

the traditional title-by-title print journal selections. These changes have been a boon to researchers, who presumably no longer have to travel across campus or even down the hall to the library for articles. Instead, they retrieve articles with just a few clicks on their home or office computers.

Libraries are reducing their print collections due to decreased utilization and increased access to online journals [1–3]. The convenience of accessing the online collection remotely instead of having to walk into the library has been cited as a reason [4]. A previous study that examined the impact of online journals on the citation patterns of medical school faculty found that when medical faculty had access to a small print collection and a large online journal collection, the use of the print collection significantly decreased. However, when faculty had access to a large print collection in addition to a large online collection, the impact on the use of the existing print collection was minimal [5]. A 2006 study that surveyed health sciences librarians also found that researchers are still using print journals in this electronic age [6].

The purpose of this study is to determine how online journal collections are impacting the citation patterns of researchers in dentistry, nursing, and pharmacy. Journal citation patterns before and after the introduction of online journals will be examined to determine whether researchers are more likely to limit the journal articles they cite to those journals available online rather than those available only in print.

## METHODS

This study examined citation data from a large urban university with a health sciences campus that included colleges in medicine, nursing, pharmacy, public health, and allied health. A retrospective, longitudinal study compared citation patterns of dentistry, nursing, and pharmacy faculty over time to determine if the advent of online journals affected the articles cited in their published research. The time period of 1996 to 2008 allowed the opportunity to examine the use of journals prior to the proliferation of online journals and after.

At the study institution, only 15 online biomedical journals were available to faculty, staff, and students in 1998. By the year 2000, more than 3,000 journals were available online, and by 2008, more than 30,000 journals were available online. In 2004, Serials Solutions OpenURL links had been made available in the majority of the institution's online database collections, providing direct links to the online articles when available. Of the 3 disciplines studied here, dentistry had the least number of available print journals (311), compared to nursing (381) and pharmacy (517). Nursing had the largest number of available online journals (369), compared to dentistry (106) and pharmacy (271).

Searches by author affiliation were performed in Web of Science to find all articles written by faculty members from the colleges of dentistry, nursing, and pharmacy. To equalize the number of journal articles

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## Impact of online journals on citation patterns of dentistry, nursing, and pharmacy faculty

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## INTRODUCTION

The past decade has seen a major shift in the journal collections of academic health sciences libraries. Libraries gained access to vast numbers of journals as never before possible when they moved into licensing large electronic journal packages instead of

compared in each discipline, an equal number of articles were randomly selected from the total number of available articles. The random sample of articles was based on the lowest number of articles published each year in a discipline. The searches were conducted for the following years: 1996, 1999, 2002, 2005, and 2008. Journals cited in these articles were separated into five categories based on their availability at the university: print only, online only, online and print, not owned, and dropped. See the methodology from De Groote's 2008 study for journal and citation inclusion criteria and an explanation of assigned journal categories [5].

Because the purpose of this study was to determine the impact online journals had on the use of the print journal collection, only print journals for which the studied library maintained continual subscriptions from 1986 through 2008 were included. Only citations to articles published in the previous ten years were examined to ensure an equitable comparison for each studied year. (The 1986 date provides ten years of citation data in 1996.) Journals that ceased or began publication during the years studied were excluded. Journals licensed online between 1999 and 2005 had to be in continuous publication between 1986 and 2008 to be included in the study.

**RESULTS**

The number of journal articles cited per year continued to increase each year in all of the disciplines examined in this study. The average number of articles cited per year increased the most for the pharmacy discipline: pharmacy increased from 21.32 in 1996 to 33.1 in 2008; nursing increased from 20.9 in 1996 to 25.0 in 2008; and dentistry increased from 20.5 in 1996 to 24.6 in 2008.

**Dentistry**

A total of 461 distinct journals were cited by dentistry researchers; 224 journals remained in the analysis because they met the study criteria. Of the 224 journals, 57 were available only in print, 3 were available only online, and 164 journals were available both online and in print. Table 1 presents the total and mean number of times journal articles were cited each year by authors in dentistry. In dentistry, where the available print journal collection was the smallest of the disciplines studied, use of the print-only journal collection decreased. The ANOVA test was performed to examine the effects of online journals on the citation patterns of authors for this discipline. There was a statistically significant interaction between the year of citation and the publication status ( $F=4.485, P<0.001$ ). 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.

**Nursing**

A total of 665 distinct journals were cited by nursing researchers; 295 journals met the study criteria. Of the

**Table 1**  
Articles cited\* by status of cited journal and year of article publication

Year article published	Dentistry						Nursing						Pharmacy											
	Print only (n=57)		Online only (n=3)		Print and online (n=164)		Total (n=224)		Print only (n=52)		Online only (n=8)		Print and online (n=235)		Total (n=295)		Print only (n=98)		Online only (n=27)		Print and online (n=390)		Total (n=515)	
	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total
1996	1.98	113	0	0	0.61	100	0.95	213	0.54	28	0.25	2	0.62	146	0.60	176	1.24	122	0.07	2	1.74	678	1.56	802
1999	0.84	48	0	0	0.38	63	0.50	111	0.88	46	0.50	4	0.75	176	0.77	226	1.34	131	0.22	6	1.69	659	1.55	796
2002	1.51	86	0.67	2	0.70	115	0.91	203	0.31	16	0.38	3	0.60	142	0.55	161	1.38	135	0.81	22	2.11	824	1.90	981
2005	1.37	78	1.33	4	1.00	164	1.10	246	0.60	31	0.13	1	0.78	183	0.73	215	1.27	124	0.59	16	1.96	764	1.76	904
2008	0.93	53	12.00	36	1.27	209	1.33	298	0.25	13	0.13	1	0.95	224	0.81	238	1.53	150	0.67	18	2.10	818	1.91	986

\* Includes only citations to articles published in the previous ten years.

295 journals, 52 were available only in print, 8 were available only online, and 235 journals were available in both online and in print. Table 1 presents the total and mean number of times journal articles were cited each year by authors in nursing. In nursing, the number of cited print-only journals decreased from 1996 to 2008, while the number of cited journals available in online format increased, although the change was not statistically significant.

### Pharmacy

A total of 1,276 distinct journals were cited by pharmacy researchers; 515 journals met the study criteria. Of the 515 journals, 98 were available only in print, 27 were available only online, and 390 journals were available in both online and in print. Table 1 presents the total and mean number of times journal articles were cited each year by authors in pharmacy. In pharmacy, where the largest number of journals was available in print, there was no statistically significant change in the number of print-only or online journals cited over the years studied. Pharmacy was the only discipline where the number of print-only journals cited increased over the years, although the change was not statistically significant.

### DISCUSSION

The number of journal articles cited over the years increased from 1996 to 2008 for all of the disciplines studied. It is possible that online databases such as PubMed, CINAHL, Web of Science, and EMBASE facilitate awareness of potential research articles and have contributed to the increase in articles being cited over time.

The average number of journal articles cited per journal varied by discipline. While dentistry and nursing appeared to rely more on the journal articles published in an online format, pharmacy researchers continued to cite articles from titles available to them only in print. Citation of print-only articles increased over time for the articles produced by the pharmacy researchers. In the 2008 article examining the citation patterns of medical researchers at the same institution, it was observed that when researchers had access to a large print journal collection, their use of the print journals did not decrease [5]. This may explain why in pharmacy the use of the print collection did not decrease over time. 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.

Again comparing to the earlier study [5], the small size of the print dentistry collection might be responsible for the decrease in its use; however, there were additional factors of interest. The decrease in the print dentistry journal collection occurred despite the fact that the number of print-only journals remained larger than the online dentistry collection. Also of note

was that the dentistry authors cited more online journals than were provided for dentistry through the institution's online subscriptions intended for dentistry. The institution had approximately 134 online dentistry journal subscriptions, but a total of 167 online journals were cited. This would suggest a willingness to use the research materials from other disciplines. One study did note that as researchers continued to grow in their reliance on online resources, there was "a relatively high use of interdisciplinary references" [7].

It cannot be fully concluded if the observations made in this study were a result of disciplinary differences or if they were a result of the size of the collection provided to the authors. For example, both dentistry and pharmacy had small online collections, compared to the print collections. It is unknown if the limited number of online journals in the discipline is a result of the overall availability of electronic journals or a limit in the subscriptions of the institution. Therefore, it is not possible at this time to generalize the results to other institutions. Nonetheless, while the dentistry print-only collection was the smallest of the three and the online journal collection was also not as substantial as the nursing and pharmacy collections, the number of online journals cited by dentistry researchers increased significantly. At the same time, pharmacy continued to cite the print-only journals at the same rate throughout the study period. Further study is needed to determine how the size of a collection and easy access to online journals in other disciplines impacts the cross-disciplinary or multidisciplinary journals cited.

### CONCLUSION

The number of articles cited by each of the disciplines has increased from 1996 to 2008. In some disciplines, the impact of online journals can be seen in the citation patterns of research faculty. Dentistry and nursing faculty appear to be less frequently citing journals that are available only in print. Pharmacy citations do not exhibit the same citation pattern. Medical faculty also do not appear to be less frequently citing print-only journals when the available print collection is large [6]. While the decreased use of the physical print collection is not in question, some specific uses of the print collection, such as for research purposes, are impacted in different ways and to different extents, depending on the discipline of the user.

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