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**Title:** Supply and demographic characteristics of Ontario's ophthalmologists from 2010–2019: a population-based analysis

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**Reviewer 1:** Yvonne Buys

**Institution:** Department of Ophthalmology and Vision Sciences, University of Toronto  
General comments (author response in bold)

The authors may wish to add a relevant paper that previously evaluated vision care in Canada including ophthalmology subspecialties and optometry; Ali AA, Hallingham S, Buys YM: Workforce supply of eye care providers in Canada: optometrists, ophthalmologist, and subspecialty ophthalmologists. Canadian Journal of Ophthalmology 2015;50:422-8.

**We thank the reviewer for their comment. We have now referenced this study in the introduction and discuss some ways in which our study will improve upon existing data:**

**“To understand how these factors impact the sustainability of eye care delivery, human resource analyses have been performed to assess for the adequacy of the current and future supply of ophthalmologists that will serve the Canadian population (7-11). One of these studies reported 4.91 times more optometrists than ophthalmologists in Ontario in 2012 (11).”**

**“Some of these studies were cross-sectional and relied on CMA data, which may be outdated, given that data were collected in 2012 for most recent study (10,11). These datasets may include inactive ophthalmologists and are based on self-reported fellowship training. We identified a need to use physician billing data, assess longitudinal trends and explore supply using practice patterns as opposed to fellowship training.”** (Page 3, lines 108-112, 114-118)

How were the various thresholds for low-, moderate- and high- volume cataract surgeons determined?

**As per your comment and the editor's comment, we have added more detail regarding the definitions of these categories. In the methods, we now indicate: “Definitions were reviewed by 1-3 ophthalmologists from each area of care and adjusted based on expert feedback.”** (Page 6, lines 158-159)

Did 'general medical ophthalmologist' include lasers and or intravitreal injections?

**Yes, an individual could do lasers and injections and fall into this category if they do not meet criteria for 'retina medical' for example. (N/A)**

How many ophthalmologists were represented in more than one group?

**4-8 ophthalmologists were counted in multiple areas of care, depending on the fiscal year. We have now clarified in the limitations that “Additionally, some definitions were not mutually exclusive and it was possible for an ophthalmologist to be included in multiple areas of care (range of 4-8 ophthalmologists were counted in multiple categories in a given fiscal year)”** (Page 12-13, lines 311-314)

In order to obtain a comprehensive analysis of vision care manpower shouldn't optometrists be included?

**Our study represents one facet of multiple that influence health human resources of eye care delivery. Our a priori research question for this study was to evaluate the supply of ophthalmologists in Ontario during the study period. Evaluation of optometrist supply was beyond the scope of our analysis, however this is an excellent idea that should be explored in future studies.**

**In the conclusions, it's indicated that "Additionally, the current and future role of optometry in the delivery of Ontario's eye services was beyond the scope of our research question, but an important consideration when developing policy for future human resource requirements." (N/A)**

Page 8, line 185, please define IQR when first used.

**This has been addressed and defined as Interquartile Range before being abbreviated as IQR. (Page 7, line 192)**

Table 2. Suggest adding columns to show the proportion of female ophthalmologists in each of these categories in 2010 and 2019 followed by the column as shown with the change in proportion.

**This has been addressed as per the editor and reviewer comments. For tables 3-4. we have now provided counts and percent for 2010 and 2019. We have also added a change in counts in addition to the percentage change. (See Tables 3-4)**

Table 3. In each of the columns suggest adding the change by gender for the various career stages.

**Unfortunately, these data were unavailable to us as it was not included in our a priori data application form submitted to the OMA/MOH. (N/A)**

Table 4. Perhaps the first and third column should be 2019 rather than 2010 since this would be more reflective of the current situation. In the same table please also add 'overall' as this would help to provide a perspective for changes specific to each area of care.

**We have addressed this comment. We have added an "overall" row and have changed the first and the third column to 2019. (See Table 5)**

Figures 1-4 are confusing to follow and perhaps would be better represented by a line graph with each line representing one of the 5 categories. With the current bar graphs it is hard to visualize the year-to-year changes in each of these specific categories.

**Figures 2-7 are now line graphs.**

Figures 5 and 6. As above please change to a line graph.

**Figures 2-7 are now line graphs**

Page 9, lines 200-202. Why was a change of +5.8% for female high-volume comprehensive cataract surgeons called an increase while a change of +4.7% for female subspecialty surgeons was called stable?

Workforce data using headcounts and number per 100,000 population although interesting does not provide information in regards to outcomes. In addition the lack of benchmarks prevents meaningful interpretation. With improved efficiencies perhaps each ophthalmologist is able to provide more care; for example although overall there is a decrease in 'all comprehensive cataract surgeons' perhaps the outcomes are the same given the increase in 'high-volume comprehensive cataract surgeons'. Aside from reporting these trends, how does this information inform policy?

**We have changed this sentence to indicate that both had increased female representation. “Moderate-volume (+11.5%), high-volume comprehensive cataract surgeons (+5.8%) and non-comprehensive surgeons (+4.7%) had increased female representation”**

**There are several other variables not explored in this study that influence human resource adequacy; we have emphasized this in the final paragraph of our study. We are in the process of designing manuscripts exploring some of these variables and have mentioned that these are important policy considerations. We kept conclusions objective and data-driven without policy recommendations until further data from other papers are available. (Page 8, lines 206-209)**

What are the authors views as to the future of the comprehensive ophthalmologist and optometry?

**While an interesting argument to discuss, to maintain objectivity and data-driven claims, we have avoided the inclusion of commentary or viewpoints that were not directly supported by our data. Detailed discussions of optometry were also beyond the scope of our research question, but we acknowledged that this as an important future direction to explore. (N/A)**

Page 14, line 319 add ‘or’ to ‘greater than [or] equal to’.

**This has been removed from the manuscript due to space limitations. (N/A)**

**Reviewer 2:** Mišo Gostimir

**Institution:** Faculty of Medicine, University of Ottawa

General comments (author response in bold)

An important note is made in the Limitations section, where the authors state that their intention was to “evaluate providers of care and not training”. While the spirit of this statement is appropriate and adheres to the stated purpose of this study, the manuscript includes several conclusions that seem to contradict this point. Namely, the authors refer to increases/decreases among various subspecialists (Line 196; Line 203-205; Line 223-225; Line 229-231; Line 237-242; this list is not exhaustive) and include discussion points about trends in the availability of certain subspecialists. If the authors are specifying that they only assessed the provision of subspecialty care (i.e. via billing codes), then the commentary should also refer to the provision of care rather than the number of subspecialists. The latter has tremendous implications which could be misguided if the methodology did not accurately identify specialists, but instead the provision of subspecialty care (which the authors admit is done by comprehensive ophthalmologists in many cases). For example, Line 304-306 states that there has been growth in the amount of low vision rehabilitation ophthalmologists due to an increase in demand for this subspecialty. The methods and results of this manuscript only suggest that there has been an increase in the provision of low vision care, rather than an increase in the number of residents pursuing fellowship training in low vision rehabilitation. Based on the described methodology, this may be the result of increased billing for low vision care among comprehensive ophthalmologists and subspecialists in fields other than low vision rehabilitation. This is an important distinction that is critical to the human resources implications of this study. Unfortunately, it seems that the only solution to this matter is to remove or rephrase any statements that pertain to the number of subspecialists, as this is an extrapolation beyond the limits of the available data.

**We thank the reviewer for their comment. The term “subspecialty” area of care throughout the manuscript has now been re-phrased to “non-comprehensive” area of care to avoid the implication that our study examined subspecialty areas based on training as opposed to areas of care based on physician practice patterns.**

**Our discussion regarding low-vision care has also been removed from the manuscript.** (Changes made throughout manuscript)

Some of the data-handling was also not ideal, such as the decision to convert age to an ordinal variable with broadly defined categories (e.g. “early career” defined as <45). As a result, changes over the last 10 years may not have been accurately reflected in the defined age categories, but the conclusions based on age were still reported in a general sense. While it may be difficult to change this aspect of the study at this point, the authors may consider including this as a limitation in their discussion.

**We have acknowledged the reviewer’s point as a limitation: “Furthermore, classifying the career stage of ophthalmologists using age did not consider the possible early and late entry of physicians into ophthalmology. The use of different age cut-offs could lead to different interpretations of data and highlights the drawback of using an ordinal variable.”** (Page 13, lines 316-318)

Not entirely. The authors note that “Previous studies in Ontario have explored workforce trends in focused subspecialty areas”, but there have been at least a few studies that explored workforce trends that are not specific to subspecialties (e.g. Lin, Xu, Hooper. CJO. 2016 and Micieli. CJO. 2014). The current phrasing makes it seem as though this is the first study of its kind, which does not seem to be the case. The authors should consider updating the introduction to be more reflective of current knowledge and to highlight how their study adds to the existing knowledge base

**We have more descriptively reported the need and rationale for our study and what it can add to the existing knowledge base.**

**As per the editor comment, we have acknowledged the previous studies in this setting as noted by reviewers 1 and 2. We have also included a description of the drawbacks of some of the previous studies and the need for the present study to address some of these limitations: “Some of these studies were cross-sectional and relied on CMA data, which may be outdated, given that data were collected in 2012 for most recent study (10,11). These datasets may include inactive ophthalmologists and are based on self-reported fellowship training. We identified a need to use physician billing data, assess longitudinal trends and explore supply using practice patterns as opposed to fellowship training.”**

**We have also clarified that “While some longitudinal studies have explored workforce trends in focused areas of care (12-17), there has yet to be a recent and comprehensive analysis assessing all areas of care in ophthalmology.”** (Page 4, lines 114-119)

4a.

The variables obtained in the dataset are not specifically named. The STROBE statement lists that this information is available on page 6-7, but it does not seem to be presented on these pages.

4b.

The age categories that were selected have important implications in several of the discussion and conclusion points. Since the age categories are not of equal size, the authors should justify why those cutoffs were chosen and whether they are consistent with existing studies.

4c.

The category of “subspecialty surgeons” is used numerous times throughout the manuscript, but is not defined in the Methods. While it seems to be defined in some of the figures, the authors should specify the makeup of this category in the Methods section, as several subspecialties in the Results include non-surgical fields.

4d.

If subspecialties were inferred based on billing codes, and if certain subspecialty billing codes could be used by general ophthalmologists, is it possible that a single ophthalmologist was counted in more than one category (e.g. comprehensive cataract surgeon and glaucoma surgeon)? If so, this has significant implications and should be rectified. Otherwise, the authors should consider clarifying this point in the Methods section.

**4a. We now indicate in the methods, “To characterize Ontario’s ophthalmology workforce, variables included supply, sex and age of ophthalmologists in each fiscal year, both overall and in specific areas of care.”**

**4b. A previous study has used “years since graduating medical school” as a metric for age. Though a reasonable metric, we did not have this data available to us. This referenced study also had unequal groupings (Micieli et al., 2014= <15 years, 15-25, 25+). Assuming 26 is the typical graduation year from medical school, <15 years from medical school = <40 years old, 15-25 years from medical school = 41-51 years old, and >25 years from medical school = 52+ years old. Our current values align to these cut-offs. Some studies (Bellan et al. 2007 and 2013) also explored the age of ophthalmologists by examining the % of ophthalmologists who are 55+, which is the cohort definition used in our study for ‘late career ophthalmologist’. As a result, we now indicate that “As guided by previous studies, ophthalmologists younger than 45 years old were considered early-career physicians, those 45-55 years old were middle-career physicians and those older than 55 years old were late-career physicians. (9-10,14)”**

**4c. We thank the reviewer for their comment. We have clarified that “For this study, comprehensive areas of care included general medical ophthalmology, and low, moderate, and high-volume comprehensive cataract surgeons; non-comprehensive areas of care referred to all other medical and surgical areas of care. Comprehensive cataract surgeons included low, moderate, and high-volume cataract surgeons; non-comprehensive surgeons included corneal surgeons, glaucoma surgeons, retinal surgeons, and oculoplastic surgeons.”**

**4d. We thank the reviewer for their comment. As mentioned in the limitations, this was possible provided that not all categories were mutually exclusive but was overcome by conservative thresholds. Per the comment of reviewer 1, we have specified the rate at which this occurred. Additionally, some definitions were not mutually exclusive and it was possible for an ophthalmologist to be included in multiple areas of care (range of 4-8 ophthalmologists were counted in multiple categories in a given fiscal year) (4a. Page 5, lines 140-141; 4b. Page 6, lines 166-169; 4c. Page 6, lines 159-164; 4d. Page 12-13, lines 311-314)**

5a. “Gender gaps... were evident” (Line 334-335): the reported data show a trend of increasing proportions of females in several categories over the past decade, which represents a different sentiment than the conclusion that was made by the authors. While it is true that gender gaps continue to exist (which should be and is emphasized), this conclusion reflects only one aspect of the data and doesn’t highlight an important finding that this study was designed to determine (i.e. the trends over time).

5b.

“Women continued to be underrepresented relative to their male colleagues, most strikingly in surgical subspecialties such as retinal surgery” (Line 267-268): same comment as above. Furthermore, these data are not presented in the Results section or in any of the Tables/Figures.

5c.

The authors allude to the new billing codes that likely inflated the perceived % change in neuro-ophthalmologists, but still mention that neuro-ophthalmologists had the most growth in numerous parts of the paper. This conclusion should be made with caution because of the limitation.

5d.

“Several subspecialties increased in supply over the study period” (Line 250-252): this statement inaccurately alludes to an increase in the number of subspecialists, whereas the methodology suggests that it is rather an increase in the provision of subspecialty procedures.

5e.

“The proportion of early-career ophthalmologists remained comparatively stable, middle-career ophthalmologists decreased by 7.6% and late-career ophthalmologists increased by 6.4% over the study period.” (Line 255-256): this statement is an extrapolation based on the age categories defined by the authors, which can be problematic because the ranges for each category are of different sizes. The use of different cutoffs would lead to different interpretations for a statement like this, which highlights the drawback of using an ordinal variable.

5f.

“Although neuro-ophthalmologists, glaucoma surgeons and low vision rehabilitation ophthalmologists had the most notable increases in supply, these were also subspecialties with the smallest baseline proportion of ophthalmologists and the analyses was therefore sensitive to small changes in supply” (Line 287-290): see other comments about referring to provision of care vs. fellowship training.

**5a. We have clarified that while there were gender gaps, there was also an increase in female representation. This statement in the Conclusions has been updated to “While female representation increased, gender gaps in the provision of non-comprehensive and high-volume surgical care were evident, as was the trend that early-career ophthalmologists had lower surgical volumes relative to late-career peers.”**

**5b. This is referred to in the results section: “The areas of care with the least and greatest proportion of female ophthalmologists were retina surgeons (7.5% in 2019) and paediatric ophthalmologists (48.0% in 2019), respectively.”**

**“... non-comprehensive surgeons (+4.7%) had increased female representation ...”**

**5c. We agree that conclusions should be made with caution. Therefore, it is emphasized in the conclusions “The growth in some of these areas was also likely confounded.”, with an explanation for why this is the case. We also indicate that “these were also subspecialties with the smallest baseline proportion of ophthalmologists and the analyses was therefore sensitive to small changes in supply.”**

**5d. As noted, we now refer to specialties as “non-comprehensive “areas of care to avoid reader confusion.**

**5e. Please see above response regarding age cut-offs. The limitation of age is also mentioned in the manuscript. “Furthermore, classifying career stage of ophthalmologists using age did not consider possible early and late entry of physicians into ophthalmology. The use of different age cut-offs could lead to different interpretations of data and highlights the drawback of using an ordinal variable.”**

**5f. As per the reviewer’s recommendation, we have re-phrased this term throughout the manuscript and no longer refer to these areas as “subspecialties” to avoid reader confusion. (5a. Page 13, lines 326-328; 5b. N/A; 5c. N/A; 5d. Throughout manuscript; 5e. Page 13, lines 316-319; 5f. Throughout manuscript)**

6. The increasing proportion of general medical ophthalmologists among the early-career cohort. The authors may consider including this result in their discussion and/or conclusion. Why are new graduates practicing non-surgical ophthalmology?

**The number of early career general medical ophthalmologists only increased by 3 ophthalmologists (2%) as indicated in our table. (N/A)**

7. “Amongst high-volume comprehensive cataract surgeons, there was only considerable growth amongst late-career physicians, who make up nearly half of the physicians in this area (46.3% in 2019)”. A similarly sized decrease in high-volume surgeons was seen in the middle-career category.

**We have added this in the Discussion that “A similar size decrease was also seen in the middle-career physicians who make up approximately one quarter of this category (26.8% in 2019)” (Page 11, lines 267-268)**

8a. Figures 1-6 are confusing by design and overwhelming in the amount of variables included. If the Y-axis represents proportions (seems that “percentage” a more appropriate term), it is confusing to see the bars exceed 100. The “stacked” style also makes it difficult to compare proportions for the different categories. The authors might consider side-by-side presentation of the bars, rather than the stacked format.

8b. The presentation of the “% change” in many of the tables removes a lot of the important detail. It may be more helpful to include the absolute numbers from 2010 and 2019, in addition to the % change. It would be most ideal to include the absolute workforce numbers from every year, if possible, although this may take up too much space.

**8a. We have adjusted all figures based on the editor and reviewer #1 comments, so this no longer a concern.**

**8b. We have made these changes based on your comment as well as previous editor and reviewer comments. Specifically, for tables 3-4 we have now provided counts and percent for 2010 and 2019. We have also added a change in counts in addition to the percentage change. (8a. See figures 1-7; 8b. See Figures 3-4)**

9. If the data are available, the authors should consider presenting raw data and summary measures for the age and sex of ophthalmologists. They should also consider presenting raw data and summary measures for the number of cataract surgeries (and other common procedures) performed, by year.

**9. We have added raw data for supply and sex as per the editor comments. As previously mentioned, based on our contract with the OMA, raw age data cannot be provided due to privacy limitations. These other data (cataract surgeries, other procedures) were beyond the scope of the current study and will be explored in future papers. (See Tables 2A and 2B)**

10a. The use of age as an ordinal variable defined by cutoffs that create imbalanced categories. See previous comments about this variable.

10b. The definition of some “areas of care” was based on existing literature, but some were not and were instead defined by the authors, which deserves to be acknowledged as a limitation. In particular, the definition used for an oculoplastic surgeon may be misleading because it includes “ $\geq 20$  tumour biopsies”, which is commonly reached by many comprehensive ophthalmologists.

10c. Limitations inherent to the use of billing codes should be acknowledged. Billing codes have an inherent inaccuracy simply by the overlaps and gaps among them. Billing codes do not reflect group billing scenarios, or scenarios where care is performed by trainees.

**10a. This has been addressed above in this reviewer’s previous comments.**

**10b. This limitation has now been addressed in the manuscript “Furthermore, some definitions were literature based while others were created by the authors, however, all definitions underwent a thorough consultative process by experts.”**

**10c. We have acknowledged in the manuscript “We also do not capture the nuances of group billing scenarios using billing codes.”**

**However, even when care is provided by trainees, the associated billing code for that service is submitted by the supervising staff and not by the trainee. (10a.**

**Page 13, lines 316-319; 10b. Page 12, lines 309-311; 10c. Page 12, lines 308-309)**

Line 60: The proportion \*of\* female ophthalmologists

**We have addressed this comment. (Page 2, line 59)**

Line 65-67: The sentence structure is confusing in that the primary subject should be the “supply” and not the category of surgeon (i.e. “The greatest supply reduction was noted to be among moderate-volume surgeons)

**We thank the reviewer for this comment. We have addressed this comment with a new sentence in the Abstract, which now reads: “The greatest supply reduction was among moderate-volume comprehensive cataract surgeons (-20.2% overall and -35.4% relative to the population 65 and over).” (Page 2, lines 65-67)**

Line 281: Before shifting focus to the ideal vs. current ratio for >65-year-old patients, the authors should discuss the current ratio for all patients and compare that with the ideal ratio that was introduced on Line 273-274. The comparison between the ideal vs. current ratio for > 65-year old patient could be emphasized dedicating a paragraph to this subset of the population.

**The current ratio was compared to the ideal ratio in the beginning of this paragraph: “Although the number of ophthalmologists/100,000 people in 2019 (3.27) seems adequate given the proposed ideal ratio of 3.37 indicated by The Royal College ....”**



**While we would have liked to discuss the ideal ratio for patients >65, there is currently no such ideal value in the literature. (N/A)**

Line 337: “compromise”

**As mentioned in the next box, we have removed this statement. (N/A)**

Line 336-338: “Notably, these findings compromise only one critical component amongst a multitude of others that influence the current and future sustainability of eye care delivery in the province.” This statement is vague and confusing as it stands. The authors should consider rephrasing or removing this sentence.

**We have removed this statement. (N/A)**

Table 4- “percentage change” not clear. Is this over the entire period, or per year? Would be helpful to have the number of ophthalmologists/100,000 in 2019 as well, and in other years too if that fits.

**We thank the reviewer for their comment. We have clarified in the table that this is percentage change from 2010 to 2019. As per this comment and reviewer #1 suggestion, we have changed the column from 2010 to the 2019 fiscal year. (See Table 5)**

Figure 4, 6- Y-axis title extends off chart

**This has been revised. (All figures have been updated)**