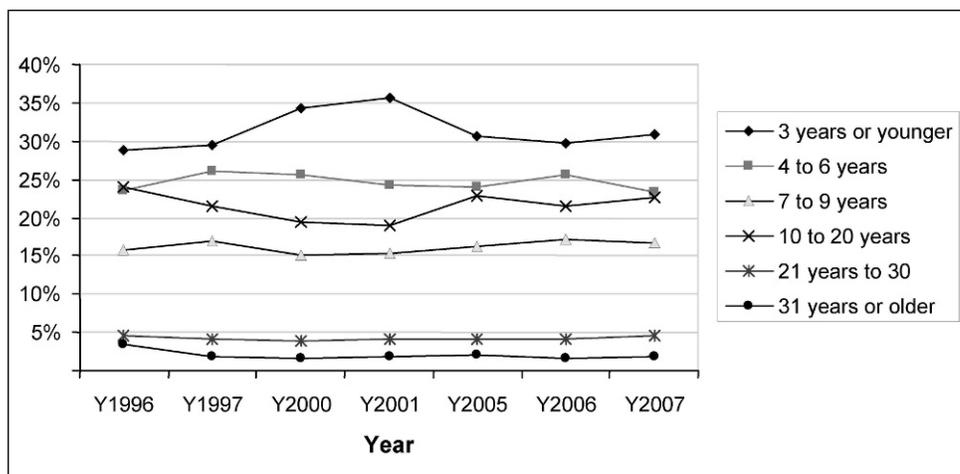
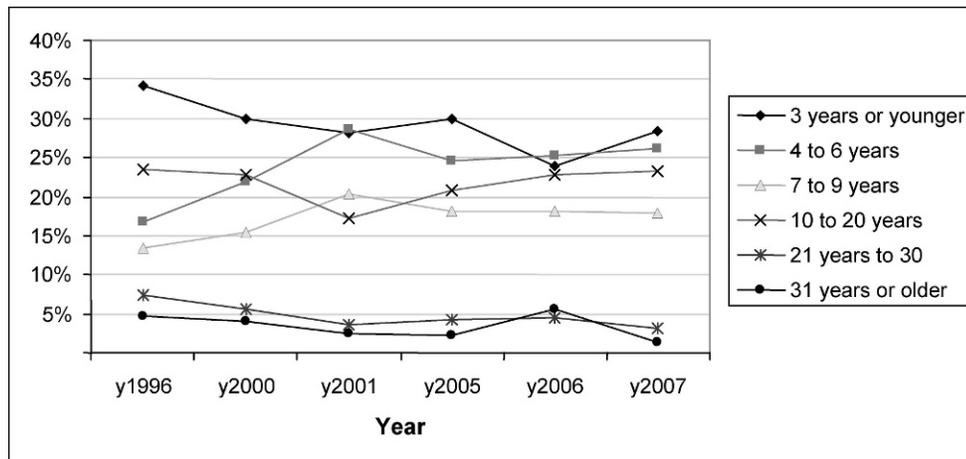


Figure 2
Percentage of use of journal issues by year and age of journal, regional campus



years old or older. While this finding might suggest that medical authors on the regional campus were not accessing older issues of journals, it is important to note that this library only maintained ten to twenty years of the journal volumes, so authors would not have had access to older print material from the library at this location.

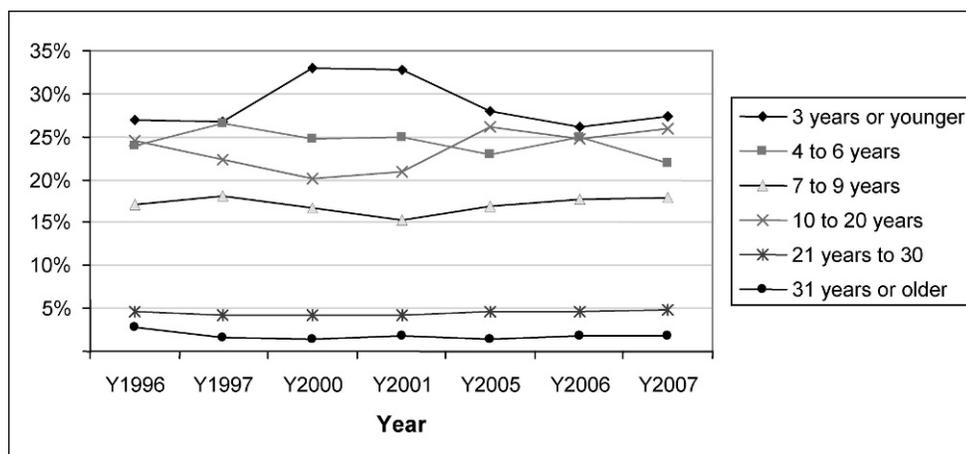
DISCUSSION

In the institutions studied here, print-only journals were cited on average more than the other journals, which suggested that core print titles remained valuable for research purposes as evidenced by citation patterns. The study results also demonstrated that in libraries with large online collections and small print collections, authors might be less motivated to obtain limited print-only material for research purposes, suggesting a possible sacrifice of quality for convenience. At the Peoria regional library, material

not owned in print can easily be obtained for free through the library's ILL service. It is possible that the material available only in print is seen as an expense in terms of retrieval or photocopying time. As a result, it may be necessary to consider solutions to facilitate access to the print-only collection. Particularly in the health sciences, it is important that information not be missed because of potential harm to human life. The importance of older research is highlighted by the 2001 death of a healthy volunteer enrolled in an asthma study at Johns Hopkins University, whose death was attributed in part to an inadequate literature search regarding the drug used in the study [12].

This study also suggests that in situations in which a large print journal collection exists, even with the existence of a large online journal collection, authors continue to cite journals available only in print. The large print journal collection on the urban campus includes current journal subscriptions that are available only in print and older journal issues that are not

Figure 3
Percentage of use of journal issues by year and age of online and print journals, urban campus



yet available online. Having a large number of journal resources available only in print may make a trip to the library for research purposes worthwhile, particularly when there is a potential for obtaining multiple materials.

Despite the fact that print-only journals continued to be cited consistently, it appeared that there was also an increase in use of journals available online. Although not statistically significant, citation of journals available only online increased on the large urban campus. Citation of such journals might have been affected by the perceived quality or authoritativeness of the journals that fell into the online only category because the category comprised those titles available only online and not in print or both formats. Libraries in both locations likely subscribed to print or print-and-online versions of core titles typically deemed authoritative or of high quality.

Faculty have also been shown to prefer to access material online when available [13]. In addition, the number of articles cited in this study increased from 1996 to 2007, similar to the results seen in the 2005 study [10]. This increase in citations can be attributed to the increase in online databases. Authors at the study institution have access to multiple databases including MEDLINE through PubMed and Ovid, Web of Science, Current Contents, CINAHL, PsycINFO, EMBASE, and many more. Brennan et al. similarly noted that faculty believed online databases allowed more timely literature searching by providing quick access to a greater number of articles [14].

Limitations

One limitation of the current study was related to the online-and-print journals. In this situation, it was not possible to tell if authors accessed the journals in print or online formats, although the author assumed the use was in the online format when possible. In addition, it was possible that faculty and staff did not come to the library for print issues but relied on their own or their colleagues' personal subscriptions or prior knowledge of sources from earlier work. However, as citation patterns did not change over the years, it was likely that whatever means researchers used to access the materials that were available in print at the library did not change.

Also, though anecdotal evidence does not support significant crossover, it is possible that authors from both campuses were working collaboratively on publications, providing material to each other from the other campus. In addition, UIC authors collaborating with authors from other institutions could have gained access to other material from collaborating authors. While this study's citation data represent a snapshot of patterns at two locations, the differences in available collections (large print+large electronic and small print+large electronic) may help to increase the generalizability of the results.

This study also infers the use of the print and online collection based on citations in published articles; it does not consider use of the print or online collections

for other purposes such as patient care or current awareness. Blecic's 1999 study found that many clinical journals had low faculty citation rates but high in-house use, indicating that some types of journals were apparently being used for educational and patient care purposes but not for research [15]. Further study is required to determine how and why faculty and staff are using more recent and older journal issues.

CONCLUSIONS

Libraries' actions to facilitate access to information, such as subscriptions to online databases, have been successful, as can be seen in the increasing number of cited references in this study. But at the same time, libraries may also have limited access by introducing tools, such as federated search engines, to make searching seamless, which may result in less relevant results than searching individual databases [16]. Similarly, providing quick access to online material without simultaneously examining ways to provide quick, affordable access to relevant print-only material may be inhibiting access to some research. Tools such as links to journal full text from databases may at the same time limit access to other information because users are likely to access the most easily accessible material most of the time. Additional research could investigate such unintended consequences as well as probe authors' mode of access to journals (print vs. electronic format) and the reasons they can use one format over another. Further research could also compare use statistics of print and electronic materials to citation patterns to contextualize understanding of how journal collections are employed.

In addition, an understanding of the use of the print collection in relation to the size of the print-and-online journal collection should be useful in making collection development decisions regarding continuing to collect print journals for research purposes and the need to provide access to the older print collection for research purposes. In this study, older materials were still being used for research purposes; however, only 7% of cited articles were 20 years or older—a finding in agreement with previous work [17]. Other findings suggest that the use of the print journal collection has decreased significantly since the introduction of online journals [6, 18], and it must be recognized that the use of articles for other purposes has likely declined. Thus, maintaining the collection in a general use area may not be necessary, but it may be more practical to implement a system for ready access to the material when requested to free library space for alternative purposes.

The results of this study should help other librarians make decisions about the need to keep print collections accessible or support decisions to purchase online retrospective access to older volumes of journals as these "backfiles" increasingly become available. In addition, traditional services offered by libraries may need to change. In the case of libraries with larger print collections, perhaps material can be

moved to storage, freeing up library space for other purposes but still ensuring quick access to the print-only collection when needed. Libraries with smaller print collections may wish to investigate new models for providing print-only material so that important information is still retrieved, and convenience does not win out over quality.

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