ORIGINAL ARTICLE

Research productivity of Canadian ophthalmology departments in top 10 ophthalmology and vision science journals from 2001 to 2010

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ABSTRACT • RÉSUMÉ

Objective: To evaluate the research productivity of Canadian ophthalmology departments in terms of research volume, impact, funding, and cost-efficiency, and compare these measures with the top 6 U.S. departments.

Design: Systemic review.

Methods: Using the Web of Science, we obtained the number of peer-reviewed research articles and citations in which an author listed an ophthalmology department (or affiliated university or hospital) from 2001 to 2010 in the top 10 ophthalmology and vision sciences journals, as well as the *Canadian Journal of Ophthalmology*. Federal research funding received from the Canadian Institutes of Health Research and National Institutes of Health was also obtained.

Results: The 3 universities that produced the highest number of articles were the University of Toronto (UofT), McGill University, and the University of British Columbia (UBC). UofT also produced the largest number of citations, followed by UBC and Dalhousie University. For the number of citations per article, the top 3 were the University of Ottawa, Dalhousie University, and the University of Calgary. McGill University, the University of Montreal, and UofT received the most federal funding. The 3 Canadian universities with the lowest funding (cost) per article were UofT, UBC, and McMaster University. The top contributors to the *Canadian Journal of Ophthalmology* from 2001 to 2010 were UofT, the University of Ottawa, and McGill University.

Conclusions: Larger Canadian departments tended to generate higher research volume and obtained more federal funding, but smaller departments also contributed significantly, and sometimes surpassed larger departments, in terms of research impact and cost-efficiency. The top 6 U.S. departments generated higher research volume and received more federal research funding than their Canadian counterparts. However, when research impact and cost-efficiency were examined, Canadian departments performed similar to the top U.S. departments.

Objet : Évaluation de la productivité de la recherche des départements d'ophtalmologie du Canada pour ce qui est du volume, de l'impact, du financement et du rapport coût-efficacité de la recherche, et comparaison avec les six premiers départements des É.-U.

Nature : Revue systématique.

Méthodes : En utilisant les sites Web de la science, l'on a obtenu le nombre d'articles de recherche revus par les pairs et de citations où les auteurs indiquaient un département d'ophtalmologie (ou des affiliations à une université ou un hôpital) de 2001 à 2010 dans les dix principaux journaux d'ophtalmologie ou des sciences de la vision de même que dans le Journal canadien d'ophtalmologie. Le financement fédéral de la recherche, venant des Instituts canadiens de la recherche en santé et l'Institut oculaire national, a aussi été obtenu.

Résultats : Les trois universités qui produisirent le plus grand nombre d'articles étaient l'Université de Toronto (UofT), l'Université McGill et l'Université de la Colombie-Britannique (UBC). L'UofT a aussi produit le plus grand nombre de citations, suivie de l'UBC et de l'Université Dalhousie. Pour le nombre de citations par article, les trois premières furent l'Université d'Ottawa, l'Université Dalhousie et l'Université de Calgary. L'Université McGill, l'Université de Montréal et l'UofT ont reçu les plus hauts financements fédéraux. Les trois universités canadiennes ayant reçu les plus faibles financements (coûts) par article furent l'UofT, l'UBC et l'Université McMaster. Les plus grands contributeurs du Journal canadien d'ophtalmologie de 2001 à 2010 furent l'UofT, l'Université d'Ottawa et l'Université McGill.

Conclusion : Les plus grands départements canadiens, qui ont tendance à générer les plus grand volume de recherche, ont reçu plus de financement fédéral, mais les départements plus petits ont aussi contribué de façon significative, et parfois surpassé les grands départements, quant à l'impact et au rapport coût-efficacité de la recherche. Comparativement aux É.-U., les six principaux départements américains ont généré un volume plus élevé de recherches et reçu plus de financement fédéral pour la recherche que leurs homologues canadiens. Toutefois, lors de l'examen de l'impact et du rapport coût-efficacité, les départements canadiens ont eu des rendements similaires à ceux des principaux départements des É.-U.

A major role of a university department is to create and disseminate new knowledge through research. With limited resources and budgetary constraints, there is an increasing need and pressure to evaluate research productivity using objective measures. Commonly used measures include the number of published articles, number of citations, and amount of research funding received over a specified period. Two recent studies have examined the research productivity of university departments in the field of ophthalmology.[1,2] One study examined the total number of articles published in 5 ophthalmology journals over a 5-year period (2002–2006) by country.[1] The

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United States was found to be the most prolific, publishing approximately 4 times more than the second highest producing country, the United Kingdom, followed by Japan, Germany, Australia, and Canada. When population-adjusted productivity was examined, Singapore, Iceland, and Australia were ranked the top 3 in terms of number of publication per 1 million population, with the United States ranking number 7 and Canada not making the top 10.[1] A second study reviewed the research output among ophthalmology departments across Canada over a 5-year period (2005–2009).[2] It attributed research articles to a university department based on first author affiliation only. It found that the University of Toronto (UofT) had the highest number of published articles and ''total impact score,'' followed by the University of British Columbia (UBC) and McGill University. Although including only the first author is a methodology that has been used previously,[3–6] it may not accurately reflect the research productivity of a department. Other authors, especially the most senior author who is often listed last, may have contributed equally to a paper but may not belong to the same university as the first author.

Although research volume is an important parameter to evaluate research productivity, research impact and cost-efficiency are equally important. The purpose of this study was to systematically investigate the research volume (number of published articles), impact (number of citations and citations per article), and cost-efficiency (federal funding received per article and per citation) of ophthalmology departments across Canada over a 10-year period from 2001 to 2010. To put the research productivity of Canadian ophthalmology departments into a larger context, we also collected similar information from the top 6 ophthalmology departments in the United States.

Methods

Journal selection

The top 10 vision-related journals were chosen using the Web of Science Journal Citation Reports' list of ophthalmology or vision sciences journals with the highest 5-year impact factor scores. The impact factors ranged from 9.11 to 2.65, and included the following journals in descending order: *Progress in Retinal and Eye Research*, *Ophthalmology*, *Investigative Ophthalmology and Visual Science*, *Archives of Ophthalmology*, *Journal of Vision*, *American Journal of Ophthalmology*, *Retina—The Journal of Retinal and Vitreous Diseases*, *British Journal of Ophthalmology*, *Experimental Eye Research*, and *Journal of Cataract and Refractive Surgery*. The *Canadian Journal of Ophthalmology* (*CJO*) was also included.

Article selection

Journal articles were obtained from the Web of Science published from 2001 to 2010. Only research articles were included. The following article types were excluded: reviews, editorials, bibliographies, addresses, biographies, interviews, legal cases, legislation, newspaper articles, patient education handouts, retractions of publication, publications erratum, research support, dictionaries, directories, duplicates, periodical indices, and Festschrift articles.

Citations

All citations for the included articles as of 2010 were recorded using the Web of Science database.

Author affiliation

All authors irrespective of their order were included. An ophthalmology department was counted if any author identified an affiliation with that department, university, or any affiliated hospital. Departmental web sites were used to determine all hospitals affiliated with each department. Based on these criteria, more than 1 ophthalmology department could be counted for each article, but the ophthalmology department was counted only once if there were multiple authors from the same department.

Ophthalmology department selection

All Canadian universities and their affiliated hospitals were included in the analysis of 3 measures: the number of articles, number of citations, and federal research funding received. For all other measures—the number of citations per article, federal research funding per article, federal research funding per citation, number of articles per faculty member, and number of citations per faculty member—only Canadian universities with ophthalmology residency training programs were included. The University of Manitoba was excluded because its training program only recommenced in 2010.

Federal research funding

Grant funding received from Canadian Institutes of Health Research (CIHR) in Canadian dollars by each university between 2001 and 2010 was obtained through email correspondence with the CIHR.

Number of faculty

An email was sent to the department chair of every Canadian ophthalmology department requesting information on the number of faculty, including all clinical faculty, research faculty, and adjuncts. All department chairs responded.

Productivity measures

The following were obtained and calculated: the number of articles, number of citations, number of citations per article, total amount of federal research funding received, federal research funding per article, federal research funding per citation, and number of articles per faculty member.

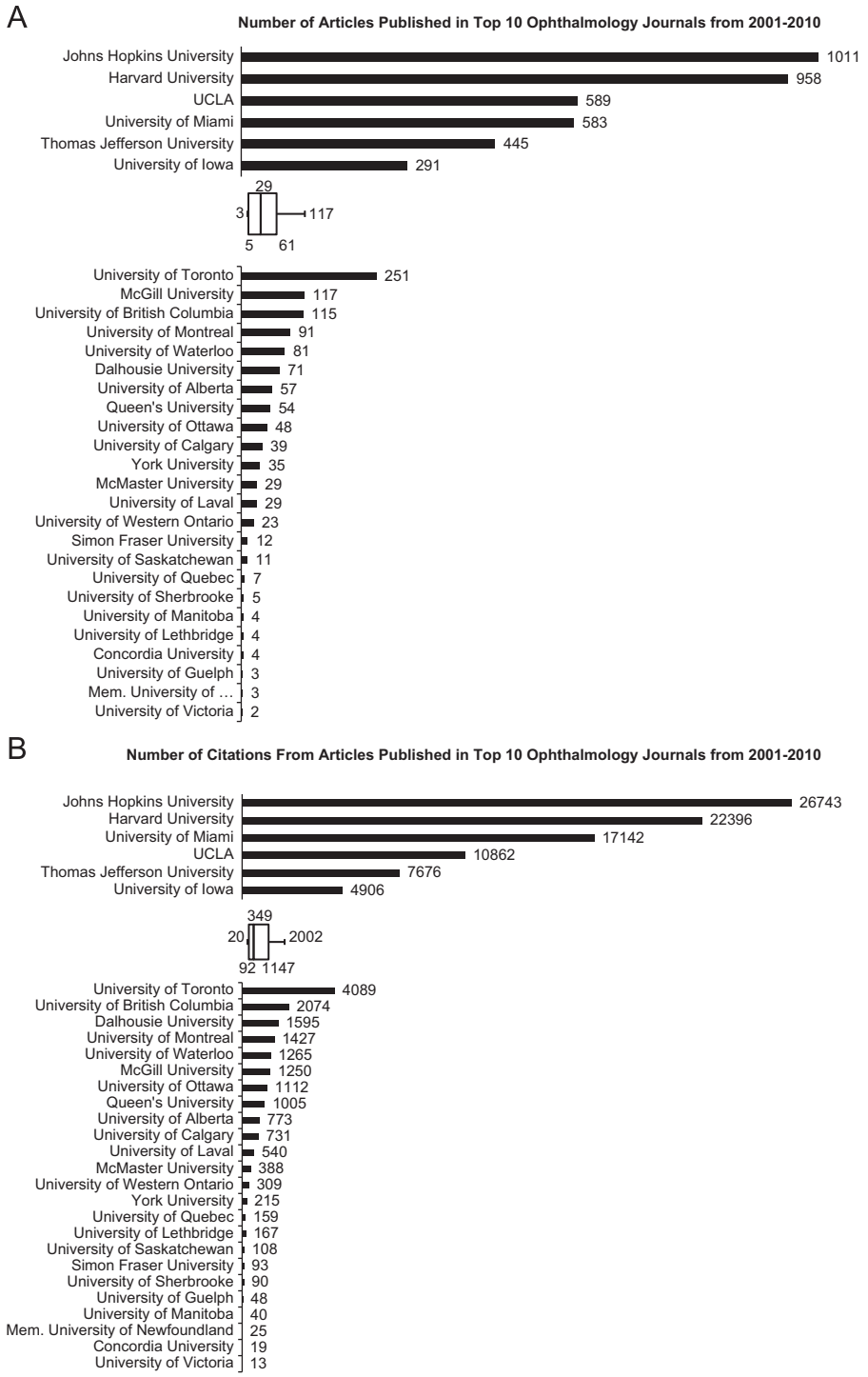

Fig. 1—Number of articles (A) and number of citations (B) published in top 10 ophthalmology journals from 2001 to 2010. Box plot represents data from Canadian departments only. UCLA, University of California Los Angeles.

Data analysis

Descriptive statistics were used. Results were displayed as bar graphs and box plots with 5th, 25th, 50th (median), 75th, and 95th percentile values.

Comparison with U.S. ophthalmology departments

The top 6 ophthalmology departments based on the 2010 *U.S. News & Report*[7] and 2009 *The Ophthalmology Times*[8] were included for comparison: Bascom Palmer Eye Institute of University of Miami, Wilmer Eye Institute of Johns Hopkins University, Wills Eye Institute of Thomas Jefferson University, Jules Stein Eye Institute of University of California Los Angeles, University of Iowa, and Massachusetts Eye & Ear Infirmary of Harvard University. Federal research funding received from the National Institutes of Health (NIH) in U.S. dollars by

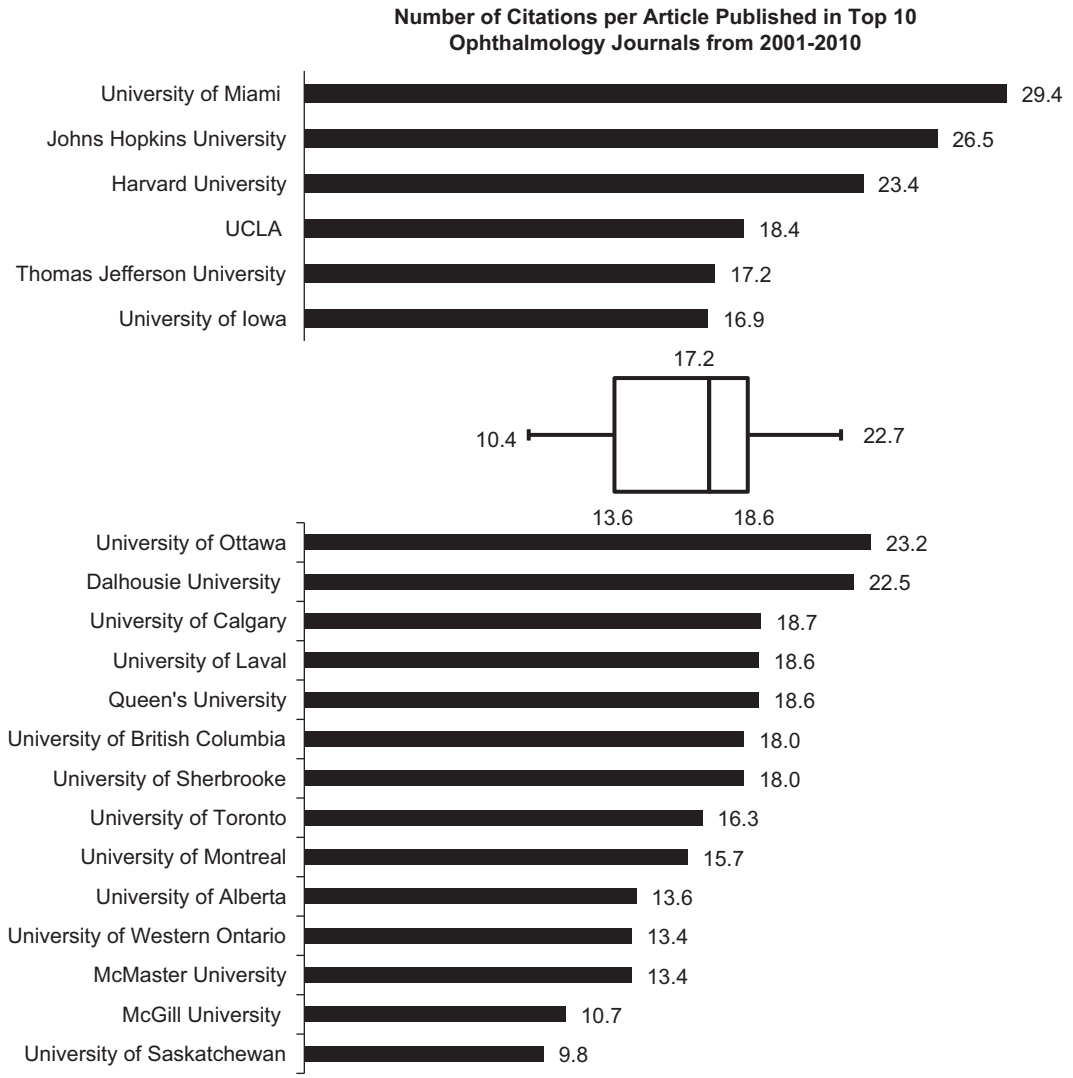

Fig. 2—Number of citations per article published in top 10 ophthalmology journals from 2001 to 2010. Box plot represents data from Canadian departments only. UCLA, University of California Los Angeles.

each U.S. department was obtained from the Blue Ridge Institute for Medical Research web site (this information was available from 2006 to 2010 only), although this information was not available for Wills Eye Institute and Massachusetts Eye & Ear Infirmary.[9] Of note, the U.S. funding includes overhead and physician salaries, whereas the Canadian funding does not. The number of faculty of the U.S. departments was obtained from their annual reports and departmental web sites.[10–15]

Results

Over the 10-year period from 2001 to 2010, the 3 Canadian universities that produced the highest number of articles in the top 10 ophthalmology and vision science journals were the UofT (251), McGill University (117), and UBC (115) (Fig. 1A). The UofT accounted for almost a quarter of all Canadian research output and generated at least twice the number of articles than that produced by any other Canadian department. The UofT also produced the largest number of citations (4089), followed by the UBC (2074) and Dalhousie University (1595) (Fig. 1B).

For the number of citations per article, the top 3 departments in Canada were the University of Ottawa (23.2), Dalhousie University (22.5), and the University of Calgary (18.7) (Fig. 2). Although the UofT produced the largest number of articles and citations, it ranked eighth in terms of number of citations per article.

During the 10-year period from 2001 to 2010, the CIHR provided a total of $108 million of research funding to all ophthalmology departments. The 3 universities that received the most funding were McGill University ($16.60 million), University of Montreal ($15.94 million), and UofT ($15.92 million) (Fig. 3A). These 3 universities together accounted for approximately

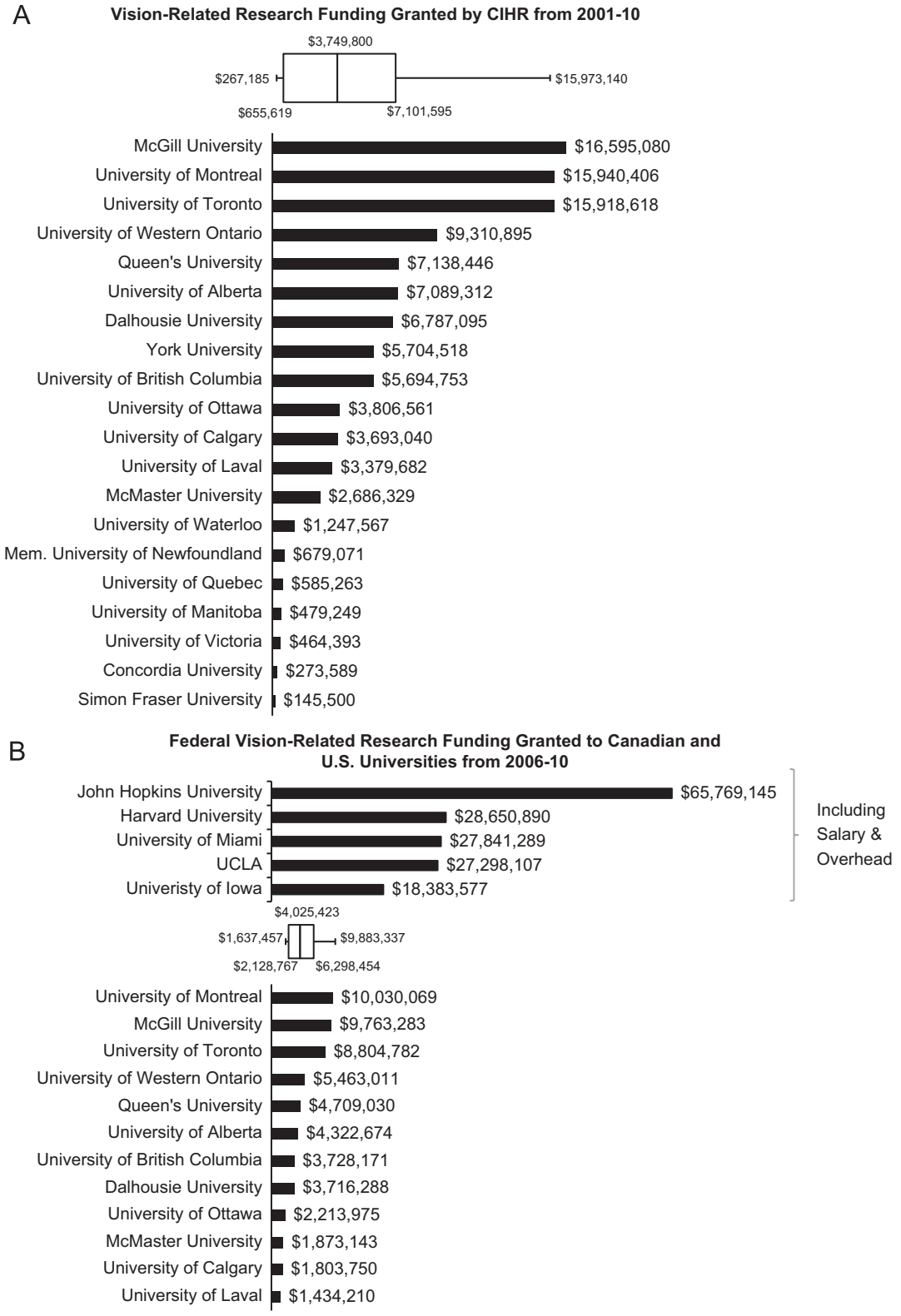

Fig. 3—Vision-related research funding granted from the Canadian Institutes of Health Research (CIHR) from 2001 to 2010 (A), and federal vision-related research funding granted to Canadian universities (CIHR) in Canadian dollars and U.S. universities (National Institutes of Health) in U.S. dollars from 2006 to 2010 (B). Box plot represents data from Canadian departments only. UCLA, University of California Los Angeles.

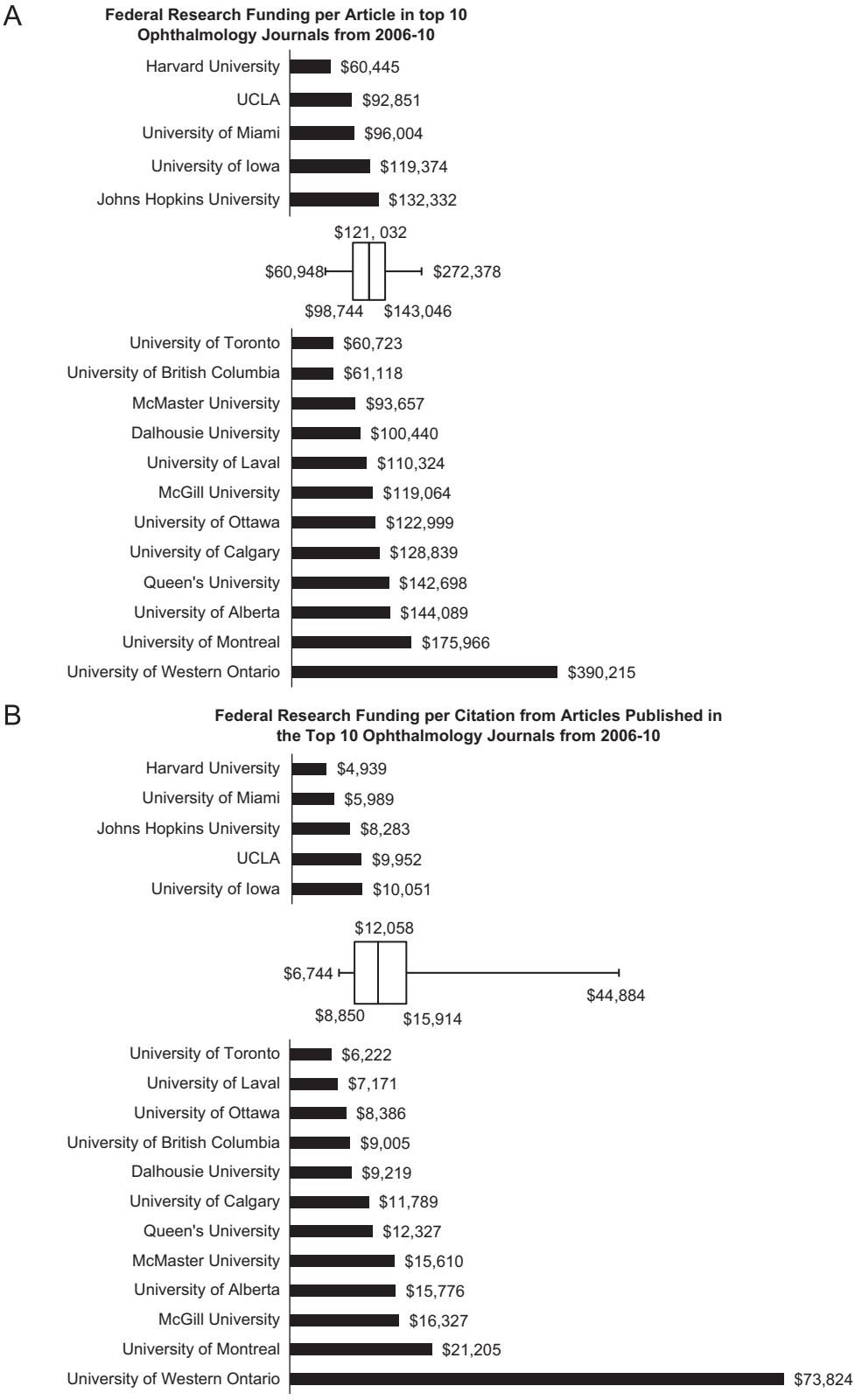

Fig. 4—Federal research funding per article (A) and per citation (B) in top 10 ophthalmology journals from 2006 to 2010. Box plot represents data from Canadian departments only. Canadian dollars were used for Canadian universities and U.S. dollars were used for U.S. universities. UCLA, University of California Los Angeles.

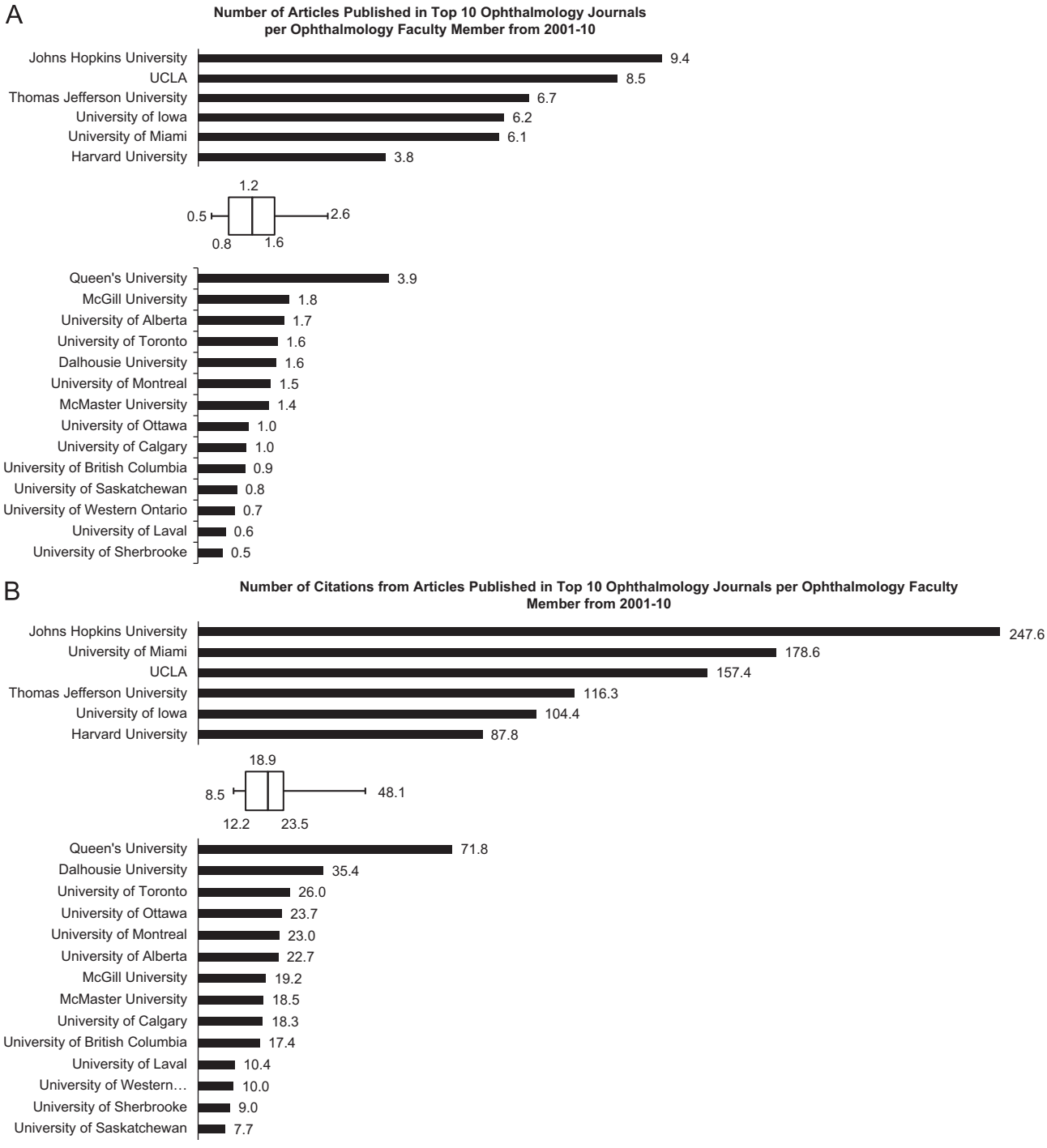

Fig. 5—Number of articles (A) and citations (B) published in top 10 ophthalmology journals per ophthalmology faculty member from 2001 to 2010. Box plot represents data from Canadian departments only. UCLA, University of California Los Angeles.

45% of the total CIHR funding for vision-related research. During the 5-year period from 2006 to 2010, the CIHR provided a total of $65 million for vision-related research, with the University of Montreal ($10.03 million), McGill University ($9.76 million), and UofT ($8.80 million) receiving the most funding (Fig. 3B).

In terms of cost-efficiency, from 2001 to 2010, the top 3 Canadian departments with the lowest federal funding per article published were the UofT ($60,700), UBC ($61,100), and McMaster University ($93,700) (Fig. 4A). On a funding per citation basis, the 3 most cost-efficient were the UofT ($6,000), University of Laval ($7,000) and University of Ottawa ($8,000) (Fig. 4B).

Weighting research volume by faculty size, the 3 Canadian departments that published the most articles per faculty member were Queen's University (3.9), McGill University (1.8), and the University of Alberta (1.7) (Fig. 5A). For citations per faculty member, the top

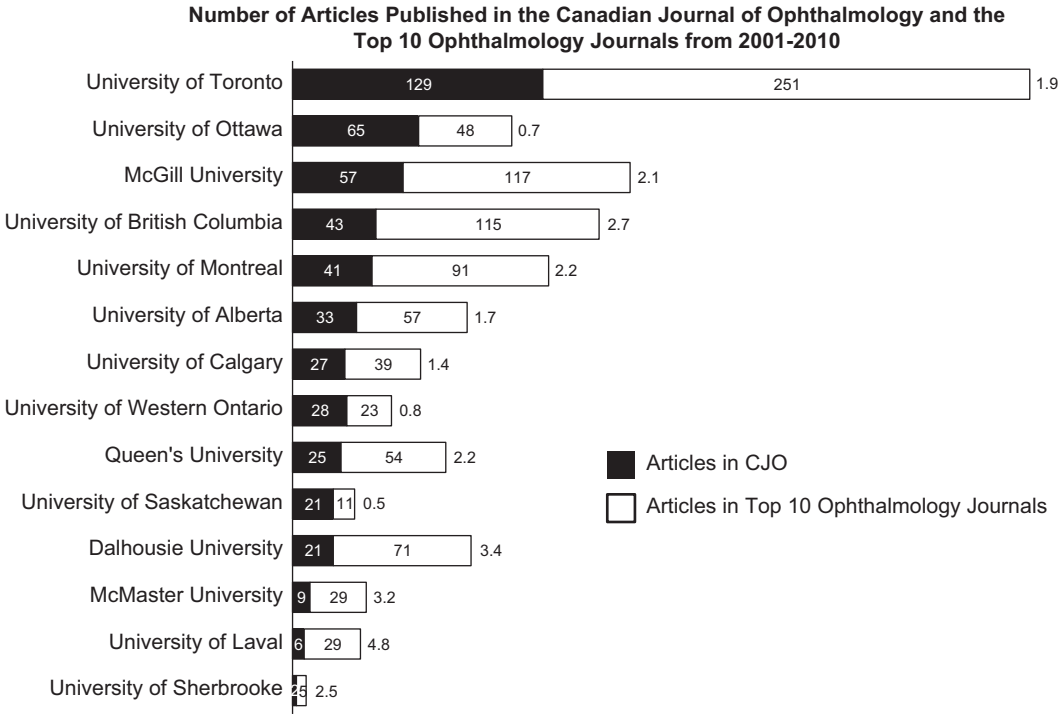

Fig. 6—Number of articles published in the *Canadian Journal of Ophthalmology* (*CJO*) and the top 10 ophthalmology journals from 2001 to 2010. Values on the left of the bars represent the ratio of the number of articles published in the top 10 journals to the number published in *CJO*.

3 departments were Queen's University (71.8), Dalhousie University (35.4), and UofT (26.0) (Fig. 5B).

The highest contributors to *CJO* from 2001 to 2010 were the UofT (129), the University of Ottawa (65), and McGill University (57). Some Canadian departments were more likely to publish articles in *CJO* than others (Fig. 6). For instance, the University of Laval published 5 times more in top 10 journals than in the *CJO*, whereas the University of Saskatchewan and the University of Ottawa published more in *CJO* than in the top 10 journals.

Compared with the United States, the total number of articles and citations produced by each Canadian department was lower than any of the top 6 U.S. ophthalmology departments (Fig. 1). The 2 highest producing U.S. departments, Johns Hopkins University and Harvard University, produced more than 4 times the number of research articles generated by the highest producing department in Canada. Although U.S. departments had higher research volume in terms of number of articles and citations, the number of citations per article generated by the top 7 Canadian departments was within the same range as the top 6 U.S. departments (Fig. 2). Regarding research funding, the NIH provided a total of US$924 million in the United States to support vision-related research from 2006 to 2010. Johns Hopkins University received US$66 million from the NIH, which was more than all Canadian universities combined. However, it should be noted that the NIH funding includes overhead and physician salary support, which is not the case for CIHR funding. The amount of funding per article of 8 Canadian departments (Fig. 4A) and the amount of funding per citation of 5 Canadian departments (Fig. 4B) were within the same range as the top 6 U.S. departments.

Conclusions

To the best of our knowledge, this is the first study to evaluate the research productivity of Canadian ophthalmology departments in terms of research volume, impact, funding, and cost-efficiency over the past 10 years, and benchmark their productivity to select U.S. ophthalmology departments. We found that, in general, larger Canadian departments generated higher research volume and obtained more federal research funding, but smaller departments also contributed significantly, and sometimes surpassed larger departments, in terms of research impact (number of citations per article), cost-efficiency (funding per article and per citation), and articles per faculty. The top 6 U.S. departments generated higher research volume, received more federal research funding, and produced more articles per faculty than their Canadian peers. However, when research impact and cost-efficiency were examined, many Canadian departments performed similar to the top U.S. departments.

This study has several limitations, and it also highlights the complexity of measuring research productivity of any academic department in any given field. Our research methodology for identifying article affiliations is university specific, but not department specific. Thus, although an article may come from an ophthalmology faculty, it

may also come from a faculty member who does vision-related research but belongs to another department within a university (e.g., psychology, optometry). Ideally, this study would capture only articles from faculty affiliated with ophthalmology departments. However, filtering by department (which is not possible in Web of Science) would also be problematic because some authors (or journals) disclose only the university and not the department. We believe our approach is the best surrogate for departmental productivity from the data and search algorithms available.

Regarding journal selection, we included only the top 10 ophthalmology or vision sciences journals with the highest 5-year impact factor scores. The pitfalls of using impact factor as a measure of journal quality have been well documented.[16] In addition, because the included journals are specialty journals in the field of ophthalmology, articles published in more general scientific and medical journals that have higher impact factor such as *Nature*, *Science*, *Journal of the American Medical Association* (*JAMA*), *New England Journal of Medicine* (*NEJM*), and *Canadian Medical Association Journal* (*CMAJ*), as well as those published in some subspecialty journals, may have been excluded. This may have artificially lowered the research productivity of departments that published more articles in higher-impact journals other than those in the field of ophthalmology, especially articles pertaining to basic science and large clinical trials. Ideally, all journals should be included in the analysis, but this is beyond the scope of this study and also introduces new biases and complexities, such as how to account for journals with vastly different impacts.

Regarding article selection, our criteria may not reflect the total scholastic contribution of a department by excluding reviews and editorials. Although reviews and editorials serve to disseminate existing knowledge, in this study, we aimed to evaluate how well a department contributes to the creation of new knowledge; therefore, we included only research articles in our analysis.

The disadvantages of using the number of articles and number of citations to assess research productivity have been well documented.[17] For example, the number of articles does not account for the quality of the publications, whereas the number of citations can be disproportionately skewed as a result of a single publication of major influence or through self-citation.[18] In addition, the number of citations does not consider the context of citations (e.g., citations made in a negative context and citations made to fraudulent or retracted work).

With regard to author affiliation, we included all authors listed on an article irrespective of the order of author placement in the authors list. This approach has the advantage of avoiding misclassification bias as a result of including the first author or the last author only.[19] In addition, by allowing more than 1 department to be counted for each article, our approach eliminates the bias of having to determine subjectively which institution was most responsible for a particular article and helps to reflect true multidepartment collaborations more accurately.

Collecting data on research funding proved to be most challenging. In addition to major federal funding sources (e.g., the CIHR), ophthalmology departments also received funding from a variety of sources, including other federal agencies (e.g., Natural Sciences and Engineering Research Council of Canada) and nonfederal agencies such as national nonprofit organizations (e.g., Heart and Stroke Foundation, Foundation Fighting Blindness), provincial or state agencies (e.g., Ontario Ministry of Health), and industrial or private grants. Unfortunately, there is no uniform reporting of grant support among departments, making it virtually impossible to obtain the total amount of research funding received by each department. Because of this difficulty, we decided to use data from 2 major federal funding agencies (the CIHR in Canada and NIH in the United States) as a proxy estimate of research funding, because these data are more readily available. Unfortunately, the CIHR and NIH data are not directly comparable. The CIHR funding data are university-specific whereas the NIH data are specific to the ophthalmology department, which may overestimate the Canadian funding. In contrast, as previously mentioned, the NIH data include overhead/physician salary support, whereas the CIHR funding does not, which will overestimate the U.S. funding. In addition, because there may not be a positive correlation between the amount of federal and non-federal funding received by a department, the funding results, as well as cost-effectiveness analysis, should be interpreted with caution. Lastly, there is inevitably a time lag when research funding was received and when results were published.

Despite these limitations, this study provides valid and reproducible metrics to measure research productivity. Larger studies that include all journals, more comprehensive data on all sources of funding, and all U.S. departments should be undertaken to compare the research productivity of Canadian and U.S. departments. Researchers from other disciplines could also consider using a similar methodology to benchmark the research productivity of their disciplines.

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References

1. Guerin MB, Flynn TH, Brady J, O'Brien CJ. Worldwide geographical distribution of ophthalmology publications. *Int Ophthalmol*. 2009;29:511-6.

2. Micieli A, Micieli JA, Smith AF. Analysis of the publication volume of Canadian ophthalmology departments from 2005 to 2009: a systematic review of the literature. *Can J Ophthalmol*. 2011;46:66-71.
3. Bliziotis IA, Paraschakis K, Vergidis PI, Karavasiou AI, Falagas ME. Worldwide trends in quantity and quality of published articles in the field of infectious diseases. *BMC Infect Dis*. 2005;5:16.
4. Falagas ME, Papastamataki PA, Bliziotis IA. A bibliometric analysis of research productivity in Parasitology by different world regions during a 9-year period (1995-2003). *BMC Infect Dis*. 2006;6:56.
5. Skevaki CL, Koliaraki V, Papadopoulos NG, Tsakris A, Pararas MV. Global research productivity in allergy. *J Investig Allergol Clin Immunol*. 2011;21:156-8.
6. Tsui BC, Li LX, Ma V, Wagner AM, Finucane BT. Declining randomized clinical trials from Canadian anesthesia departments? *Can J Anaesth*. 2006;53:226-35.
7. U.S. News best hospitals: ophthalmology. 2010. Available at health.usnews.com/best-hospitals/rankings/ophthalmology. Accessed December 14, 2011.
8. Webb JA. Bascom Palmer takes top honors in annual survey *Ophthalmology Times*. 2009;34:1.
9. Roskoski R. Ranking tables of NIH funding to US medical schools 2010. Available at www.brimr.org/. Accessed April 12, 2011.
10. Wilmer Eye Institute at John Hopkins University. All Wilmer faculty. Available at www.hopkinsmedicine.org/wilmer/employees/. Accessed April 2, 2011.
11. Bascom Palmer Eye Institute, University of Miami Health System. All Bascom Palmer doctors. Available at bascompalmer.org/doctors/all-doctors. Accessed April 2, 2012.
12. Miller, JW. Massachusetts Eye and Ear annual report 2010. Boston: Harvard University, 2010.
13. Mondino, BJ. Jules Stein Eye Institute annual report 2010-2011. Los Angeles: University of California Los Angeles; 2011.
14. Jefferson University Hospitals. Find a doctor—ophthlamology. Available at http://www.jeffersonhospital.org/FindDoctor.aspx. Accessed April 3, 2012.
15. Schmidt J. Iowa vision. In: Department of Ophthalmology & Vision Sciences Spring 2010 Newsletter. Iowa City, Iowa: University of Iowa Health Care; 2010.
16. European Association of Science Editors. EASE statement on inappropriate use of impact factors. 2008. Available at www.ease.org.uk/artman2/uploads/1/EASE_statement_IFs_final.pdf. Accessed December 29, 2011.
17. Lehmann S, Jackson AD, Lautrup BE. Measures for measures. *Nature*. 2006;444:1003-4.
18. Campbell FM. National bias: a comparison of citation practices by health professionals. *Bull Med Libr Assoc*. 1990;78:376-82.
19. Rudnisky CJ, Damji KF, Tennant MT, MacDonald IM. Re: analysis of the publication volume of Canadian ophthalmology departments from 2005 to 2009: a systematic review of the literature. *Can J Ophthalmol.*. 2011;46:440-1.