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The effect of physician supply on health status: Canadian evidence

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ABSTRACT

We estimate the relationship between per capita supply of physicians, both general practitioners and specialists, and health status of Canadians. We use data from the Canadian National Population Health Survey and the Canadian Institute for Health Information. Two measures of quality of life, self-assessed health status and the Health Utility Index, are explored. Random effects ordered probits are used to model self-assessed health status, and quantile regressions are used for the Health Utility Index. A higher supply of general practitioners is correlated with better health outcomes as measured by both measures of health status, albeit for different age groups, and it is correlated with a higher HUI for some individuals who report having a chronic condition. A higher supply of specialists is correlated with worse health outcomes for the HUI for some individuals. It is possible that a higher supply of general practitioners increases the likelihood of diagnosing and treating health conditions in a timely manner and that this in turn affects health status. Specialists, due to the nature of their expertise could affect negatively health, both through the use of riskier procedures and due to their clientele being in relatively worse health. Based on our findings, we therefore would recommend maintaining a robust supply and distribution of GPs across Canada.

1. Introduction

The supply of physicians across Canada, particularly in remote areas, has been a much-publicized issue in the health care debate. Media reports in the 1990s depicted a brain drain towards the US, suggesting that remote areas especially had trouble attracting physicians and convincing them to remain once they had started practicing. Since then, the exodus towards the US has subsided [1] and even rebounded [2,3]. Do more physicians in an area lead to better health outcomes? This is what this paper explores.

Little Canadian research has explored either how physician supply affects health status or which types of doctors (general practitioners (GPs) vs. specialists[1]) have the greatest effect on health status. Most studies examine how physician supply affects individuals with specific health problems in the US and find that a higher supply of GPs is associated with better health outcomes [4–12]. However, some researchers [13] do not find such a relationship concerning avoidable mortality using OECD data, and others

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[1] We use the term GP for both family physicians and general practitioners.

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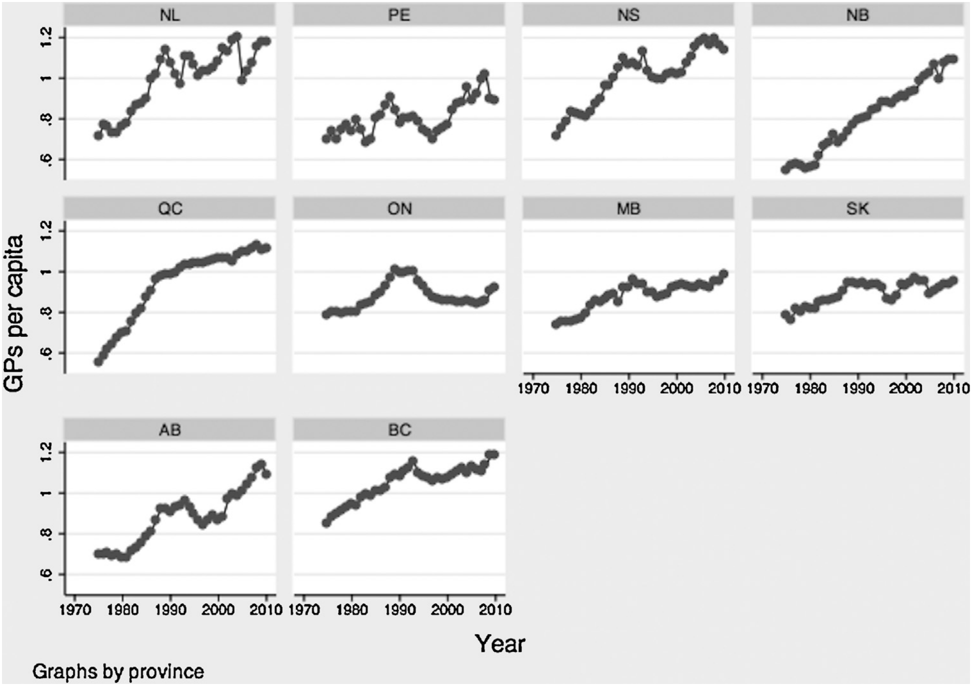

Fig. 1. Number of GPs per capita: 1982–2010.

[14] find a negative association between Hospital Standardized Mortality Ratios and the supply of GPs in Holland. Sundmacher et al. [15] find that a higher supply of physicians is correlated with small decreases in avoidable deaths rates due to some cancers. Sarma and Peddigrew [16] using cross-sectional Canadian data find a positive relationship between GPs and specialists supply and general health, while Shi et al. and Shi et al. [11,12] find that a higher supply of primary care physicians is associated with a higher probability of reporting good self-rated health.

The evidence for specialists is mixed, as a higher supply is either beneficial [5] or detrimental [4], depending on the outcome studied. Some studies [17,18] find that a higher supply of physicians is correlated with a higher use of some services - but not necessarily all of them [17]. Other studies [19,20], using the mortality of individuals with specific health problems, find that being admitted or treated by a specialist is associated with a lower risk of mortality. Others [21–24] find no difference in outcomes of most patients.

Our paper differs from the existing literature in a number of ways. First, we use panel data concerning the health of the general Canadian population, rather than focusing on individuals with a specific condition. These data enable us to study an individual's overall health status, instead of measures of specific outcomes (mortality rates, complications, stage at diagnosis) or acute health problems. These data also enable us to control for socioeconomic status at the level of the individual; previous studies have typically used the average of the variable over a geographical unit. Most studies have used American or European data. The universal nature of the public health insurance system in Canada makes it easier to estimate this supply effect. Second, we are interested in the health of individuals while they are living, and hence avoid basing our study solely on mortality rates, which has generally been the case in previous literature. Third, we take into account the endogeneity of physician supply, which has not typically been done in previous studies (one notable exception is Auster et al. [25]). Fifth, we control for past health status and include interaction terms between age, the presence of a chronic condition and physician supply, which has not been done in most of the existing literature. We estimate a reduced form model in which present health status is a function of both past health and current individual-specific risk factors, and provincial physician supply.

As can be seen in Fig. 1, there was a decrease in per capita GP supply in the mid-1990s across many provinces, although the general tendency over time is for the supply of GPs to increase. Comparatively, specialists supply remains relatively stable over the period although it also increases slightly in most provinces, as is clearly evident in Fig. 2. These exogenous changes in health resources enable us to estimate the effect of fluctuations in physician workforce on health status.

Our findings confirm some of those achieved in the literature: a higher supply of GPs is correlated with better health outcomes for some individuals, while a higher supply of specialists is correlated with worse health outcomes as measured by the HUI for the bottom end of the distribution. This is consistent with most of the existing American literature as well as some more recent related papers [26]. We also find that having a diagnosed chronic condition is correlated with worse health for the HUI but a higher GP supply is correlated with a higher HUI for some of these individuals. Finally, we find that there is no consistent difference in the impact of physician supply for different age

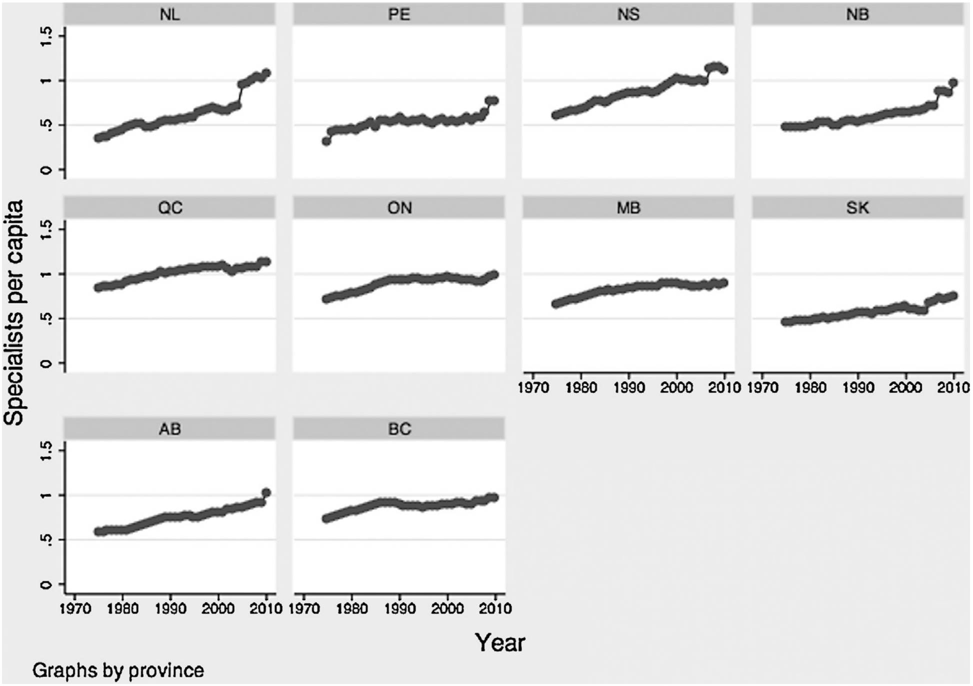

Fig. 2. Number of specialists per capita: 1982–2010.

groups for the HUI but that there is for self-assessed health status (SAHS): a higher supply of GPs is correlated with a higher likelihood of reporting excellent health for individuals over the age of 40. Overall, the correlation between physician supply and health status is dependent on the category of individuals we are looking at, i.e. the age group, and the effect is not statistically significantly different from zero for all health status categories or HUI quantiles.

2. Methods

2.1. Data

The NPHS is a survey of approximately 15,000 households conducted by Statistics Canada. Starting with the first cycle in 1994–1995, we draw data from eight subsequent waves up to 2010–2011. One individual aged 12 or over was randomly selected per household to answer questions pertaining to their health status, health problems and use of health care services [27]. We sample 13051 individuals in the first cycle who were at least 18 years old in 1994 and through attrition, are left with 5583 in cycle 9. Exact sample sizes for each cycle are reported at the bottom of the table in the appendix. These data enable us to control at the individual level for lifestyle factors as well as socioeconomic characteristics. They also enable us to assess health impacts and outcomes over a period of particular significance: the post-1994 period during which the cutbacks in federal transfers for health care and medical school enrolments in some provinces occurred. The sample covers all 10 provinces but excludes the population residing on Indian Reserves, Canadian Forces Bases and remote areas in Quebec and Ontario.

Fig. 3 depicts that while the HUI and SAHS are correlated, they strongly differ for some observations. SAHS (excellent, very good, good, fair or poor) is subjective, but the literature shows that it is highly correlated with other measures of health status [28]. The HUI 3 [29] is constructed using answers to yes/no questions asked of survey participants and usually varies between 0 and 1, but can take negative values for health statuses considered worse than death. The questions are used to measure the functionality of individuals based on eight characteristics: vision, hearing, speech, ambulation, dexterity, emotion, cognition and pain. Usually, five or six categories are used for each attribute. See Furlong et al. [29] for a full description of the HUI 3 and how it is calculated. Figures A and B, in the online appendix, show how average self-rated health status and the average HUI evolve across provinces and over the course of the NPHS (1994–2010).

The HUI differs from SAHS in several ways: first, it is based on reports of attributes such as vision, speech and hearing, which may not be taken into account in the SAHS variable.[2] The reverse is also true. Second, it explicitly incorporates inter-personal utility comparisons. These measures of health status, while they are correlated, measure health status according to different criteria. They both have merits and hence we use them both, although critics argue that the HUI is flawed, for example, because it does not take into account the strength of preferences over different health states (see McCabe et al. [30] for more

[2] While needing glasses to recognize a friend on the other side of the street lowers the HUI, it is unclear that this would be taken into consideration by an individual self-assessing their own health.

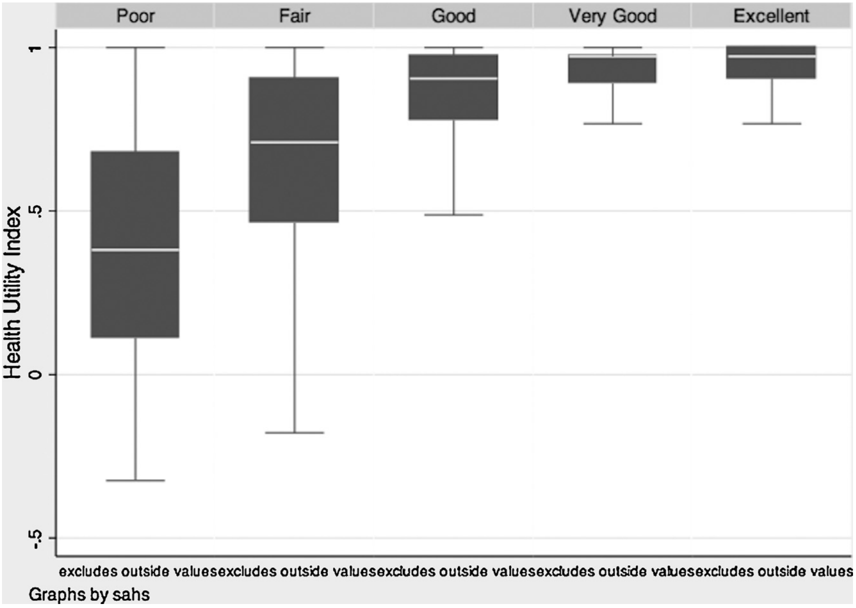

Fig. 3. Distribution of the HUI vs self-assessed health.

information on this topic). We steer away from the controversy and simply use it as a measure of health status. We also use the available information on chronic conditions. As there are often small numbers of individuals diagnosed with a specific chronic condition in the survey, we merge together all individuals who have a chronic condition. This empirical strategy assumes that the effect specialists have on health status is constant across specialties and health ailments. The impact of such aggregation is unclear.

We use the NPHS data in conjunction with CIHI's data on the number of GPs and specialists per province from 1982 to 2010. The CIHI data comes from the Scott's Medical Database [31] and reports the number of physician per specialty in each province in a given year. No adjustment is made for activity of these physicians. We also control for the supply of nurses per province, which are also data obtained from CIHI [32]. Summary statistics by cycle for the sample can be found in the appendix.

2.2. Model and estimation strategy

We consider the following specification for the determinants of health status of the *i*th individual in the *t*th time period.

$$Y_{it} = \alpha_i + X_{it}\beta + MD_{it}\gamma + u_{it} \quad (1)$$

where the X_{it} variables control for socioeconomic and demographic effects that are well known health determinants. We control for gender, immigrant status, age, marital status, whether the individual lives in a rural area, household income, education, smoking and binge drinking, whether individuals own their dwelling, which might capture a wealth effect, and the logarithm of the size of the household. Lastly, we control for health status in the preceding period, using either dummies controlling for the different levels of SAHS (default is very good health) or the HUI in the preceding cycle and control for province of residence and cycle-specific fixed effects.

The MD_{it} variables control for the number of specialists and GPs separately per 1000 individuals, as well as for interaction terms between physician supply and age of individuals and physician supply and the presence of a chronic condition. We limit the length of time to two years given the relatively immediate impact a physician visit has on health status.[3] We also control for the number of regulated nurses per 1000 individuals in the province. We estimate random effects ordered probit regressions when using SAHS, and quantile regressions for the HUI.[4]

The random effects ordered probits are used because our dependent variable is ordinal and varies over time (our data are a panel) and because we control for lagged health status in all of our regressions.[5] The marginal effects

[3] E.g. comparatively to expenditures on capital. In our model, the supply of physicians today will have an effect on the health of individuals two years from now, but not afterwards.

[4] The literature on panel quantile regressions is in its infancy. There are a few fixed effects estimators ([33], [34]) that have been developed but they rest on hypotheses that do not apply to our data. There is one estimator for random effects ([35]) but there is no application that has been published in the context of a dynamic model such as ours.

[5] A fixed effects approach was not pursued because the coefficients of the variables of interest are only estimated when the variable changes. Some of our regressors do not change over the course of the cycle, individuals have a tendency to not deviate from their initial health rating, especially at the tails of the distribution, which means that our sample would have been biased towards individuals whose health status fluctuates, more often negatively. As an alternative, we tried to estimate the model specification employed by Contoyannis et al. [36] and reported by Greene et al. [37] but were not able to, most likely because our model is close to being over-identified and because of the factors mentioned above, i.e. that average health status and average physician supply do not vary greatly over the course of the survey.

reported reflect what effect a change in a given correlate has on the probability of reporting each category of SAHS. The quantile regressions enable us to estimate the relationship between the correlates of interests and the dependent variable at every 10th percentile of the distribution. We expect that the effect of the various correlates will vary over the distribution of the HUI: physician supply, for example, could have a different effect on the health of individuals who have a low HUI than it would on the health of an individual whose health ranked higher as measured by the HUI. The coefficients reported reflect what effect a change in a given regressor has on the HUI measured at a given percentile.

2.3. Test of endogeneity

Endogeneity between the number and type of physicians and health status of the individuals in a province is theoretically possible: physicians may go to provinces where there is the highest need for their services. Canadian public policy appears so far geared towards enticing physicians to choose to practice in areas where there are relatively few physicians per capita, not where there are relatively many health problems per capita. Furthermore, these public policies have focused on intra-provincial, not inter-provincial, physician migration [38].

We test for potential endogeneity using the Smith-Blundell [39] test of exogeneity for probit regressions. Because the tests reject exogeneity at least some of the time, we lag the effect of physician supply by one cycle (two years): the average supply of physicians during the two years before the survey is a proxy for current physician supply.[6] Although physician supply two years ago can still have an effect on health status today, the reverse is not true. The variables controlling for past supply of physicians are highly correlated with the present supply and are therefore a good proxy. Moreover, adding lagged health controls contributes to lessening the potential for endogeneity as it controls for the effect of past physician supply on health status and other factors that remain fixed over time and not controlled for (e.g. genetic predispositions) and factors that change over time that affect future health (e.g. health problems not controlled for through the chronic conditions variable). Grossman's model [40] and various other models of health status include lagged health as a correlate in its own right. Because present health might determine present physician demand (and supply), past health can do the same for past physician demand and supply. Present health can be determined by past health, but the opposite effect does not exist.[7]

3. Results

3.1. Random effects ordered probits

Marginal effects for each health status category are reported in Table 1. In most regressions, we observe the expected signs for the health determinants we control for.[8] Physician supply, both general practitioners and specialists, do not have a statistically significantly effect on self-assessed health. The interaction terms between ages 40–59, 60–79 and 80 years old and older and GP supply have a statistically significant effect: an additional physician per 1000 is correlated with a 5–20% higher likelihood of reporting excellent health, depending on the age category. It is also correlated with a 19% lower likelihood of reporting very good health for individuals over 80 years old. The interaction terms between specialist supply and age 40–59 is also statistically significant; it increases the likelihood of reporting poor health by 2%. The binary variable controlling for whether the individual has a chronic condition has no statistically significant effect and neither do the physician supply variables when interacted with it. Lagged health status is a good predictor of present health: having excellent health status in the previous period increases the likelihood of reporting excellent health by 14% while reporting poor health in the previous period decreases the likelihood of reporting excellent health by 0.3%.[9]

3.2. Quantile regressions

In the regressions corresponding to the lower quantiles, in Table 2, the variables controlling for physician supply are statistically significant: the number of GPs per capita is associated with a higher HUI with marginal effects varying between 0.01 and 0.16, for the 10th, 20th, 30th, 40th and 80th percentiles, significant at the 10% level of confidence or better. Specialists per capita are negatively correlated with the HUI with coefficients varying between −0.09 and −0.04, significant at the 5% level of confidence for the 20th and 30th percentiles.

The dummies controlling for the presence of a chronic condition have a negative and statistically significant effect at the 10% level of confidence or better in the 10th, 20th, 30th and 40th percentile regressions, varying between −0.14 and −0.04. The interaction terms between physician supply and age do not have a statistically significant effect but the interaction term between general practitioners

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6 E.g. for an individual in cycle 1 (1994–1995), we control for the average supply of physicians in 1992 and 1993.

7 Introducing a lagged dependent variable may lead to bias. Wooldridge [41] suggests a method in which lags and leads of the regressors can be included as well as the value of the dependent variable in the first period of the panel. This specification is similar to Contoyannis et al.'s model [36], in the sense that numerous lags and leads must be included rather than the average of the variable over the cycle. We would not be able to estimate this model for the same reasons as stated above. We estimated a random effects ordered probit that excluded lagged health status as a robustness check and obtained very similar results as the ones reported in this paper. These results are available from the author.

8 These marginal effects are available from the author.

9 Note that the results for the random effects ordered probits could not be bootstrapped using the method developed by Yeo [42]. The command in Stata does not support weights and is too computationally intensive to permit 500 replications. In regressions where bootstrap weights can be used, such as the quantile regressions, we observe that the standard errors obtained in the bootstrapped regressions are consistently higher. Bootstrapped standard errors are larger than standard errors that allow for Moulton's correction [43], used when merging aggregate data such as our physician supply variables, with individual-based data, such as the data from the NPHS. Standard errors are typically underestimated in such situations [43].

Table 1
Random effects ordered probits: self-assessed health.

	Poor	Fair	Good	V.G.	Exc
Conditional probability of observing the outcome	0.0106	0.0627	0.3379	0.4422	0.1466
GPs per capita (in'000)	−.0086	−0.0176	0.0562	−0.0215	−0.0085
	(0.0183)	(0.0405)	(0.0710)	(0.0708)	(0.0437)
Specialists per capita (in'000)	−0.0209	−0.0161	0.0061	−0.0364	0.0673
	(0.0168)	(0.0367)	(0.0646)	(0.0641)	(0.0401)
GPs * Age 40–59	−0.0027	−0.0099	−0.0754	−0.0100	0.0980[b]
	(0.0122)	(0.0303)	(0.0579)	(0.0593)	(0.0389)
GPs * Age 60–79	0.0019	−0.0446	−0.0346	0.0177	0.0543[c]
	(0.0125)	(0.0325)	(0.0667)	(0.0696)	(0.0315)
GPs * Age 80p	0.0203	−0.0307	−0.0004	−0.1929[c]	0.2037[b]
	(0.0153)	(0.0439)	(0.1027)	(0.1109)	(0.0875)
Spec. * Age 40–59	0.0222[b]	0.0035	−0.0324	0.0429	−0.0363
	(0.0108)	(0.0263)	(0.0496)	(0.0494)	(0.0329)
Spec. * Age 60–79	0.0006	0.0059	−0.0033	−0.0208	0.0176
	(0.0111)	(0.0278)	(0.0569)	(0.0581)	(0.0431)
Spec. * Age 80p	0.0019	0.0192	−0.0028	0.0541	−0.0723
	(0.0134)	(0.0383)	(0.0915)	(0.0993)	(0.0823)
GPs * CC	0.0102	0.0261	−0.0044	−0.0623	0.0304
	(0.0158)	(0.0331)	(0.0562)	(0.0547)	(0.0344)
Spec. * CC	0.0177	0.0205	0.0506	−0.0691	−0.0197
	(0.0138)	(0.0282)	(0.0474)	(0.0452)	(0.0293)
LH Excellent	0.0030[c]	0.0021	−0.0403[a]	−0.1008[a]	0.1360[a]
	(0.0018)	(0.0038)	(0.0063)	(0.0060)	(0.0047)
LH Good	−0.0030[a]	0.0227[a]	0.1586[a]	−0.1484[a]	−0.0299[a]
	(0.0009)	(0.0025)	(0.0049)	(0.0051)	(0.0037)
LH Fair	0.0099[a]	0.1631[a]	0.1148[a]	−0.2398[a]	−0.0479[a]
	(0.0016)	(0.0064)	(0.0081)	(0.0088)	(0.0070)
LH Poor	0.0754[a]	0.2532[a]	0.0132	−0.2933[a]	−0.0485[a]
	(0.0070)	(0.0144)	(0.0167)	(0.0183)	(0.0163)
Rho	0.3104[a]				
Number of observations	67240				

Notes: Marginal effects of the correlates of interest are reported and their standard errors are reported below between parentheses. V.G., very good health, Exc, excellent health. LH stands for lagged health while CC stands for chronic condition. We include controls for age (default is 18–39, dummies for ages 40–59, 60–79 and 80+), gender (default is male), household income (default is $20,000–39,999, dummies for less than $20,000, $40,000–$59,999, $60,000–$79,999 and over $80,000), province of residence (default in Ontario), marital status (default is single; interaction terms between gender and marital status are included), immigrant status in the past 10 years, dwelling ownership, lives in a rural area, the log of the household size, education better (default is high school graduation, dummies for less than high school, some post-secondary education and an undergraduate degree), smoking and binge drinking behaviour, provincial nurse supply per 1000 and its interactions with age and chronic condition status and cycle-specific fixed effects in these regressions.

[a] Statistically significant at the 1% level.
[b] Statistically significant at the 5% level.
[c] Statistically significant at the 10% level.

and the presence of a chronic condition is statistically significant in the 40th percentile regression; the coefficient takes a value of 0.02. The best predictor of current health is past HUI and the coefficients vary between 0.16 and 0.99, always statistically significant at the 1% level of statistical significance, except in the 90th percentile regression. The effects are larger for worse health status. One must note that these regressions are not panel regressions, such as the SAHS regressions presented earlier. Here, individuals who appear in all cycles are treated as different observations.

The largest coefficients associated with physician supply variables are for lower quantiles of the HUI distribution. One can therefore conclude from these results that increasing the supply of GPs would ceteris paribus shift the left side of the distribution towards the right, i.e. that the distribution of the HUI, which is bounded by 1, would become narrower and the left tail thicker. The standard errors are bootstrapped using the method recommended by Yeo [42] and the program BSWREG written by Piérard, Buckley and Chowhan [44].

3.3. Sensitivity analysis: survivors and individuals who do not report a chronic condition

We use two sub-samples to assess how sensitive our results are: a sub-sample of individuals who did not die during the survey period (survivors) and a second sub-sample of survivors who do not report a chronic condition. The individuals sampled are on average healthier than in the general population.

Briefly, in the sample of survivors, none of the physician-supply related variables have a systematic statistically significant impact on SAHS, except for specialists supply by itself and GP supply for some groups over the age of 40 that are both positively correlated with a higher likelihood of reporting excellent health.[10] Marginal probabilities are otherwise similar to what was observed for the whole

[10] Results of these estimations are available from the author.

Table 2
Quantile regressions: health utility index.

	10th %	20th %	30th %	40th%	50th %	60th %	70th %	80th %	90th%
GPs per capita	0.160[a]	0.066[b]	0.025[b]	0.008[c]	0.000	−0.000	0.002	0.006[c]	−0.0004
	(0.040)	(0.026)	(0.012)	(0.004)	(0.006)	(0.002)	(0.003)	(0.003)	(0.001)
Specialists per capita	−0.118	−0.090[b]	−0.040[b]	−0.008	−0.000	−0.000	−0.0002	−0.001	0.001
	(0.076)	(0.043)	(0.019)	(0.008)	(0.006)	(0.003)	(0.003)	(0.005)	(0.002)
GPs per capita × Age 40–59	−0.034	−0.021	−0.023	−0.001	0.000	0.000	0.001	−0.005	−0.001
	(0.063)	(0.037)	(0.020)	(0.008)	(0.005)	(0.005)	(0.010)	(0.005)	(0.003)
GPs per capita × Age 60–79	−0.016	−0.016	−0.004	−0.023	0.000	0.000	−0.002	−0.002	0.008
	(0.124)	(0.057)	(0.042)	(0.027)	(0.021)	(0.00)	(0.001)	(0.018)	(0.037)
GPs per capita × Age 80p	−0.130	−0.118	−0.047	−0.080	0.000	0.014	0.065	0.016	0.032
	(0.266)	(0.185)	(0.165)	(0.153)	(0.177)	(0.207)	(0.170)	(0.111)	(0.038)
Specialists per capita × Age 40–59	−0.001	−0.0004	0.007	−0.004	0.000	0.000	−0.003	−0.001	−0.001
	(0.060)	(0.036)	(0.021)	(0.009)	(0.005)	(0.005)	(0.010)	(0.005)	(0.002)
Specialists per capita × Age 60–79	0.056	0.044	0.017	0.021	0.000	0.000	0.001	0.007	−0.010
	(0.126)	(0.059)	(0.045)	(0.025)	(0.014)	(0.007)	(0.006)	(0.015)	(0.029)
Specialists per capita × Age 80p	0.094	0.014	−0.074	−0.042	0.000	−0.004	0.058	0.018	−0.009
	(0.273)	(0.216)	(0.203)	(0.172)	(0.131)	(0.112)	(0.127)	(0.101)	(0.031)
Chronic condition	−0.137[c]	−0.079[a]	−0.070[a]	−0.037[a]	0.000	−0.000	−0.001	0.002	0.0001
	(0.077)	(0.031)	(0.018)	(0.012)	(0.007)	(0.003)	(0.004)	(0.004)	(0.003)
GPs per capita × Chronic condition	−0.010	−0.024	0.026	0.022[b]	−0.000	−0.000	0.001	−0.003	0.0001
	(0.055)	(0.037)	(0.023)	(0.009)	(0.008)	(0.003)	(0.004)	(0.004)	(0.002)
Specialists per capita × Chronic condition	0.045	0.026	0.011	0.004	−0.000	0.000	−0.0005	0.001	0.0004
	(0.055)	(0.035)	(0.016)	(0.008)	(0.004)	(0.003)	(0.002)	(0.003)	(0.002)
Lagged HUI	0.992[a]	0.906[a]	0.862[a]	0.791[a]	0.627[a]	0.455[a]	0.293[a]	0.163[a]	0.033
	(0.038)	(0.025)	(0.019)	(0.027)	(0.031)	(0.023)	(0.022)	(0.020)	(0.024)
Constant	−0.034	0.120[a]	0.153[a]	0.206[a]	0.373[a]	0.545[a]	0.708[a]	0.838[a]	0.969[a]
	(0.091)	(0.045)	(0.031)	(0.028)	(0.034)	(0.022)	(0.023)	(0.024)	(0.022)
No. of Obs.	43978	43978	43978	43978	43978	43978	43978	43978	43978
Pseudo R^2	0.3850	0.3453	0.2876	0.2527	0.1965	0.1340	0.0974	0.0749	0.0184

Notes: Coefficients of the correlates of interest are reported and their standard errors are reported below between parentheses. The quantile at which the regression is estimated is reported at the top of the column. We include controls for age (default is 18–39, dummies for ages 40–59, 60–79 and 80+), gender (default is male), household income (default is $20,000–39,999, dummies for less than $20,000, $40,000–$59,999, $60,000–$79,999 and over $80,000), province of residence (default in Ontario), marital status (default is single; interaction terms between gender and marital status are included), immigrant status in the past 10 years, dwelling ownership, lives in a rural area, the log of the household size, education better (default is high school graduation, dummies for less than high school, some post-secondary education and an undergraduate degree), smoking and binge drinking behaviour, provincial nurse supply per 1000 and its interactions with age and chronic condition status and cycle-specific fixed effects in these regressions.

[a] Statistically significant at the 1% level.
[b] Statistically significant at the 5% level.
[c] Statistically significant at the 10% level.

sample. The best predictor of future health remains lagged health status in all regressions.

For the quantile regressions using the HUI, we obtain very similar results for both sub-samples of individuals to the ones we had obtained for the original sample; the interactions between age and physician supply tend to show that there is a statistically significant association more often but the sign is in line with what we have observed elsewhere (general practitioners are correlated with better outcomes while we observe the opposite for specialists). Results are however less credible for better categories of the HUI, most likely due to the skew towards better health statuses in these sub-samples.

4. Discussion

Overall, there is a statistically significant association between physician supply-related variables and the health of individuals who are in worse health as measured by the HUI. The association tends to be negative when we look at the supply of specialists and positive in the case of the supply of GPs. We also find that a higher supply of GPs is correlated with better health outcomes for SAHS for individuals over the age of 40. A higher supply of GPs is correlated with a higher HUI for individuals with a chronic condition at the 40th percentile of the distribution. The results concerning the variables controlling for the supply of GPs and specialists by themselves (not in interaction with age or the presence of a diagnosed chronic condition) confirm what others had found [7,8]. While the results differ in terms of the age groups concerned, we observe a positive statistically significant association for the general population in the quantile regressions and for individuals over the age of 40 in the random effects ordered probits when considering excellent health. The difference in these results can be due both to the nature of the dependent variable used and to the nature of the econometric models used (panels for SAHS, pooled cross-sections for the HUI).

According to results obtained for the HUI, the strength of the correlation for physician-related variables are more important for individuals in worse health (the lower quantiles). The size of the coefficient of the variable controlling for the supply of specialists becomes larger (in absolute value) and remains negative, as we move towards the left tail of the distribution. Coefficients size for the variable controlling for the supply of GPs also become larger across quantiles and increase almost six-fold between the 30th and the 10th percentiles.

To put these results into context, an increase of 0.99 is similar to going from a health status close to death to perfect health except that the person would need glasses to read ordinary newsprint or recognize a friend on the other side of the street (which would be an improvement of 0.98). A decrease in the HUI of 0.03 represents going from being in perfect health on all attributes to needing glasses to recognize a friend on the other side of the street or to read ordinary newsprint with no other concurrent change in their health. Lastly, an improvement of 0.15 of the HUI would be similar to going from a health status at which one has speech and dexterity limitations (able to be understood partially by strangers and completely by people who know them well and limitations in the use of hands or fingers but no special tools or another's help required) but is otherwise healthy on all attributes to perfect health.

While the association between a higher supply of GPs and better health could come from the benefits associated with easy access to GPs (for occasional small health concerns or follow-ups of chronic or recurring health problems that are not serious enough to require the intervention of a specialist), the negative correlations concerning specialists are more puzzling, but confirm what has been found in previous studies ([4,7,8] among others). This could be due to supplier-induced demand on the part of specialists or to the nature of their expertise, as specialists order more procedures, which might be harmful to health and that are riskier on average. More research in this area is necessary to determine what exactly is causing this negative correlation.

When using the sample of individuals who do not have a chronic condition, we observe that physician-related variables are less correlated with the health of these individuals than for the health of the population in general. This confirms what intuition would suggest: people in worse health benefit more from better access to health care than do healthy people.

4.1. Limitations

Our methodology does not enable us to control for physicians' practice style or provincial fee schedules, but we doubt these would have an impact: if one province paid its physicians much more for the same services than the others, new physicians would likely flood this market. We partly and imperfectly control for provincial differences in physicians' practice style through provincial dummies. These may also capture the effect of some variables we do not control for, such as other provincial programs (e.g., welfare, education, and other sources of health care than physicians).

We are also unable to control for the number of hours a physician practices, in other words, their workload. It is possible that even if physician supply increases, the average workload of physicians would fall and that there would not be a significant difference in the quantity of physician care provided to the population, or per patient. No reliable data covering the time period of our study exist on physician workload, to the best of our knowledge.

We are limited in our analysis to using the supply of physicians at the level of the province. Supply of physicians may however vary within a province and these variations may not be completely taken into account by the variable controlling for residence in an urban or rural setting. Moreover, an individual's health status likely has little impact on the local supply of physicians; it would be more likely that a physician would decide to locate their practice in a community where there is a high need for their services from the population in general (if such considerations enter the decision process of graduates), or in a community where they have personal or family attachment. While the Canadian provinces are also subdivided into health regions, patients are not forced to consult physicians located in their health region. In fact, when it comes to specialist care, some patients are referred by their family practitioners to specialists outside of their health region, if a specialist with a specific expertise is not available in the health region, or if there was a significant differences in wait times across health regions to see a given specialist. This is the case, for example, for pediatric care: some children are referred to children's hospitals in great centres for acute ailments. There are administrative barriers to consulting a physician outside of one's home province but these barriers do not exist across health regions.

Using the province-level supply has its advantages: it is also possible that an individual foreseeing that they will need more health care in the future will decide to relocate closer to an area where access to care will be better. It is also possible that some individuals will choose to travel long distances to gain access to medical care if needed. Using province-level data rather than regional data circumvents these problems as it isn't clear that a variable representing the local physician supply would allow for this.

We control for the number of physicians per 1000 individuals. One more physician per 1000 is approximately equivalent to doubling the supply of physicians in any given province. This would be highly unlikely to happen in any province in the short term and speaks to the modest impact physician supply has on the health of individuals, net of the effect of lagged health status and other socio demographic characteristics of individuals.

Last, we cannot control for possible double counting of physicians in the data: some physicians could practice in multiple provinces. Physicians can earn more income by working in two different practices and billing two provincial governments. It is likely that only a minority of physicians shares their time between provinces and that the effect is small in our study, especially since in areas other than the Atlantic provinces, Canada's geography would limit opportunities to do this for the majority of physicians.

5. Conclusion

We examine the effect of physician supply on Canadians' health status. We perform random effects ordered probits using SAHS and quantile regressions on the HUI. To minimize the effect of potential endogeneity, we lag the effect of physician supply by two years, hypothesizing that the effect physician supply has on a patient's health lasts for two years.

We sample all individuals who were not lost over the period of the survey and were at least 18 in the first cycle. Generally, we find that per capita supply of GPs is associated with better health outcomes, while per capita supply of specialists is associated with worse health, when it has a statistically significant effect.

Although the HUI and SAHS measure different aspects of health status, our results were similar, albeit for different age groups. While specialists likely do not have a negative effect on health status per se, it is possible that GPs have a wider view and are better equipped to detect health problems that specialists, with their more specific areas of expertise, might miss. As well, specialists are likelier to order more risky procedures due to the nature of their expertise and are also more likely to have to treat patients who are on average much sicker, as they were sick enough to be referred to them by GPs. The negative correlation observed between specialist supply and health status may not be due to causation but rather to the risks inherent to their practice. We therefore would support maintaining a robust supply and distribution of GPs across Canada. The association measured between the supply of GPs and the HUI is generally quantitatively larger than the association between the supply of specialists and the HUI; overall, the shape of the distribution of the HUI would change following an increase in the supply of GPs in the province making it more narrow and thickening the left tail. According to our results, individuals would also report better SAHS, if they are over the age of 40, ceteris paribus, if the provincial supply of GPs was higher.

We control for the number of physicians per 1000 individuals. One more physician per 1000 is approximately equivalent to doubling the supply of physicians in any given province. This would be highly unlikely to happen in any province in the short term and speaks to the modest impact physician supply has on the health of individuals, net of the effect of lagged health status and other socio demographic characteristics of individuals.

Results suggest that more research is needed on how past and present physician supply affects health status, in particular, on how sensitive the results are to using different measures of health status. The mechanisms of how physician supply affects health status need be explored in more details: while this has not been done in previous research either, it is particularly concerning that we observe, as other research has as well, a negative association between specialist supply and health status. Once the literature on panel quantile regression methods will have converged more, these methods should be applied to these data. Adding data on hospital beds occupancy, or on prescription drugs usage to our data might also help shed light on some of these results, as a high proportion of patients who consult specialists do so from a hospital bed and that prescription drugs can be used as a complement to physician services.

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Appendix A. Supplementary Data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.healthpol.2014.07.003.

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