



Research Article

Connecting Users to Articles: An Analysis of the Impact of Article Level Linking on Journal Use Statistics

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Abstract

Objective – Electronic resource management challenges and “big deal” cancellations at one Canadian university library contributed to a situation where a number of electronic journal subscriptions at the university’s health sciences library lacked article level linking. The aim of this study was to compare the usage of journals with article level linking enabled to journals where only journal level linking was available or enabled.

Methods – A list of electronic journal title subscriptions was generated from vendor and subscription agent invoices. Journal titles were eligible for inclusion if the subscription was available throughout 2018 on the publisher’s platform, if the subscription costs were fully funded by the health sciences library, and if management of the subscription required title-by-title intervention by library staff. Of the 356 journal titles considered, 302 were included in the study. Negative binomial regression was performed to determine the effect of journal vs. article level linking on total COUNTER Journal Report 1 (JR1) successful full-text article requests for 2018, controlling for journal publisher, subject area, journal ranking, and alternate aggregator access.

Results – The negative binomial regression model demonstrated that article level linking had a significant, positive effect on total 2018 JR1 (coef: 0.645; $p < 0.001$). Article level linking increased the expected total JR1 by 90.7% when compared to journals where article level linking was not available or enabled. Differences in predicted usage between journals with article level linking and those without article level linking remained significant at various journal ranking levels. This suggests that usage of both smaller, more specialized journals (e.g., *Journal of Vascular Research*) and larger, general journals (e.g., *New England Journal of Medicine*) increases when article level linking is enabled.

Conclusions – This study provides statistical evidence that enabling article level linking has a positive impact on journal usage at one academic health sciences library. Although further study is needed, academic libraries should consider enabling article level linking wherever possible in order to facilitate user access, maximize the value of journal subscriptions, and improve convenience for users.

Introduction

Library link resolver systems are designed to facilitate seamless connections between full-text journal content and article databases and library discovery layers. When working optimally, link resolvers connect users directly to a full-text HTML or PDF version of a particular journal article. Linkage failures remain common in libraries, however, despite attempts to make improvements (Stuart, Varnum, & Ahronheim, 2015).

One form of suboptimal linking occurs when link resolvers connect at the journal level rather than the article level. In journal level linking, a link to a particular article resolves to the table of contents or homepage of a journal, rather than the article itself. The user must then browse to the volume and issue of interest, or search the journal platform for the article. Article level linking functionality depends on the availability of accurate linking parser information in an institution's link resolver software, as well as support for link resolvers from journal vendors.

At Memorial University's Health Sciences Library, many journal titles lacked article level linking throughout 2018. A number of factors contributed to this situation, including the cancellation of several "big deal" publisher

packages during the preceding years. Big deal journal packages are becoming financially unsustainable for many institutions, but provide greater efficiencies with regard to electronic resource management processes (Cleary, 2009). In some cases, big deal publisher package linking can be activated with a few mouse clicks. In contrast, creating and maintaining link resolver information for individual journal titles can be labour intensive. Library personnel must select individual titles to activate, edit journal holdings information to match institutional entitlements, and ensure that linking information is accurate.

Big deal cancellations increased the number of individual journal subscriptions at Memorial University Libraries, thus creating additional burdens on acquisitions personnel (Ambi, Morgan, Alcock, & Tiller-Hackett, 2006). Moreover, Memorial University Libraries had transitioned to a new library services platform during this time period. The transition meant that many electronic collections required cleaning and updates, and it took some time to determine what electronic resource management workflows would work best for the institution.

While journal level linking is not ideal for users, the situation at the Health Sciences Library created a unique opportunity to study the effects

of article level linking on journal usage. Article level linking was unavailable for many smaller publishers, and also for a variety of larger publishers including Cambridge, Oxford, Wiley, Springer, and Elsevier. This resulted in a more wide-ranging sample than would typically be possible in an observational study of article level linking.

Literature Review

Initially developed in the late 1990s by Herbert Van de Sompel, link resolvers were quickly recognized as a “silver bullet solution” to the problem of context sensitive linking (McDonald & Van de Velde, 2004, p. 32). Link resolver tools provided seamless connections between bibliographic databases, publisher websites, and library catalogue holdings. In the following years, link resolver technologies were described as “indispensable” (Singer, 2006, p. 15) and “essential” (Chisare, Fagan, Gaines, & Trocchia, 2017, p. 93) for academic libraries.

Early research into OpenURL tools and link resolvers suggested that their implementation increased electronic journal usage. Kraemer (2006) observed that electronic journals with advanced linking features were more highly used at the Medical College of Wisconsin Libraries, while McDonald (2007) reported that OpenURL resolver availability was correlated with a large and significant increase in publisher-reported electronic journal usage in a number of subject areas. Early research also indicated that patrons exhibited positive attitudes towards link resolver services (Eason, MacIntyre, & Apps, 2005).

Link resolvers are not the only way for library users to access journal content, however. IP-authenticated users may click on publisher-direct article links in databases such as PubMed to access content directly. IP-authenticated users may also access articles through publisher-direct article links on search engines such as Google. In contrast to the usage gains and favourable patron attitudes reported during earlier

research, more recent studies suggest that many library users bypass library link resolvers for publisher-direct linking. One study of health science journal usage found that publisher website usage statistics were much higher than usage reported by link resolver click-through statistics (De Groote, Blecic, & Martin, 2013). This trend is even more apparent in a study from 2017, which reports:

On average (for the 18 months in the sample) the publishers’ full text request report was 45,512 per month. The average full text requests registered from the library discovery tool (through its URL link resolver service) in the same period was 14,612 per month (i.e. publishers report 3.1 times more downloads than requested from the library discovery tool). (Greenberg & Bar-Ilan, 2017, p. 460)

Creating and maintaining link resolver tools is a complex and time-consuming process (Samples & Healey, 2014). Journals that require title-by-title intervention demand even greater resources in terms of library staff time, so it is useful to understand the relationship between article level linking and journal usage by library patrons. If the effect size is small or insignificant, it might indicate that libraries should allocate their resources elsewhere. Alternatively, if the effect size is larger, it might signal that libraries should prioritize link resolver maintenance and cleanup. To date, there appear to be no published studies that examine the impact of article level linking versus journal level linking on publisher reported usage statistics.

Aims

This observational, cross-sectional study attempts to understand the effects of article level linking at one academic health sciences library. The study uses statistical modeling to compare the usage of journals with article level linking enabled to journals where only journal level linking was available. The study attempts to

control for other factors which may affect journal usage.

This study's research question is: What is the effect of article level linking vs. journal level linking on publisher reported successful full-text article requests at one academic health sciences library, controlling for journal subject area, journal ranking, publisher, and alternate aggregator access?

Methods

Journals were eligible for inclusion in the study if they met the following criteria: the journal subscription cost was fully funded by the health sciences library, the journal was available via a publisher-direct platform, access to the journal was available throughout 2018, and the journal was part of a selective e-collection. Selective e-collections require at least some amount of title-by-title intervention during electronic resource management processes. Journals available through packages that did not require title-by-title intervention were excluded from the study (e.g., LWW Nursing and Health Professions Premier Collection). Journals partially funded by the health sciences library were excluded because the size and composition of the user group for partially funded titles (e.g., *Nature*) varies significantly from the size and composition of the user group for fully funded titles.

A list of selective journal subscriptions requiring title-by-title intervention was developed from publisher and serial agent invoices. Print and electronic ISSNs from this list were input into the Ex Libris Alma Overlap and Collection Analysis module in order to generate a spreadsheet outlining electronic resource portfolio availability. Duplicate journal titles, which resulted from the use of both electronic and print ISSNs, were removed.

Journals missing one or more variables in the statistical model were excluded from the study (e.g., Journal Report 1 [JR1] was unavailable).

Journals that changed publishers or platforms mid-year were also excluded from the analysis, as these changes can cause significant variation in usage (Bucknell, 2012). A total of 356 journal titles were considered for inclusion in this study; JR1 reporting was unavailable for 21 journal titles, Journal Impact Factor (JIF) was unavailable for 41 journal titles, and 3 journal titles changed publishers or platforms over the course of the year. The final dataset included 302 journal titles.

Dependent Variable: Total JR1 for 2018

This study used vendor-supplied COUNTER reports in order to measure IP-authenticated, publisher-direct journal usage by library users at Memorial University. Librarians frequently use COUNTER reports to evaluate electronic resources and make subscription decisions (Baker & Read, 2008). Project COUNTER (Counting Online Usage of Networked Electronic Resources) is a non-profit member-based organization of libraries, publishers, and vendors that have developed standards and definitions for electronic resource usage data. The COUNTER Code of Practice improves comparability of electronic resource usage data between vendors, although several studies suggest that vendor platform design decisions may lead to inflated usage statistics for some publishers (Davis & Price, 2006; Kohn, 2018; Wood-Doughty, Bergstrom, & Steigerwald, 2019).

COUNTER Release 4 usage reports for January 1 through December 31, 2018 were obtained for all included journal titles. Usage reports were examined for usage spikes and other indications of potential misuse (Bucknell, 2012). No indications of misuse were observed.

Although a number of different types of COUNTER reports are available, JR1 was selected for this study due to its ready availability and frequent use by librarians in journal evaluation. Journal Report 1 indicates the number of successful monthly full-text

article requests in both HTML and PDF format on the publisher's website. All successful requests are included, regardless of how the request originated (e.g., library link resolver, direct to publisher links in databases or search engines, journal browsing). Journal Report 1 includes usage of backfile content, as well as gold open access articles. Journal Report 1 excludes usage of journal content through other platforms such as aggregators (Journal Usage Statistics Portal, 2013). Journal Report 5 (JR5), which reports monthly requests by year of publication, was also considered as a potential outcome measure. The availability of JR5 reports was more limited, however, as fewer publishers were able to provide JR5 reports. Using JR1 allowed for the inclusion of more small publishers in the study.

Total JR1 is a count variable, and the shape of its frequency distribution is long-tailed. Dependent variables that are not normally distributed require specific considerations in statistical modelling, as described in further detail below.

Independent Variable: Article Level Linking

In May 2018, journal title electronic portfolios were examined via Ex Libris Alma to determine whether article level linking was enabled for the journal. Article level link testing was also conducted in the user-facing Ex Libris Primo interface. No substantive changes were made to portfolio linking level until mid-December 2018, when article level linking was enabled wherever possible. It was expected that the December update would not result in substantial changes in usage due to academic holidays.

Control Variables

A number of other factors may impact the usage of journal titles. This study attempts to control for these factors by including them in the statistical model.

Journal publisher is included as a categorical variable because there is evidence that publisher

platform design decisions affect usage statistics (Davis & Price, 2006; Kohn, 2018; Wood-Doughty et al., 2019). Publishers are anonymized within the study due to license restrictions around the sharing of usage data. It would take considerable effort to obtain permission to share usage data from each publisher included in the study, and the effort did not seem sufficiently beneficial given that publisher platform effects were not the variable of primary interest. Publishers comprising less than 5% of the total number of journals included in the dataset were grouped together in an "other" category.

There is also evidence to suggest that usage statistics are impacted by academic discipline or subject area (Gorraiz, Gumpenberger, & Schlögl, 2014; Mongeon, Archambault, & Larivière, 2018). Included journals were categorized by top-level Scopus subject area. In cases where a journal was included in more than one top-level subject area, the subject area where the journal had the highest Scimago ranking was selected. Subject area categories comprising less than 5% of the total number of journals included in the dataset were grouped together in an "other" category.

Journal usage may also be influenced by the relative size and importance of a journal. Here, journal size is defined by the number of articles that the journal publishes in a given year. A 2004 study demonstrates that indicators of journal quality are correlated with journal usage in one medical library (Wulff & Nixon, 2004). Both Scimago's Scientific Journal Rank (SJR) and Clarivate's Journal Impact Factor (JIF) were explored as proxy measures of journal size and importance. These measures are strongly correlated, suggesting that either measure may be appropriate (Elkins, Maher, Herbert, Moseley, & Sherrington, 2010). Ultimately, JIF was selected because it provided a slightly better model fit.

Finally, alternate access to journals via an aggregator database may decrease usage on

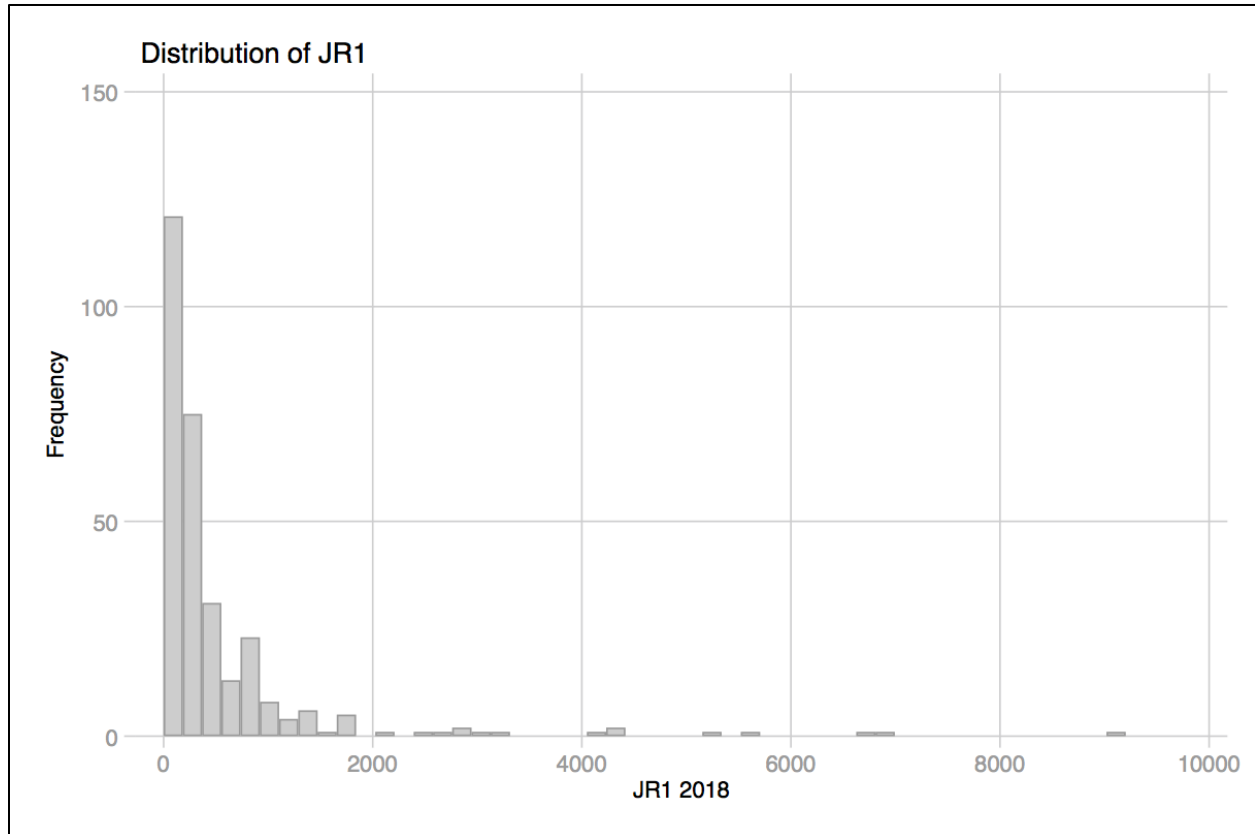


Figure 1
Distribution of JR1 2018 (dependent variable). Created using 538 Schemes (Bischof, 2017).

publisher websites (Bucknell, 2012). Due to the importance of recency in medical libraries, journals were categorized as having alternate aggregator access if the embargo period for the journal title was six months or less.

Because there is some evidence of home country bias in journal readership (Thelwall & Maflahi, 2015), a dummy variable representing Canadian journal titles was initially considered for inclusion in the model. The number of Canadian journal titles within the sample was small ($n = 7$), however, so ultimately this variable was not included.

Statistical Modelling

Like many outcomes of interest in library and information science, the dependent variable in

this study is not normally distributed (Figure 1). In such cases, it is not generally appropriate to use multiple linear regression, and generalized linear models should be considered.

A study analyzing statistical modelling of infometric data suggests that the negative binomial regression model (NBRM) may be most appropriate for infometric studies with count response variables (Ajiferuke & Famoye, 2015). The study dataset was modelled in Stata (Release 15) with both the Poisson regression model and the NBRM using methods outlined by Long and Freese (2006). Ultimately, the NBRM with robust standard errors was selected because there was significant evidence of overdispersion ($G^2 = 1.5e+05$, $p < 0.001$).

Table 1
Descriptive Statistics for Categorical Variables

Variables	Article Level Linking Enabled		No Article Level Linking		Total	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
<i>Publisher</i>						
Publisher A	76	76.8	23	23.2	99	33
Publisher B	32	100.0	0	0.0	32	11
Publisher C	18	94.7	1	5.3	19	6
Publisher D	21	100.0	0	0.0	21	7
Publisher E	27	96.4	1	3.6	28	9
Other publisher (reference category)	19	18.4	84	81.6	103	34
<i>Aggregator Access Available to Most Recent 6 Months</i>						
Yes	40	65.6	21	34.4	61	20
No	153	63.5	88	36.5	241	80
<i>Scimago Subject Category</i>						
Biochemistry, genetics, and molecular biology	19	67.9	9	32.1	28	9
Nursing	14	63.6	8	36.4	22	7
Other subject	31	64.6	17	35.4	48	16
Medicine (reference category)	129	63.2	75	36.8	204	68
Total	193	63.9	109	36.1	302	100

Table 2
Descriptive Statistics for Continuous Variables

Variables	Mean	Median	Std. Dev.	Min.	Max.
<i>JR1 2018</i>	553.97	234.50	1039.94	0	9202
Subgroup - article level links enabled	676.91	273	1228.04	16	9202
Subgroup - no article level linking	336.28	187	508.19	0	3271
<i>JIF 2017</i>	6.57	3.75	8.92	0.42	79.26
Subgroup - article level links enabled	7.57	3.87	10.53	0.66	79.26
Subgroup - no article level linking	4.8	3.63	4.43	0.42	23.43

Table 3
Results of Negative Binomial Regression Model with Robust Standard Errors

Variable	Coefficient	z	p value	% change in expected count for unit increase in X
<i>Independent Variable</i>				
Article level linking enabled	0.645***	3.819	.000	90.7
<i>Control Variables</i>				
Publisher				
Publisher A	0.063	0.353	.724	6.5
Publisher B	-1.353***	-5.312	.000	-74.2
Publisher C	0.019	0.058	.954	1.9
Publisher D	-0.336	-1.109	.267	-28.5
Publisher E	-1.055***	-4.009	.000	-65.2
Other publisher (reference category)	-	-	-	-
Aggregator access available	0.106	0.531	.595	11.2
JIF 2017	0.039***	5.031	.000	4.0
<i>Scimago Subject Category</i>				
Biochemistry, genetics and molecular biology	0.005	0.021	.983	0.5
Nursing	1.052***	3.995	.000	186.3
Other subject (non-medicine)	0.355*	2.106	.035	42.6
Medicine (reference category)	-	-	-	-

* $p < .05$; ** $p < .01$; *** $p < .001$.

Results

Tables 1 and 2 present summary statistics relating to variables that were included in the NBRM. For the 302 journals included in the study, the average total JR1 usage in 2018 was 554 per journal. The median JR1 usage was 234.5, with a range from 0 uses to 9202 uses. Article level linking was enabled for 64% of included journals ($n = 193$), and journal level linking was offered for 36% journal titles ($n = 109$).

Table 3 presents the results of the NBRM with robust standard errors. Regression coefficients, z , and p values are presented. The table also includes the percent change in the expected

count for each unit increase in order to assist with interpretation of the coefficients. For categorical variables that do not have defined units, the percent change in the expected count for each unit increase indicates the change that would occur when switching from one category (e.g., no article level linking enabled) to another (e.g., article level linking enabled), controlling for other variables.

Article level linking is shown to have a positive effect on total JR1, and the relationship is significant ($p < .001$). Article level linking increases expected total JR1 by 90.7%, when compared to titles with journal level linking and controlling for other variables.

Several control variables were statistically significant. As expected, JIF had a significant, positive effect on total JR1. For every one-point increase in JIF, a 4% increase in total JR1 would be expected. Interestingly, only two publisher dummy variables reached significance when compared to the reference category (all other publishers). In both cases, the relationship was negative. The nursing and “other” subject category dummy variables also reached statistical significance when compared to the reference category (medicine).

In order to clarify the effects of journal level vs. article level linking at various journal ranking

levels, the marginsplot Stata command was used to graph predicted total JR1 over the 95% range of JIF 2017, holding other variables constant. Figure 2 presents the predicted results for JIF scores ranging from 0–20, and includes the 95% confidence interval. Plotting the predicted margins results demonstrates that the difference in usage between journal level and article level linking remains significant at both lower and higher levels of journal impact. This suggests that usage of both smaller, more specialized journals and larger journals increases when article level linking is enabled.

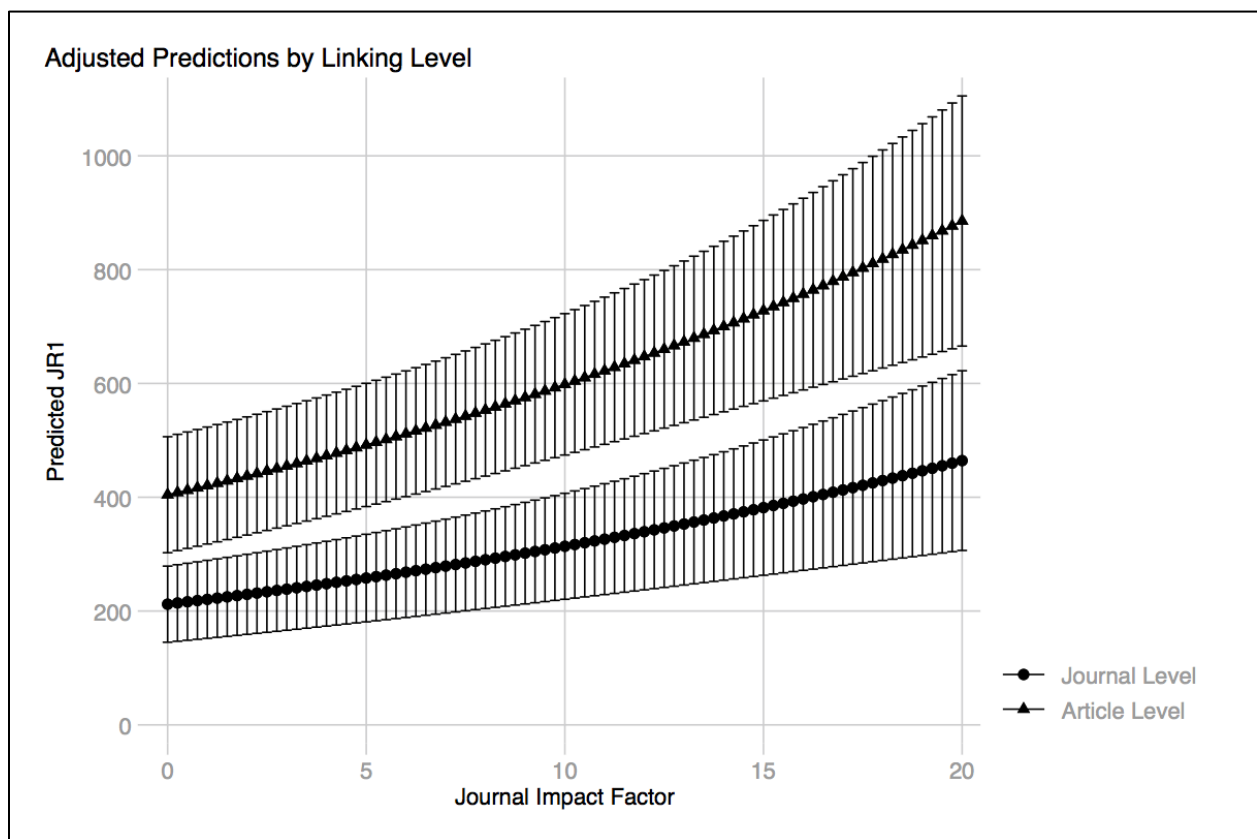


Figure 2
Adjusted JR1 predictions by linking level, including 95% CI. Created using 538 Schemes (Bischof, 2017).

Discussion

Amid emerging priorities in academic libraries such as research data services, digital humanities support, and research impact assessment (Lewis & Proffitt, 2019), it is important to examine the value and impact of current library practices (Booth, 2006). What practices should be prioritized, and what should libraries stop doing?

The circumstances surrounding this study provided a unique opportunity to assess the impact of article level linking versus journal level linking on journal usage. Although maintaining article level linking can be a relatively simple process for packages and consortial purchases, configuring and maintaining link resolver information for a multitude of individual journal titles can be time consuming and labour intensive. Past research provides evidence that a high percentage of journal usage originates outside of link resolver pathways (Greenberg & Bar-Ilan, 2017), so it is important to examine the impact of article level linking to determine whether efforts to maintain link resolver information for individual titles are worthwhile.

The results of the study demonstrate that article level linking has a large, statistically significant effect on journal usage at one academic health sciences library. Enabling article level linking increases journal usage by 90.7%.

Contextualizing the size of the effect is challenging due to the paucity of quantitative research on factors contributing to journal usage in academic libraries. Nevertheless, it is difficult to think of other interventions that the library might be able to implement that would increase journal usage so substantially.

Enabling article level linking wherever possible also improves the library user experience. Convenience is an extremely important factor in information seeking behaviours (Connaway, Dickey, & Radford, 2011); enabling article level linking wherever possible provides more

convenient pathways for library users. For example, a report by a library link resolver implementation team at the University of Michigan noted that journal level linking “requires a substantial increase in user attention and effort” (Varnum et al., 2016, p. 21). With article level linking, average time elapsed to first user interaction with the article was 35 seconds; with journal level linking, this time increased to 2 minutes, 45 seconds. Another study indicated that having to perform additional steps to locate articles on publisher websites can result in students becoming confused and overwhelmed (Mann & Sutton, 2015). Finally, an early study of the SFX link resolver observed that journal level linking is a source of user frustration (Wakimoto, Walker, & Dabbour, 2006).

Overall, this study provides evidence to support the importance of enabling article level linking at Memorial University’s Health Sciences Library. Although enabling article level linking for individual journal titles is labour intensive, it increases journal usage and thus maximizes the value of library subscriptions. Furthermore, enabling article level linking increases convenience for users and lowers the click burden. Providing convenient access to articles should be prioritized by libraries, particularly given the rise of highly convenient, alternative access avenues such as Sci-Hub (Nicholas et al., 2019).

While not of primary interest, several other control variables included in the model were statistically significant. In comparison with the reference category that included all other publishers, Publisher B and Publisher E demonstrated a strong, negative impact on expected usage counts when controlling for all other variables. Unlike other recent work (Wood-Doughty et al., 2019), this study did not observe evidence of usage inflation by publishers. However, it should be noted that this study was smaller, and that publisher inflation was not of primary concern. The other control variable of note was the nursing subject category. In comparison with the reference

category (medicine), the nursing subject category increased expected usage by 186%. While it is difficult to understand this result without further study, it may be related to the number of subscribed journals per user in the medicine and nursing programs. The study included far fewer journals in the nursing subject category than in the medicine subject category, which is likely related to the greater availability of, and greater user requirements for, specialized medical journals.

This study was undertaken at one academic health sciences library, and results may or may not be replicable at other libraries or institutions. While it seems likely that article level linking would increase journal usage at other institutions as well, further research investigating the size of the effect is warranted. A further limitation of the study is that it is observational in nature. Like other observational studies, there may be confounding variables that have not been accounted for in the statistical model. While attempts have been made to control for various factors that could affect usage, the groups of journals with and without article level linking enabled may have been different in other ways that are not considered. For example, the number of gold open access articles in each journal may have had an impact on usage. Future studies may be better positioned to control for the presence of gold open access articles due to the enactment of the COUNTER 5 Code of Practice in early 2019. COUNTER 5 Journal Request reports now exclude gold open access usage.

Conclusions

This study analyzed the impact of article level linking on journal usage statistics at one academic health sciences library. Negative binomial regression was used to examine the impact of article level linking on JR1, while controlling for journal subject area, journal ranking, publisher, and alternate aggregator access. Article level linking increased total JR1 by 90.7% ($p < 0.001$), when controlling for all

other variables. The differences between journal level linking and article level linking remained statistically significant at various journal ranking levels. This study provides evidence that article level linking should be prioritized at Memorial University's Health Sciences Library, since it increases usage and provides greater convenience for users. Although further study is needed, academic libraries should consider enabling article level linking wherever possible in order to facilitate user access, maximize the value of journal subscriptions, and improve convenience for users.

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