Analysis of the publication volume of Canadian ophthalmology departments from 2005 to 2009: a systematic review of the literature

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ABSTRACT • RÉSUMÉ

Objective: To assess the publication volume of Canadian ophthalmology departments over a 5-year period, 2005–2009.
Design: Systematic review of the literature.
Methods: MEDLINE was searched for papers published from 2005 to 2009 where the designated affiliation corresponded to a Canadian ophthalmology department. The papers were sorted by year, university, and study design. A total impact score (the impact factor of the journal multiplied by the number of papers published in that journal per year) was also calculated for each university.
Results: In the 5-year period there was an increasing trend in the total number of published ophthalmology papers. The University of Toronto had the highest number of published papers (224), followed by the University of British Columbia (143) and McGill University (120). The *Canadian Journal of Ophthalmology* published the most papers, followed by *Investigative Ophthalmology and Visual Science*. The most frequent study design category was basic science research and a total of 11 different randomized controlled trials were retrieved.
Conclusions: The publication volume of Canadian ophthalmology researchers increased significantly from 2005 to 2009 with larger institutions accounting for the majority of published papers. Like researchers in other countries, Canadian ophthalmology researchers preferred to publish in domestic journals.

Objet : Évaluation du volume de publication des départements d'ophtalmologie canadiens sur une période de 5 ans, 2005–2009.
Nature : Examen systématique de la littérature.
Méthodes : L'on a fouillé dans MEDLINE les articles publiés entre 2005 et 2009, qui indiquaient une affiliation avec un département d'ophtalmologie canadien. Ces articles ont été répartis par année, université et modèle d'étude. Le score d'impact total (le facteur d'impact du journal multiplié par le nombre d'articles publiés dans ce journal annuellement) a aussi été calculé pour chaque université.
Résultats : Dans la période de 5 ans, le nombre total d'articles traitant d'ophtalmologie a eu tendance à s'accroître. L'Université de Toronto a eu le plus grand nombre d'articles publiés (224), suivie de l'Université de la Colombie-Britannique (143) et l'Université McGill (120). Le *Journal canadien d'ophtalmologie* a publié la plus grande part des articles, suivi de *Investigative Ophthalmology and Visual Science*. Le modèle d'étude le plus fréquent portait sur la recherche scientifique fondamentale et l'on a retrouvé en tout 11 différents essais cliniques aléatoires.
Conclusions : La volume de publication des chercheurs canadiens en ophtalmologie a augmenté de façon significative de 2005 à 2009 et les grandes institutions ont présenté la majorité des articles publiés. Comme les chercheurs des autres pays, les chercheurs canadiens en ophtalmologie ont préféré publier dans les journaux nationaux.

Continuing development of the practice of ophthalmology is dependent on the academic research efforts of clinicians and scientists. Recent advances in eye care, including novel therapies, improved diagnostic tools, and advances in surgical techniques, result from the efforts of many academic centres around the world, including those in Canada. Of the 16 Canadian universities with medical schools, 14 have formal residency training programs in ophthalmology,[2] which means that Canadian researchers have been involved in a number of important clinical trials and scientific discoveries that have improved the state of scientific knowledge and the delivery of health care for patients with ocular conditions. The *Canadian Journal of Ophthalmology* and the Canadian Ophthalmological Society provide additional forums for Canadian scientists to collaborate and share their work with an international audience. However, to date, knowledge of the productivity and efforts of Canadian ophthalmology departments and academic centres remains limited.

Scientific publications not only communicate research findings, they also increase an author's recognition within the medical community and help investigative groups obtain additional funding to continue their research.[3] Productivity is assessed using the number of papers published in a discipline's peer-reviewed scientific journals.[4] The impact factor (IF) of a scientific journal can be used to quantify the importance or influence of the journal because it incorporates the number of citations of papers from that journal over a specific period of time.[5] The goal of our study was to quantify the publication volume of the ophthalmology departments in Canada by determining the number of published papers in peer-reviewed journals as an index of the work performed over the last 5 years (January 2005–December 2009). In addition, our data were

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sorted into 14 study design categories and a ''total impact score,'' which incorporates the IF, was used to assess the quality of the journals in which the papers were published.

METHODS

An observational study examining the total number of papers published by ophthalmology departments in Canada over the past 5 years was performed. The total number of published papers was obtained from the MEDLINE database using the PubMed search engine with the search terms limited to the address of the first author ''[ad],'' date published ''[dp],'' and publication type ''[pt]'' combined with the Boolean operators AND, OR, or NOT. Specifically, the search parameter used was ''ophthalmology[ad] OR eye[ad] OR ophtalmologie[ad] AND (Canada[ad] OR British Columbia[ad] OR BC[ad] OR Alberta[ad] OR Alta[ad] OR Saskatchewan[ad] OR Sask[ad] OR Manitoba[ad] OR Ontario[ad] OR Ont[ad] OR Quebec[ad] OR Que[ad] OR Newfoundland[ad] OR Nfld[ad] OR Nova Scotia[ad] OR NS[ad]) NOT letter[pt] NOT comment[pt] AND (2005[dp] OR 2006[dp] OR 2007[dp] OR 2008[dp] OR 2009[dp]).'' The search was done in December 2009 for the years 2005–2008 and on January 18, 2010, for the year 2009 to ensure all papers published in print in 2009 were indexed in MEDLINE. Papers that were published online, ahead of print, were classified in the year that they appeared in print. Validation of the search criteria was performed by randomly selecting 1 or 2 authors from each university and checking their publication history to ensure the search criteria was catching all appropriate papers.

To assign each journal an overall score, we used a ''total impact score'' (the total number of papers published in a journal in a given year that met our search criteria was multiplied by the impact factor for that journal).[6] The impact factor for each journal was obtained from the Thomson Reuters *Journal Citation Reports* (JCR), on the Thomson Reuters Web of Knowledge website, which defines an impact factor as the average number of times papers published in the journal in the previous 2 years have been cited in the JCR year. The appropriate JCR year was used to account for the yearly changes in journal IFs. The total impact scores were calculated to take into account the IFs. The criteria for including a paper were that it was (*i*) included in MEDLINE, (*ii*) included in the Science Citation Index, and (*iii*) published by a Canadian ophthalmology department or an affiliated hospital between January 2005 and December 2009. Journals included in PubMed but not in the Science Citation Index were not included in the total impact score calculation.

Two independent authors sorted the papers by university and then further sorted them by year. The concordance rate was high between the 2 authors and any disagreements were resolved by consensus. If the affiliation included only a hospital, the paper was accredited to the university affiliated with that hospital. Titles and abstracts were manually reviewed and papers were categorized into 14 study designs (Table 1) based on the Cochrane Collaboration Glossary[7] and similar previous studies.[6] The research designs included animal studies, basic science research, case control studies, case reports, case series, clinical trials, cohort studies, meta-analysis, non-clinical studies (historical papers, economic evaluations, education, etc.), randomized controlled trials (RCTs), multicentre RCTs, reviews, surveys, and systematic reviews (Appendix 1, available online). If an abstract was not available, the full text article was assessed. Statistical analysis using the Pearson correlation was conducted to determine significant changes in publication numbers and types of study designs over the 5-year period. Pearson correlation coefficient and linear regression analyses were performed using Microsoft Excel 2007 (Microsoft Corporation, Redmond, WA) to assess the relationships between variables. A correlation coefficient of ≥ 0.7 suggests a strong relationship between the 2 variables and a p value < 0.05 defines statistical significance.

RESULTS

The search strategy identified 774 published papers; 764 (98.7%) of these were authored by a member of an ophthalmology department at a Canadian university or its

Table 1—Study designs published by Canadian universities by year

	2005	2006	2007	2008	2009	Total	Pearson correlation coefficient (*r*)
Animal studies	4	18	7	8	9	46	0
Basic science research	35	36	59	54	29	214	0.10
Case reports	19	25	24	30	23	121	0.52
Case series	38	29	39	48	53	208	0.83
Case controls	1	2	2	1	4	10	0.65
Clinical trials	2	2	1	7	6	18	0.76
Cohort	0	1	0	1	1	3	0.58
Meta-analysis	0	0	1	0	0	1	0
Non-clinical	8	10	4	10	5	37	−0.34
Randomized controlled trials	2	1	3	3	0	9	−0.24
Randomized controlled trials, multicentre	0	0	0	1	1	2	0.87
Reviews	7	12	14	17	18	69	0.98
Systematic reviews	0	2	2	3	2	9	0.72
Survey	3	4	3	4	3	17	0

affiliated hospital. A linear regression of the data revealed an increasing trend in the total number of published ophthalmology papers, with the most papers (187) published in 2008 (Fig. 1). In the 5-year period from 2005 to 2009, the University of Toronto had the highest number of published papers (224), followed by the University of British Columbia (143) and McGill University (120) (Table 2, Fig. 2). In addition to having the most published papers, the University of Toronto also had the highest total impact score (503.54) and accounted for 29.32% of Canadian papers published from 2005 to 2009. The top 3 universities—the University of Toronto, University of British Columbia, and McGill University—accounted for 63.75% of Canadian ophthalmology papers published, with a combined total of 487.

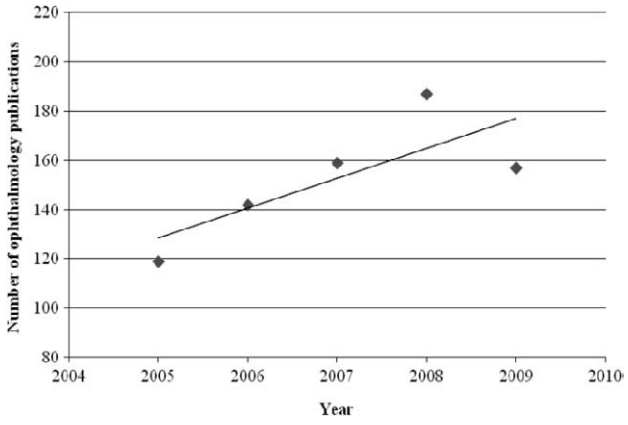

Fig. 1—Linear regression of the total number of Canadian ophthalmology papers published from 2005 to 2009.

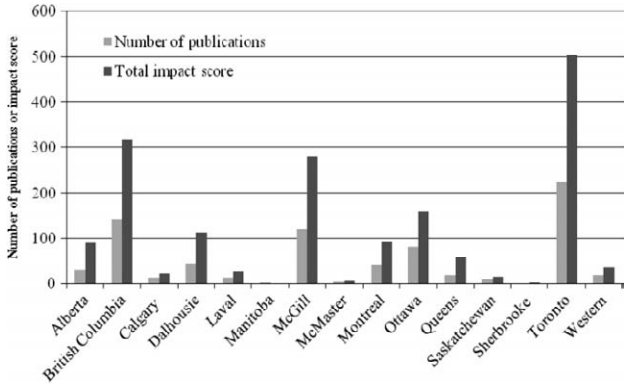

Fig. 2—Total number of published papers and total impact score for each Canadian university from 2005 to 2009. The total impact score was calculated by multiplying the number of papers published per year in a particular journal by the impact factor of the journal.

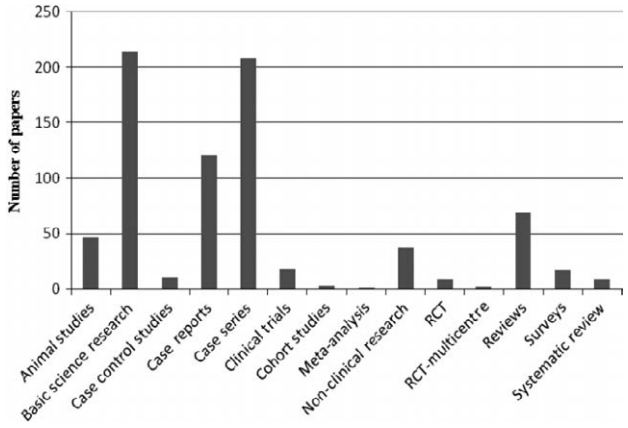

Fig. 3—Types of ophthalmology papers published by Canadian universities from 2005 to 2009. Each paper was manually classified into one of 14 different study designs.

Only the University of British Columbia and Dalhousie University demonstrated significant increases in publication volumes, $r = 0.97$ and 0.90, respectively (Table 3). Publication volumes for both the University of Toronto and McGill University increased each year from 2005 to 2008, but decreased in 2009. The *Canadian Journal of Ophthalmology* published the most Canadian papers (149 papers, 19.5%), followed by *Investigative Ophthalmology and Visual Science* (42 papers, 5.5%) and *Vision Research* (38 papers, 5.0%) (Table 4). The 3 journals with the highest IFs were *Journal of the American Medical Association* (31.7), *Nature* (31.4), and *Nature Medicine* (27.6), in which one paper from Queen's University, the University of Toronto, and the Université de Montréal, were respectively published. Of the 157 journals in which Canadian papers were published, 130 (82.8%) were indexed in the Science Citation Index.

Over the 5-year period, the most frequently published study designs were basic science research (214), case series (208), and case reports (121). A total of 11 different RCTs were conducted (Table 5, Fig. 3). Case series ($r = 0.83$) and reviews ($r = 0.98$) were the only study designs whose publication frequencies increased over the 5 years. For the top 3 universities, the most frequently published study designs were case series (35%, University of Toronto) and basic science research (27%, University of British Columbia and 66%, McGill University) (Table 5).

Table 2—Ophthalmology papers and total impact scores from 2005 to 2009

Canadian university	Papers published (%)	Papers published in SCI journals	Total impact scores
Alberta	31 (4.06)	28	89.79
British Columbia	143 (18.72)	128	317.22
Calgary	14 (1.83)	13	22.79
Dalhousie	45 (5.90)	42	112.37
Laval	13 (1.70)	11	28.07
Manitoba	2 (0.26)	2	1.45
McGill	120 (15.71)	113	279.87
McMaster	4 (0.52)	3	6.43
Montreal	41 (5.37)	37	91.80
Ottawa	81 (10.60)	76	160.04
Queen's	18 (2.36)	18	58.62
Saskatchewan	9 (1.18)	9	15.74
Sherbrooke	1 (0.13)	1	2.51
Toronto	224 (29.32)	218	503.54
Western	18 (2.36)	18	35.15
Total	764 (100.02)	717	1725.36

Note: SCI, Science Citation Index.

Discussion

In an era of evidence-based medicine, publication of scientific papers is one of the most recognized ways of measuring scientific productivity. Scientific research is essential for the development of any medical specialty and is necessary to develop more effective and efficient means to treat an ever increasing aging population. This research can be quantified by examining specific academic centres or entire countries in terms of total number of papers published in peer-reviewed scientific journals. However, a MEDLINE search and a more extensive examination of the literature found no previous study that examined the publication volume of Canadian universities in the field of ophthalmology. Publication volumes of other medical specialties in Canada such as anaesthesia,[6] clinical genetics,[8] and Canadian human studies[9] have been analyzed. Our study provides a foundation on which the rate of research in Canadian ophthalmology can be further analyzed to determine whether it is progressing at a rate that is comparable with that of other academic disciplines and whether the current infrastructure is sufficient to carry the field into the coming years when demand for eye care services is expected to rise.[10]

Our study showed an increasing trend in Canadian ophthalmology publication volume over the 5-year period. This trend is not only seen in Canada; Guerin et al.[11] found a similar tendency in worldwide ophthalmological publication volume. Using a strategy similar to ours, they found an overall increase of 29% in ophthalmology papers

Table 3—Canadian ophthalmology papers published yearly by university

Canadian university	2005	2006	2007	2008	2009	Pearson correlation coefficient (*r*)
Alberta	7	5	5	7	7	0.29
British Columbia	22	24	30	33	34	0.97
Calgary	2	3	4	3	2	0
Dalhousie	6	6	7	13	13	0.90
Laval	1	2	5	1	4	0.44
Manitoba	1	0	1	0	0	−0.58
McGill	17	25	29	29	20	0.29
McMaster	0	0	1	2	1	0.76
Montreal	11	7	7	8	8	−0.48
Ottawa	16	25	14	17	9	−0.60
Queen's	5	0	3	5	5	0.36
Saskatchewan	2	1	4	0	2	−0.11
Sherbrooke	0	0	1	0	0	0
Toronto	26	42	44	64	48	0.77
Western	3	2	4	5	4	0.69

Table 4—Top 10 journal rankings

Journals publishing the most Canadian papers		Journals with the highest impact factors	
Journal	Papers published	Journal	Impact factor
Canadian Journal of Ophthalmology	149	*Journal of the American Medical Association*	31.72
Investigative Ophthalmology and Visual Science	42	*Nature*	31.43
Vision Research	38	*Nature Medicine*	27.55
British Journal of Ophthalmology	32	*Current Biology*	10.78
Ophthalmic Plastic and Reconstructive Surgery	30	*Proceedings of the National Academy of Sciences*	9.38
Journal of the American Association for Pediatric Ophthalmology and Strabismus	26	*Diabetes*	8.40
Cornea	25	*Canadian Medical Association Journal*	7.46
Archives of Ophthalmology	25	*Journal of Neuroscience*	7.45
Journal of Cataract and Refractive Surgery	24	*Human Molecular Genetics*	7.25
Ophthalmology	21	*Neurology*	7.04

Table 5—Top 3 study designs in papers published by Canadian universities from 2005 to 2009*

	Rank		
	1	2	3
Alberta	Basic science research (27%†)	Case series (27%)	Case report (16%)
British Columbia	Basic science research (27%)	Case series (26%)	Case report and review (13%)
Dalhousie	Case series (27%)	Basic science research (18%)	Review (18%)
McGill	Basic science research (66%)	Case report (15%)	Case series (13%)
Montreal	Case series (41%)	Case report (22%)	Basic science research (17%)
Ottawa	Case report (32%)	Basic science research (20%)	Review (12%)
Queen's	Case series (33%)	Case report (17%)	Basic science research (11%)
Toronto	Case series (35%)	Basic science research (18%)	Case report (14%)
Western	Case series (39%)	Basic science research (22%)	Case report and clinical trial (11%)

*Universities not listed published fewer than 18 papers from 2005 to 2009.
†Numbers in parentheses are the percentages of published papers in this category for the university.

published in 2006 compared with 2002. A comparison of Canada with 67 other countries revealed that Canada ranked 6th (behind the United States, United Kingdom, Japan, Germany, and Australia) in total number of papers published between 2002 and 2006. Canada's contribution to the world's publications has increased from 2.5% in 1984 to 3.9% in 1997–2001.[12] Unlike Canada, other countries such as Australia, New Zealand, Singapore, Argentina, Brazil, Chile, Uruguay, and Japan have all reviewed their contributions to ophthalmology literature.[12–16] Australia and New Zealand increased their relative productivity at a greater rate than North America.[17] Moreover, Australia, New Zealand, Singapore, and Brazil show similar trends to Canada as the numbers of their peer-reviewed publications are increasing.

A number of factors may have contributed to the increasing trend of ophthalmology papers published in Canada over the past 5 years. Increased funding to support Canadian researchers in ophthalmology has been available from certain Canadian agencies. For instance, funding from the Canadian Glaucoma Research Society of Canada increased from more than $130 000 in 2007 to more than $205 000 in 2009.[18] In 2009, 12 different projects were funded by this society compared with 6 projects in 2004 and 5 projects in 1994. More faculty positions, stimulated by government efforts to reduce wait times for key eye care areas, may have also contributed to the growing trend in publication volume as most academic clinical faculty are expectated to publish some research. In addition, the number of ophthalmology residency positions have been increased to counter the shortage of physicians that resulted from cutbacks in the 1990s.[19] The increase from 16 graduates in Canada in 1998 to 32 in 2006 may have contributed to the growing number of ophthalmology publications as most programs require research activity from their residents and fellows, which in turn may stimulate future projects.[10] Interestingly, a survey aimed at assessing the motivations and future goals of Canadian ophthalmology residents showed 62% intended to pursue post-residency research activities, which may help foster this increasing trend into the future.[20]

Canadian ophthalmologists and vision researchers showed a domestic journal preference for the *Canadian Journal of Ophthalmology*, similar to trends seen in other parts of the world. A clear preference for publishing in domestic or regional journals was shown for specific countries over a 5-year period, 1991–1995.[12,15] For example, Australian and New Zealand researchers published most of their papers in *Clinical and Experimental Ophthalmology* (previously the *Australian and New Zealand Journal of Ophthalmology*), Swedish researchers in *Acta Ophthalmologica Scandinavica*, Brazilian researchers in the *Brazilian Journal of Medical and Biological Research*, and Chilean researchers in *Revista Médica de Chile*. Two papers from Canadian ophthalmology departments were published in the top 10 IF-ranked journals: the *Journal of the American Medical Association* and *Nature*.[21] Publishing in leading international journals reflects the quality of research performed by Canadian ophthalmologists and vision researchers, increases international recognition, and provides additional collaborative opportunities.

Our study has a few limitations. When assigning a paper to 1 of the 16 Canadian universities, only the first author's affiliation was considered. Therefore, the extent of collaboration between scientists from different institutions or countries was not considered. In addition, the number of researchers per university was not accounted for as rankings were based on the total number of ophthalmology papers published. Consequently, the productivity per faculty was not considered as this would have required additional data from each university to accurately depict the number of clinicians, researchers, and residents active in research. In multiple-authored papers, the first author may be a trainee (resident or fellow) and the last author is the senior author; senior researchers may have students and (or) fellows from other cities doing research in their labs. To verify a strong correlation between the first and last author's addresses, the full-text papers for the first 30 multiple-authored papers published in 2005 were obtained. Of these, 26 papers had the same address for the first and last authors. A third limitation is the validity of using IFs to assess the importance of scientific journals as IFs have numerous criticisms. The type of research reported can affect the IF; general journals tend to have higher IFs than more specialized ones.[22] The IF calculation is based on the arbitrary selection of a 2-year reference period and many publications achieve their maximal scientific impact outside this time frame.[23,24] While the IF is a useful tool for assessing journal quality, it does not fully represent the citation rate of individual papers or authors.

The various study designs used in ophthalmology research differ in the quality of the scientific evidence they provide and in the time required to complete the project. RCTs, cohort studies, and clinical trials generally require more time and resources than case reports or retrospective chart reviews. For example, RCTs require additional steps such as conceiving the study design, obtaining ethics approval, and recruiting patients. To address this limitation the 14 study designs may be ranked according to the quality of the research they provide, with RCTs and clinical trials having a higher ranking or score than other types of published research. However, such a scoring system is limited because of the complexity and subjectivity of assigning a score value to each study design. In addition, not all highly ranked research designs, such as RCTs, are of high research quality and some lower ranked designs, such as case reports or systematic reviews, may provide a higher quality of research. Further evaluation is required to grade each paper for study design quality.

This paper provides a benchmark from which changes in Canadian ophthalmology publishing trends can be followed and analyzed in the future. An increasing number of practicing ophthalmologists, in addition to an overall

increase in papers published in peer-reviewed journals from 2005 to 2009, suggests that ophthalmology and vision science research in Canada has a promising future. Studies analyzing Canadian ophthalmology publication volume in 2010 and beyond can compare data with that of the present study, allowing for an interpretation of the evolving discipline of ophthalmology in Canada.

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