Appendix for

"Physician Workforce Estimates Adjusted for Hours of Work and Population Aging: Implications for Resource Planning"

Appendix 1: Data and Methods

Data Sources

We combined four different datasets for this analysis. Statistics Canada's confidential monthly Labour Force Survey (LFS) masterfile was accessed through the Statistics Canada Research Data Centre (RDC) at McMaster University. The LFS is a general-purpose survey that is representative of the Canadian population aged 15 and over.[1]

Three public use datasets were also employed: Statistics Canada's Population Estimates,[2] the Canadian Institute for Health Information's (CIHI's) historical data on the physician supply in Canada,[3] and CIHI's data on physician expenditures by age and sex.[4] For the analyses focusing on provinces/regions, we employ province/region-specific population and expenditure measures. CIHI provides a full-time equivalent (FTE) measure in its annual Physicians in Canada report, but it adjusts based on clinical payments. This does not allow measures of trends over time in labour supplied, which are central to this analysis.[5,6]

Data Preparation and Variable Definitions

Monthly LFS files were aggregated into annual files from 1987 to 2020. We restricted the earliest date to 1987 because prior to then relevant occupational codes were unavailable in the most recent version of the LFS masterfile. The latest date is 2020 since the CIHI data were only available until 2020.

The annual samples of physicians grew from about 1700 to about 3800, and the pooled sample for 1987-2020 was around 93,000 (rounded to satisfy Statistics Canada's disclosure rules). We identified physicians using the National Occupational Classification (NOC), version 2016. The occupational code for family physicians and general practitioners is 3112, and that for specialist physicians is 3111. Using the North American Industry Classification System (NAICS), version 2012, we included only respondents whose "main job" was in an industry compatible with a practicing physician. Observations with the following NAICSs codes were included in our sample: 6211, offices of physicians; 6214, out-patient care centers; 6215, medical and diagnostic laboratories; 6216, home health care services; 6219, other ambulatory health care services; 6220, hospitals; 6230, nursing and residential care facilities; 9112, other federal government public administration; 9120, provincial and territorial public administration; 6113, universities; 5417, scientific research and development services; 5241, insurance carriers; and 3254, pharmaceutical and medicine manufacturing.

To match the CIHI administrative data's exclusion of residents as closely as possible, we excluded full-time students and those aged below 28 from our analysis. Therefore, most resident physicians are not included in our sample. We did not impose a restriction on the upper limit of age and rare physicians over age 75 are observed; the oldest practicing physician across all the years in the sample was in the 85 to 89 range. The LFS data employed do not include those

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residing in the Territories. The LFS supplies general-purpose survey weights, however, since we focused on a small and well-defined sub-population for which administrative data exist that may be used as a benchmark, we improved our estimates' precision by generating new survey weights using CIHI's physician population data within a GMM framework.[7,8] In practice, this made a modest difference and did not change the qualitative interpretation of the results.

We calculated the number of FTE physician positions each year by, first, multiplying the year's average reported weekly hours of work from the LFS with CIHI's total number of practicing physicians in Canada in that year. Second, we divided the product by 40. We consistently assumed 40 hours a week to equal one FTE. Of course, for much of the analysis we focus on an index using 1987 as the base year (i.e., setting 1987 to equal 100), and such an index is not influenced by the number of hours used to define one FTE if that number is used in all years. Similarly, comparisons across provinces were not affected by the choice of 40 to equal one FTE since the same adjustment was used in all cases. The analysis was conducted using Stata version 17.

Measuring Hours of Work Using Statistics Canada's Labour Force Survey

The decline in hours observed in the LFS and reported in the main paper is slightly steeper than that reported by the Canadian Medical Association (CMA) for the selected years where CMA data were available (1997 to 2004, 2007, 2010, 2014, 2017 and 2019), although the levels in much of the period are comparable.[9,10] However, we would not have expected them to have been identical since the two measures are conceptually distinct. The differences result from survey design issues and choices made in the analysis, and may have also been affected by survey non-response and/or survey weighting techniques.

We first address survey design issues combined with choices made in the analysis. To track hours of work, the CMA used a variety of distinct annual survey instruments with surveys administered in many but not all years. Between 1997 and 2003 it used its annual Physician Resource Questionnaire; in 2004, 2007, 2010 and 2014 it used the National Physician Survey, which was a joint effort of the CMA, the College of Family Physicians of Canada, and the Royal College of Physicians and Surgeons; and in 2017 and 2019 it used the CMA's Physician Resource Survey. These were annual retrospective surveys that asked a question such as (from 2017): "EXCLUDING ON-CALL ACTIVITIES, how many HOURS IN AN AVERAGE WEEK do you usually spend on the following activities? Assume each activity is mutually exclusive for reporting purposes (i.e., if an activity spans two categories, please report hours in only one category)." This was followed by 10 categories, including "other", and then a "total".

In contrast to the CMA data sources, the LFS was conducted once per month (always in days around the 15th) and asked questions about jobs held in the most recent week.[11,12] The LFS had a range of distinct hours questions. It asked about "usual" weekly hours for both "all jobs" and the "main job", where main was defined as the job with the highest number of usual weekly hours. It also asked about "actual" hours worked in the survey week, again separately for all jobs and the main job. We employed last week's actual hours in all jobs, which eliminated issues of recall bias and the annual averaging (with ambiguity in the treatment of holidays and other absences) that is present for the CMA data. We did not employ usual hours; however we note that, on average, over most survey months actual hours worked were less than usual hours.

The LFS also made distinctions between full and partial (relative to the person's usual activity) weeks of work, and weeks where the respondent was entirely absent from work (and it captured reasons for part- or whole-week absences such as vacation, illness, caring for others, etc.). In our analysis we wanted a comprehensive definition of actual hours supplied, so we used actual hours of work in weeks with some work and also included full week absentees with zero hours of work. As a result, our decline in hours of work reflected both changes in "actual" hours including changes in weeks of partial work, and changes in the likelihood of full weeks with no work. Conceptually, our measure of hours of work was, therefore, different than that employed by the CMA. We believe that our measure is preferable in focusing on actual (including part-weeks) rather than usual hours per week, and in including changes (a small increase) in full weeks away from work. However, the LFS cannot address sub-categories of work as can the CMA's surveys.

There were also methodological differences across surveys and measures. The CMA's surveys had the advantage of focusing exclusively on physicians. The older Physician Resource Questionnaire targeted a 15% random sample of the physician population. In the late-1990s response rates were over 80%, but they fell to about 30% by 2003.[13] It is not clear how the declining response rate affect the trend observed in the CMA data. Survey weights appear to have been initiated only in 2004 or 2007 with the advent of the National Physician Survey.

In contrast to the CMA data, the LFS provided consistent survey questions, and although it is a general-purpose survey the annual count of observations on physicians across the 12 monthly surveys was comparable to that in the Physician Resource Questionnaire, although smaller than that in the later surveys. (Note that the LFS has a six-month rotating panel design, so the number of observations is not the same as the number of unique respondents. Although we did not exploit this feature in this analysis, it permits variation in hours for individuals over six-month periods to be documented.) The LFS used survey weights to account for its survey design and nonresponse. While the results using the LFS weights provide similar results to those presented, as mentioned we developed survey weights specific to this analysis taking advantage of the population counts of physicians by age, sex and province available from CIHI. This improved the precision of the estimates, and we believe it is a superior methodology even if the basic pattern of results was unaffected.

The LFS is collected under the Statistics Act, and responses can be required of participants. Statistics Canada's survey methodologists undertake ongoing validation of various aspects of the survey and make scheduled adjustments to update the sampling strategy and other survey elements. Numerous reports are available that document these issues.[11,12,14] We are aware of no LFS validations that focus on physicians (since it is a general-purpose survey), however the LFS sampling methodology includes a special stratum that targets high income households.[14]

Adjusting Physician Utilization for Population Aging

The population, adjusted for physician service requirements, was conceptualized to grow over time because of both growth in the population count, and because of population aging since an older population is "equivalent" (in terms of hours of physician services required) to a younger population that is larger. For consistent comparisons, we held hours of physician service provision per age-sex group constant across the study period; evolving utilization by age and sex, and its implications for the size of the required physician workforce, is a potential extension to this simple analysis.

We were not, however, aware of data on hours of service for each patient age-sex group. We therefore employed relative expenditures on physicians for each patient age-sex group as a proxy for relative physician hours for each age-sex group in adjusting for utilization. We calculated base hours of care per age-sex group by multiplying the proportion of total expenditures for each group with total hours in 1987. We used 1996 as our reference year for expenditures since it is the earliest year for which these data exist for age and sex groups and extend this base to both earlier and later years; if these data had existed for 1987, then we would have selected 1987 for this adjustment. To obtain the yearly age-adjusted population in Canada, we multiplied this constant value for hours per age-sex group with the size of each group in each year; for each year, we then summed across groups. Each year's adjusted population measure, therefore, reflected how much larger the 1987 population would need to be to require the same hours of physician care as that year.

Adjusting Physician Hours for the Evolving Sex, and Age and Sex, Composition of the Physician Workforce

For the central human resource/policy question studied, adjusting for sex and/or age was not needed. Documenting the magnitude of the shifting sex and age composition of the workforce in explaining changes in hours was useful, however, for understanding the degree to which the changes in hours could be "explained" by these two factors.

Sex Adjustment

The goal was to create an adjusted series holding the physician male to female ratio constant to contrast with the unadjusted series. We, therefore, counterfactually, kept the sex composition unchanged at its value in the base year, 1987, but allowed the age distribution of each sex, and the hours of work within each age-sex cell, to vary as they did in the unadjusted data.

Focusing on females, but with analogous calculations for males, the method was as follows. We defined the proportion of female physicians in the base year, 1987, as $PropFem87$. In each year we observed the proportion of female physicians in each age group relative to the total number of female physicians. We calculated $SexAdjFem_{AgeGrp,t} = PropFem_{AgeGrp,t} * \ PropFem87$, and then multiplied this by the average hours observed for that age group in year *t* to get $SexAdjFemHrs_{AgeGrp,t}$. Finally, we added up all the age groups within each year and obtained a counterfactual annual total. Note that $SexAdjFem_{AgeGrp,t}$ varied from year to year, but within each year the sum of the proportions across age groups summed to the total proportion female in 1987. Thus, the series was counterfactually adjusted to keep the male-female ratio constant while letting the size of the physician workforce, the age distribution of each sex, and both female and male hours by age group, evolve.

Sex and Age Adjustment

As with the sex adjustment, the goal was to create an age and sex adjusted series to contrast with the other series. In this case we, counterfactually, kept both the age composition of each sex unchanged at its value in the base year, 1987, and simultaneously maintained the proportion female (male) at its 1987 value. But, we allowed the hours of work within each age-sex cell to vary as they did in the unadjusted data, and the size of the physician workforce to evolve.

We defined the proportion of male and female physicians in each age group relative to the total physicians of both sexes in 1987 as $PropMale87_{AgeGrp}$, and $PropFem87_{AgeGrp}$. We counterfactually constrained the age-sex composition to remain unchanged at the 1987 level. Then we multiplied $PropMale87_{AgeGrp}$, and $PropFem87_{AgeGrp}$ with their respective hours for each year (e.g., $AgeSexAdjFemHrs_{AgeGrp,t} = PropFem87_{AgeGrp} * FemHrs_{AgeGrp,t}$). Finally, we summed the age-sex groups within each year to obtain annual age-sex-adjusted average hours. The difference between the age-sex-adjusted and sex-adjusted hours provides the age-adjusted hours.

Ethics Approval

This analysis did not require approval from an institutional review board because the microdata were handled within a Statistics Canada Research Data Centre, and no other individual data were employed.

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