Trends in Family Physician Usage among Canadians from 2001 to 2016: An Age-Period-Cohort Analysis

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Abstract

As primary health care providers, family physicians play a critical role in Canada's health care system by providing first-level contact for patients and acting as advocates for preventative medicine. Due to their essential role in population health, public health practitioners are concerned about temporal trends surrounding family physician visits. This study uses eight cycles of the Canadian Community Health Survey, a nationally representative survey, to conducting an age-period-cohort analysis with the bounding method, while controlling for sex and race. Most notably, we discover a declining cohort trend indicating that later cohorts are less likely to visit a family doctor over a 12-month period. These results suggest that health promotion policies surrounding family physician use should not only be targeted towards middle and older aged adults who experience declining health, as the cohort effect implies that a portion of health care avoidance behaviour is molded in youth and young adulthood.

1 Background

Primary care plays a critical role in maintaining and improving population health. Described by the World Health Organization (1978) as essential first-level contact for individuals in a health care system, primary care serves to “gatekeep” specialist services (Starfield 1994; Starfield 2001; Macinko, Starfield and Shi 2003; Ferrer, Hambridge and Maly 2005), reduce unnecessary use of hospital usage (Fung et al. 2015), improve health outcomes (Ferrer et al. 2005; Barkley et al. 2016), and promote health equity (Starfield 2001; Barkley et al. 2016). In Western countries such as Canada, primary care providers mainly comprise of family physicians and general practitioners. Primary care provided by family physicians are shown to be the most economical (Franks and Fiscella 1998; Weingarten et al. 2002) and greater numbers of family physicians are associated with better health outcomes (Gulliford 2002; Shi et al. 2003).

Given this evidence on the benefits of primary care, and more specifically family physician care, there is interest in population-level family physician utilization behaviours. Several studies document the decline of family doctor visits in the US, reporting a 6% to 25% decline in rates over the past decade for commercially-insured, Medicare and nationally-representative samples (Hargraves and Frost 2018; Chou et al. 2019; Ganguli, Lee and Mehrota 2019; Rao et al. 2019; Ganguli et al. 2020). In Canada, there are few studies examining trends in population-level family physician usage. However, one Ontario-based study found that over the past two decades, fewer individuals are receiving continuous care from a primary care doctor that they are rostered to (Singh, Dahrouge and Green 2019). In general, studies examining trends in primary care usage typically only consider

the temporal variable of (time) period, although some will also control for age. Rarely will such studies consider cohort effects.

However, changes over time in family physician utilization can be attributed to being an age effect, period effect or cohort effect using an age-period-cohort analysis. The APC analysis framework has been developed in the literature over the past century (Mannheim 1927; Frost 1939; Ryder 1985; Mason et al. 1985) and is frequently used in public health research to analyze disease prevalence or mortality (Frost 1939; Clayton and Schifflers 1987; Diouf et al. 2010). Although it is rare for studies to apply an APC analysis to primary care usage, one such study focusing on adult Canadians using a hierarchical age-period-cohort model found that later cohorts are less likely to use primary care than older cohorts (Canizares et al. 2016). However, this study is limited by its use of a hierarchical model. The hierarchical age-period-cohort model is now known to arbitrarily shrink one of the APC random effects to nearly zero (Bell and Jones 2018) and results are affected by how APC variables are grouped (Luo and Hodges 2016). To the best of our knowledge, there are no other studies applying an age-period-cohort analysis to family physician usage, in Canada or otherwise.

In this study, we use data from the Canadian Community Health Survey from 2001 to 2016 regarding the frequency of consultations with a family doctor or general practitioner. The aim of this study is to understand trends in family physician utilization across age groups, time periods, and birth cohorts for adults in Canada.

2 Methodology

2.1 Source of Data

This study uses data from the Canadian Community Health Survey (CCHS), which is a recurring cross-sectional survey that collects information about health-related outcomes for the Canadian population. The survey is designed to be representative of the Canadian population 12 years of age or older living in all provinces and territories. Excluded from the survey are individuals living on reserves, full-time members of the Canadian Forces, children in foster care, or institutionalized individuals. The survey began in 2001 (cycle 1) and ran every other year until 2005. Beginning in 2007, the CCHS has run every year but with data released every two years. Therefore, survey data is available for 2001, 2003, 2005, 2007-2008, 2009-2010, 2011-2012, 2013-2014, and 2015-2016. The CCHS has a target sample size of 130 000 in the first 3 cycles. Beginning in 2007, the sample size was reduced by half to 65 000 individuals each year.

2.2 Target Population and Primary Outcome

The target population includes all adults aged 20 or above residing in Canada. Canada has a universal health care system in which there is no charge for medically-necessary health care services, although services deemed medically-necessary can vary between provinces

and/or territories. In each cycle of the survey, participants were asked if they have had a consultation with a family doctor or general practitioner about their own health in the last 12 months. Some survey years only asked for the number of consultations in the last 12 months, from which we can still conclude the same binary outcome.

2.3 Data Considerations

This question of interest was asked to all respondents in the sample except for the 2011-2012 cycle where only 6097 respondents aged 20 or older answered the question. In other years, there are approximately 55,000 or 110,000 respondents aged 20 or older for this question, depending on whether the total sample size was 65,000 or 130,000, respectively. Due to this, weights for the 2011-2012 cycle were increased to be comparable with other years. Additionally, since the age for each respondent is only provided in 5-year intervals (beginning at 20-24 and onwards), the period variable (i.e., survey year) was also grouped into 5-year intervals. It becomes important for age, period and cohort to be categorized in intervals of equal length to prevent a scissoring effect in a categorical APC analysis. This results in period categories of 2000-2004, 2005-2009, 2010-2014, and 2015-2019. Afterwards, the cohort variable is calculated by subtracting age from the period year.

2.4 General Approach Regarding the APC Problem

The main hurdle in age-period-cohort analysis is the identification problem due to the linear dependency of age, period, and cohort. This linear dependency leads to rank deficient design matrices which mean that point estimates for the age, period and cohort linear trends are not possible. There are several methods proposed in the literature that achieve point estimation by evoking additional assumptions. These include equality constraints (Fienberg, Mason and William 1979), Intrinsic Estimator (Fu 2000; Yang, Fu, and Land 2004; Yang et al. 2008), and hierarchical models (Yang and Land 2006; Yang and Land 2013), among others, most of which involve very strong and/or hidden assumptions (Bell 2019; Fosse and Winship 2019a). Unless these assumptions are explicitly stated and justified with theory, one should be cautious in interpreting such results. Instead of focusing solely on point estimation, our approach begins with a descriptive analysis using quantities that are identifiable. Following this, we introduce some weak sign and shape constraints and work towards a reasonable approximation for the age, period, and cohort linear trends. The bounding technique used in this study is outlined in Fosse and Winship (2019b). This method also follows the philosophy of Manski (2003) by first focusing on quantities for which point identification can be achieved before introducing a variety of assumptions that potentially lead to point estimation.

2.5 Model and Statistical Analysis

We consider the linearized APC model, whereby through orthogonal decomposition of the classical APC model, the APC linear and non-linear trends are separated in different terms

(Holdford 2005). We will define the model so that $i = 1, \dots, I$ represents the age groups, $j = 1, \dots, J$ represents the period groups, and $k = 1, \dots, K$ represents the cohort groups. It is necessarily true that $k = j - i + I$ and $K = I + J - 1$ due to the linear dependency. The linearized APC model is:

$$Y_{ijk} = \mu + \alpha(i - i^*) + \pi(j - j^*) + \gamma(k - k^*) + \tilde{\alpha}_i + \tilde{\pi}_j + \tilde{\gamma}_k + \epsilon_{ijk}$$

where the linear trends for age, period, and cohort are represented as α , π , and γ , respectively. The overall mean is μ and the non-linear trends are represented as $\tilde{\alpha}$, $\tilde{\pi}$, and $\tilde{\gamma}$. Additionally, we have that $i^* = \frac{I+1}{2}$, $j^* = \frac{J+1}{2}$, and $k^* = \frac{K+1}{2}$, which refer to the midpoint reference indices. This model is easily modified for a binary outcome by adding a logit link function as shown below.

$$\ln \frac{p_{ijk}}{1 - p_{ijk}} = \mu + \alpha(i - i^*) + \pi(j - j^*) + \gamma(k - k^*) + \tilde{\alpha}_i + \tilde{\pi}_j + \tilde{\gamma}_k + \epsilon_{ijk}$$

where p_{ijk} is the probability of an event when Y_{ijk} is a binary outcome.

Note that due to the logit link function, the age, period, and cohort linear trends refer to linear slopes for the log odds of the outcome, not the outcome itself. As appropriate, graphs will still be displayed on the probability scale for interpretability. We apply logistic regression with survey weights for the model above. Since the model will not run with all three APC linear components, we drop the period linear component. There are two main things to note about dropping the period linear component. First, this does not affect the non-linearities of age, period and cohort, which are identifiable and will be present graphically. Second, the age and cohort linear coefficients provided in the output will not be α and γ due to the following:

$$\begin{aligned} \text{Outcome} &= \mu + \alpha(A) + \pi(P) + \gamma(C) + \text{non-linear} \\ &= \mu + \alpha(A) + \pi(A + C) + \gamma(C) + \text{non-linear} \\ &= \mu + (\alpha + \pi)(A) + (\pi + \gamma)(C) + \text{non-linear} \end{aligned}$$

Therefore, since we dropped the period linear component, the age and cohort linear coefficients actually estimate the following identifiable values:

$$\alpha + \pi$$

$$\pi + \gamma$$

Although this is not point identification of the linear effects, it reduces the 3-dimensional parameter space for α , π , and γ to a line which we visualize using a 2D-APC graph (see section 4 of Fosse and Winship 2019a).

With these values, we present a diachronic age trend (sum of age linear, period linear and age non-linearities) and a diachronic cohort trend (sum of cohort linear, period linear and cohort linearities). Although the DAT and DCT trends are different from the

age-only and cohort-only trends since they include the period linear effect, they are still interpretable and useful since the period linear effect provides the context in which age and cohort are changing. Note that thus far we have only described values for which point estimation is possible and no additional assumptions have been evoked.

Finally, following this descriptive analysis, we also provide a bounding analysis (Fosse and Winship 2019b). We present results for each of the following three assumptions.

1. Sign Constraint: Age trend is positive.
2. Shape Constraint: Age trend is monotonically increasing between the ages of 30 and 69.
3. Constraint for Point Estimation: Age trend is approximated using the minimum monotonically increasing age slope for the age interval of 30 to 69.

Note that each assumption is stronger than the previous, eventually resulting in point estimation.

3 Results

3.1 Descriptive Analysis

Table 1 shows the results of the full APC model, which was run with the period linear component dropped. Non-linearity coefficients up the third order (cubic terms) are displayed. The non-linearities and the values of $\alpha + \pi$ and $\pi + \gamma$ are identifiable from this model. Using a standard t-test with a significance level of 0.05, there is evidence that all non-linearities up to the third order are not 0, except for the cohort quadratic component. Additionally, the sum of the age and period linear components ($\alpha + \pi$) and the sum of the period and cohort linear components ($\pi + \gamma$) are both negative and statistically significant.

	Coefficient	Estimate	Std. Error	p-value
	Intercept	1.33	0.01	***
Linear Components	Age + Period ($\alpha + \pi$)	-0.27	0.05	***
	Period + Cohort ($\pi + \gamma$)	-1.63	0.05	***
Non-Linear Components	Age Quadratic	0.17	0.04	***
	Age Cubic	-0.19	0.03	***
	Period Quadratic	-0.16	0.01	***
	Period Cubic	-0.07	0.01	***
	Cohort Quadratic	-0.10	0.05	
	Cohort Cubic	-0.23	0.04	***

Table 1: Output of logistic regression by dropping the period linear component. Non-linearities are shown up to the third order. Coefficient estimates are untransformed and on the logit scale. P-values are representing using the encoding: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

The non-linearities of age, period and cohort are displayed in Figure 1.

Figure 1: Non-linearities. Panels a, b, c show the non-linearities for age, period, cohort. These are the deviations from the unidentifiable linear trends. Deviations are shown on the probability scale. Grey bounds are the 95% confidence interval.

Figure 2 shows the 2D-APC graph. Based on the values of $\alpha + \pi$ and $\pi + \gamma$, the three-dimensional parameter space of α , π , and γ is reduced the line shown in the graph. All points on the line represent a possible value of (α, π, γ) that is consistent with the data. Based on this graph alone, we draw some conclusions regarding the sign of the linear trends. Six of the eight quadrants of the 3-dimensional space are shown in the graph. The solution line crosses four of the quadrants. Therefore, the following combinations are possible regarding the sign of (α, π, γ) : $(+, -, +)$, $(+, -, -)$, $(-, -, -)$, $(-, +, -)$.

Figure 2: 2D-APC graph. The line shows combinations of values for α , π , and γ that are consistent with the data. The horizontal axis represents values the period linear slope. The left vertical axis represents age linear slope. The right vertical axis represents the cohort linear slope. Dotted lines represent the axes.

Finally, Figure 3 shows the diatonic age trend (DAT) and diatonic cohort trend (DCT). The DAT is the age trend (linear and non-linear components) plus the period linear component. Panel (a) shows that as adults in Canada age, and simultaneously live in later time periods, the probability of visiting a family physician in the past 12 months remains relatively stable, but declines slightly. Conversely, the DCT is the cohort trend (linear and non-linear) plus the period linear component, which has the effect of age removed. Panel (b) shows that later cohorts have a lower probability of visiting a family physician that earlier cohorts, including the effect of later cohorts living in later time periods. This trend declines steadily throughout all observed cohorts, with the probability of at least one family doctor visit in the past year decreasing from 0.902 (0.895, 0.909) for the 1930 cohort to 0.492 (0.464, 0.521) for the 1995 cohort.

Figure 3: Diatonic age trend and diatonic cohort trend. Panel (a) shows the diatonic age trend, which is the sum of the age linear trend, period linear trend, and age non-linearities. Panel (b) shows the diatonic cohort trend, which is the sum of the cohort linear trend, period linear trend, and cohort non-linearities. Grey bounds indicate the 95% confidence interval.

3.2 Bounding Analysis

Assumption 1: A sign constraint

We make the assumption that the age linear slope, α , is positive. This means that on average, higher age is associated with higher family physician usage. Even with the constraint that the age linear trend is positive, the aggregated age trend including the age linear and age non-linear components may still decrease over some intervals. Panel (b) of Figure 4 shows how this constraint restricts the solution line. Immediately we see that the period linear trend, π , must be negative (or more specifically, less than -0.27). The cohort trend is also restricted to be greater than -1.36. Note that there is still an infinite number of possible solutions on the solution line.

Assumption 2: A shape constraint

The second assumption is that the age trend is monotonically increasing between the ages of 30 and 69. That is, for every subsequent age category between 30 and 69 years, the probability of annual family physician usage is greater than the previous age category. This constraint is based on the assumption that individuals become continuously more proactive about their health following early adulthood. Panel (c) of Figure 4 shows that this assumption is stronger than assumption 1. With the second assumption, we have that the period linear trend π must be less than -0.73 and the cohort linear trend γ must be greater than -0.89.

Assumption 3: Point Estimation

Finally, we achieve point estimation by approximating the age slope to the minimum monotonically increasing slope. This is the smallest age slope such that the age trend (linear and non-linear components) is monotonically increasing between the ages of 30 and 69. Once the age slope is set through this assumption, the period and cohort slopes are determined as well, since the values of $(\alpha + \pi)$ and $(\pi + \gamma)$ are known. This point estimate is shown on the 2D-APC graph in Figure 4 panel (d). Furthermore, Figure 5 shows the age, period, and cohort trends with respect to this point estimate. These are the age-only, period-only, and cohort-only effects, assuming that the values of the other two APC variables are at their average value. The age trend is stable up until age 45 where it begins to increase more rapidly. However, after age 70, the curve levels off. Notice that by construction, the age trend is monotonically increasing between the ages of 30 and 69. The period trend is relatively flat but decreases sharply from 2010 to 2015. The cohort trend undergoes the most drastic change as it decreases steadily across all cohorts.

Figure 4: 2D-APC graphs based on assumptions. Panel (a) shows the original APC graph. Panel (b) shows how the solution line is restricted based on assumption 1. The pink region shows the areas where α is positive. The solid line represents the segment of the solution line that is consistent with this assumption. Panel (c) shows the same plot for assumption 2. Panel (d) shows the point on the solution line that corresponds with the point estimate.

Figure 5: Age, period, cohort trends for assumption 3. This plot is based on the point estimate from assumption 3. It shows how the probability of visiting a family doctor changes as age, period, and cohort changes, while the other two APC variables are held constant at their average value.

4 Discussion

Regardless of the unidentified APC linear trends, this study finds that the age, period, and cohort trends are all operative for this outcome (see the significance of non-linearities in table 1). The existence of an age trend is not surprising and aligns with other literature and theories of health service utilization (Babitsch, Gohl and von Lengerke 2012). However, an important finding of this study is the presence of a cohort effect for family physician usage. Cohort trends, as argued by Mannheim (1927) and several others, are due to members of the same cohort sharing the same formative experiences, resulting in a shared frame of reference that plays a large role throughout their lives. Therefore, the presence of a cohort trend, regardless of its sign and shape, suggests that some component of an individual's health care utilization behavior is impacted by early formative experiences that are specific to their birth cohort.

Second, another key finding is that descriptively, including the effect of a changing time period but controlling for age, later cohorts are less likely to visit family physicians than earlier cohorts. The probability of visiting a family physician in the last 12 months is greater by 40.1% for an individual born in 1980 than an individual born in 1995 (figure 3b). This result shows the strength of the temporal factors of period and/or cohort on family physician usage. This finding is consistent with a similar study by Canizares et al. (2016) where the authors discover a similar declining diatonic cohort trend.

Through the bounding analysis, by merely assuming that average annual family physician usage increases with older age (i.e. assumption 1 of a positive linear age slope), our study finds that later time periods are associated with lower physician usage (i.e. linear period slope is negative). Further, this assumption on the age trend is informed by theories and prior research indicating increased health care usage in older age (Jimenez-Rubio, Smith and Van Doorslaer 2008; Babitsch, Gohl and Von Lengerke 2012; Manski et al. 2013). This is an interesting result because it is not clear from previous studies whether the period trend would be positive or negative. On one hand, the Canadian Medical Asso-

ciation (2016) reports an increasing doctor per capita since 1986 and most provinces have undertaken large-scale primary care reforms during this time period to improve access to services (Peckham et al. 2018). At the same time, certain primary care visits, such as annual physical examinations for asymptomatic adults, have been discouraged over the past two decades (Hill, Frappier-Davignon and Morrison 1979; Canadian Task Force of Preventative Health 2017) and studies show significant levels of health care avoidance (Kannan and Veazie 2014). Our results show that despite increasing numbers of doctors and health policy efforts, family physician usage declines over period years, when holding age and cohort effects constant. The second and somewhat stronger assumption is that the age curve is monotonically increasing between the ages of 30 and 69. This is backed by similar theories as the first assumption (Jimenez-Rubio, Smith and Van Doorslaer 2008; Babitsch, Gohl and von Lengerke 2012; Manski et al. 2013) and the idea that this is an age range in which many periodic screening tests start to become recommended (Shimizu, Bouchard and Mavriplis 2016). This assumption, compared to the previous, enforces a more stringent conclusion on the strength of the negative period slope.

Finally, we believe that a good approximation for the age slope is the minimum monotonically increasing age slope. Given the age non-linearities, this is the smallest age slope for the linear trend such that the overall age trend is monotonically increasing between ages 30 and 69. This is a good assumption if one believes that the age slope between 30 and 69 is approximately monotonically increasing but not necessarily so. Based on the theory and evidence presented above, we believe that such an assumption seems reasonable. This assumption results in a generally increasing age trend, a stable period trend (except perhaps for the last few years), and a declining cohort trend (figure 5). The declining cohort trend reflects a generational shift surrounding attitudes and behaviours of physician use. Further research is required to understand the exact mechanisms behind this trend. Many of the later cohorts in this study (say, birth cohorts between 1975 and 1995) are currently in early or middle adulthood, where there are still relatively few consequences of avoiding health services for several years in a row. This will change, however, as these same cohorts age. These findings suggest that health promoters and policymakers may find it more difficult to encourage subsequent cohorts to engage with the health care system when they reach old age.

4.1 Strengths and Limitations

The main strength of this study is that unlike many other age-period-cohort analyses, our methodological approach is transparent with all assumptions clearly stated and justified. Although not everyone may agree with the assumptions used in the bounding analysis or perhaps future evidence may suggest other assumptions, the descriptive analysis will still hold. In such a case, the bounding analysis can easily be updated with new assumptions. Additionally, our data came from a very large total sample size of 786,115 Canadian adults. This results in narrow confidence intervals for all identified values. The data, collected by Statistics Canada, uses a complex sampling design to ensure that each cross-sectional study

is an accurate representation of the Canadian population for that survey year.

One limitation is that the self-reporting nature of this data is subject to response bias, which is a common concern in health outcomes (Reijneveld and Stronks 2001), and as well as social desirability bias. Additionally, our dataset only provides ages in 5-year intervals, and due to this, we also group period years into 5-year intervals to prevent a scissoring effect in the results. This results in only 4 period categories, some of which only have 2 years of survey data. Another limitation is that the results of our bounding analysis are only as good as our assumptions. We have argued above why we chose the assumptions that we did, but the evidence can change. Finally, this study does not address the mechanisms behind any of the age, period, or cohort trends, or consider other variables such as sex or race. However, with the CCHS being such a rich source of demographic and health outcomes, this is a feasible next step.

5 Conclusion

This study examines how temporal changes in family physician usage can be attributed to age, period, and cohort. Our data uncovered a cohort-only trend that underscores the importance of health care policy and public health promotion that targets all individuals, not just those in old age. We find that Canadians born in later years are less likely to visit a family physician or general practitioner throughout their life. This suggests future difficulties in encouraging later cohorts to use health services, particularly when said individuals reach middle and older adulthood. Overall, this study emphasizes the importance of research and policies that consider health care usage in the context of age, period, and cohort, in order to improve the coordination and delivery of primary care in Canada.

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