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Cohort Size and Suicide Mortality in Canada: An Assessment of the Easterlin and Preston Theories in the GI through the Y Generations

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Abstract

A key component of demographic analysis is the cohort. Cohort-related factors might play a role in the strong net cohort effect reported for male baby boomers (born 1946-1966) in Canada, who have committed suicide at an unusually high rate. This study examines the impact of relative cohort size on suicide mortality in Canada and compares this effect in the province of Quebec to the effect observed in the rest of Canada and tests concurrent demographic theories of Easterlin and Preston. A Hierarchical Age-Period-Cohort Cross-Classified Random Effect Model (HAPC-CCREM) was used to assess the impacts of interest. The results in Canada support Easterlin's paradigm: large cohorts commit suicide at higher rates than small cohorts. However, the relationship appears to be specific to males, as female cohort sizes do not have significant effects on suicide mortality rates. Our findings also suggest that the effect of relative cohort size on suicide mortality is significantly greater for males in Quebec than for males in the rest of Canada.

Keywords

Suicide, relative cohort size, Canada, Quebec, Easterlin, Preston, hierarchical modeling

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1. Introduction

Ryder's classic work (1965), published nearly 50 years ago, demonstrated the importance of the cohort, a key concept used to consider demographic and social-change analyses in a two-dimensional framework of time and age. The cohort, a temporal unit, may be defined as the aggregate of individuals who experience the same event within the same time interval (Ryder 1965:845). In most research, including that on suicide mortality, the defining event for a cohort is being born in or around the same year. However, a cohort is not a summation of a set of individual histories; each cohort has a distinctive composition, and Ryder argued that cohort membership could be as important in the determination of behavior as other features of social structure, such as socioeconomic status (Land 2011). The notion of a cohort effect rests in the theory that members of a cohort share behaviors that reflect lasting effects of shared environmental exposures as they experience the same events throughout their lives.

Studies of the cohort can take various forms, leading to possible misinterpretation of results. The cohort is one of the three basic dimensions of Age-Period-Cohort (APC) analyses. A "cohort effect" encompasses the shared history of people born in or around the same year and is sometime misread as being equivalent to the "cohort size" or "relative cohort size" effect, which is the proportion of the population belonging to a given cohort. [1] Thus, the "cohort size effect" can influence general changes in the "cohort effect". Theories on the benefits and consequences of cohort size regarding the behavior of cohort members compared to members of other cohorts have two prominent concurrent paradigms that are applied to suicide mortality. The best-known theory is that of Easterlin (1980), who in "Birth and Fortune: The Impact of Numbers on Personal Welfare" supports a harmful link between suicide and large birth cohort size, as large birth cohorts have higher rates of suicide than small birth cohorts. Easterlin maintained that relative cohort size is crucial in determining one's economic and social fortunes, and a large cohort produces increased competition for scarce resources, including education, employment earnings (unemployment and job advancement), health care and public retirement. This competition can result in deprivation and increases in social disruptions (i.e., suicide) among members of large birth cohorts compared to members of smaller birth cohorts, who experience more stable life courses and economic fortunes and thus less psychological stress and lower rates of suicide and crime (Easterlin [1980] 1987:3,140). In general, Easterlin's arguments emphasize the impact of the relative number of individuals in the private labor market and how this number is affected by cohorts of unusual size. At about the same time that Easterlin's theory was proposed, a counter-theory was advanced by Preston (1984), who claimed that there was a beneficial effect (lower suicide rates) of larger cohorts. Preston argued that larger birth cohorts have an advantage in the political and economic spheres because they have enough individuals to influence public policy and acquire consumer resources (in democratic societies), while smaller birth cohorts do not. Moreover, successive smaller birth cohorts may be disadvantaged, as members of the previous larger cohorts are occupying most jobs. Preston's emphasis is primarily on how public or private transfers relate to the cohort size of those outside the labor force (Preston 1984:450).

Suicide mortality in Canada is an important public-health issue,[2] and scholars have noted successive male cohorts with higher suicide rates (Mao, Hasselback, Davies, Nichol and Wigle, 1990; Reed, Camus and Last, 1985). Several studies have demonstrated the progressively increasing cohort effects for males born after World War II in Canada (Légaré and Hamel 2013; Mao et al. 1990; Newman and Dyck 1988; Reed, Camus and Last 1985; Thibodeau 2015c) and in other countries, notably the USA, West Germany, Switzerland, the UK, Spain and Japan (Ajdacic-Gross et al. 2006; Granizo, Guallar and Rodriguez-

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[1] For example, the proportion of the population aged 15 to 24 relative to that aged 25 to 59.

[2] In 2008, it ranked 9th of all causes of death in Canada and was the principal cause of death by an external cause (Statistics Canada. 2012a. "Age-standardized mortality rates by selected causes, by sex." in *Table 102-0552*, edited by CANSIM: Statistics Canada.)

Artalejo 1996; Gunnell et al. 2003; Hafner and Schmidtke 1985; Keyes and Li 2012; Murphy and Wetzel 1980; Odagiri, Uchida and Nakano 2011; Phillips 2014; Phillips et al. 2010; Riggs, McGraw and Keefover 1996). In Canada, baby boomers born between 1946 and 1966 experience a stronger cohort effect (Thibodeau 2015c), as they were born during a well-documented period of high fertility (Grindstaff 1975; Pampel 2001; Statistics Canada 2008). In fact, the total fertility rate during that period remained at more than three children per woman and kept increasing through the late 1950s. In 1960, while the baby boom was in full swing, Canada recorded a total fertility rate of 3.91 children per woman, a record level of natural population increase of 339,000 and 479,000 children born to Canadian women (Statistics Canada 2008, 2011 [2000]). This period was followed by more than 30 years of low fertility (Statistics Canada 2008); other high-income nations experienced similar patterns. This fluctuation in fertility resulted in a substantial fluctuation in cohort size, which prompted scholars to investigate potential economic and social consequences.

Empirical studies on the relationship between suicide mortality and cohort size are limited, with variable findings. A classic cohort-size analysis by Ahlburg and Schapiro in the United States revealed a significant impact of cohort size on suicide mortality for both males and females (Ahlburg and Schapiro 1984:103), while Holigner's (1987) study on youth from 1933 to 1982 showed a positive association for those aged 15-24 but a negative association for those aged 25-64, suggesting a "youth cohort effect" (Holinger 1987:181-182). Among the most well-known comprehensive works on cohort size are those of Pampel (1996, 2001), which offer a broad overview of the problem. He found a positive association between relative cohort size and suicide mortality among young age groups and a negative association among old age groups for the 1953-1956 cohorts of 18 developed nations (Pampel 1996:354). O'Brien and Stockard's substantial contribution focuses on family structure (O'Brien and Stockard 2002; O'Brien and Stockard 2003; O'Brien and Stockard 2006; O'Brien, Stockard and Isaacson 1999; Stockard and O'Brien 2002a, 2002d). In a broad study of 19 modern nations, the effect of interest was modeled using an extension of the APCC hierarchical model. The authors found positive links between cohort size, the percentage of non-marital births and the suicide rate (Stockard and O'Brien 2006). In Canada, analyses have provided inconsistent assessments of the impact of relative cohort size on suicide rates. Leenaars and Lester (1994) tested the Easterlin hypothesis for youths aged 15 to 24 and found a negative association between cohort size and suicide rate for the period of 1969 to 1988, which was in the opposite direction of the predicted association. This finding led to the conclusion that Easterlin's cohort-size hypothesis was not relevant in Canada and the United States at that time (Leenaars and Lester 1994:189). However, the authors (1996) extended their analysis to both sexes and all age groups and found that for the period of 1969 to 1987, the suicide rate among males aged 30-34 was positively associated with cohort size. No such association was observed in Canada for the period under study, although some significant negative coefficients were found (Leenaars and Lester 1996:49-50).

These analyses are generally dated and limited in scope. While they captured to some extent the "cohort size effect" and the increases in suicide mortality rates over short time frames, these studies did not cover the net (independent) effect of sex by using vital statistics from 1926 through the beginning of the 21st century; doing so would provide highly valuable information via the inclusion of additional cohorts. Moreover, some national characteristics revealing large societal trends were reported, but previous authors did not discuss the non-uniform distribution of these characteristics across the country.[3] Indeed, suicide rates vary greatly, and these rates historically tend to increase from east to west in Canada (Langlois and Morrison 2002:14; Sakinofsky, Roberts and Van Houten 1975; Sakinofsky and Webster 2010:357); however, an increase in suicide rates in Quebec caused this province to have the highest standardized rate,

[3] High suicide rates among aboriginal people (First Nations, Inuit and Northerners) in Canada are well documented (Canada, H.C. 2013. "National Aboriginal Youth Suicide Prevention Strategy (NAYSPS) : program framework."), and while research and prevention programs focus on this population segment, this problem is beyond the scope of this study.

well above the national average, for several years (St-Laurent and Bouchard 2004:17-21).[4] In addition, this province is societally unique among Canadian provinces. For example, Quebec is among the most populous provinces and has distinct historic, religious and cultural characteristics dating from its origins as a French colony to its 1763 reincorporation into Canada. Quebec also experienced a very intense and volatile period in which hostile conditions rapidly and severely transformed social and cultural values to an extent unmatched in the rest of Canada. The erosion of traditional lifestyles was precipitated by new modern beliefs and ways of life, which affected family and *political-economic* structures and functions (Thibodeau 2015c). For example, traditional gender roles evolved drastically (emancipation of women from housework), and there was a rapid demographic movement into the city as traditional agricultural life and values were left behind. The strong social cohesion provided by the Catholic Church began to disintegrate with increased secularization in Quebec. In general, studies have shown that the lower the importance of religion in a society, the higher the suicide rate (Breault 1986; Stack 1985). An investigation of the effect of cohort size on suicide at the provincial level is necessary because of the unique position of and higher suicide rate in Quebec (Krull and Trovato 1994; Lesage et al. 2012; Thibodeau 2015c) and a recent analysis highlighted the stronger cohort effect in Quebec compared to the rest of Canada (Thibodeau 2015c). Nevertheless, no study to date has performed such an investigation.

Furthermore, a gender-stratified analysis is needed because this phenomenon differs by gender. Men commit suicide more frequently than women regardless of the point in time; only the ratio of male to female suicides varies (Baudelot and Establet 2006; Mao et al. 1990; Reed et al. 1985; Trovato 1988). Additionally, the cohort effect is primarily observed among males in Canada, in keeping with the general international pattern of more modest (or no) cohort effects for females and the specific pattern of relative cohort size appearing to have a stronger influence on male suicide rates than female suicide rates (Beaupré and St-Laurent 1998; Keyes and Li 2012:424; Légaré and Hamel 2013:122; Mao et al. 1990; Newman and Dyck 1988:679; O'Brien and Stockard 2006:1545; Phillips 2014; Reed et al. 1985:46; Thibodeau 2015c).

Finally, the challenge in explaining the temporal consequences of the cohort size effect (a component of the cohort dimension) is the decomposition of each APC dimension to estimate the contribution of each parameter. The search for a reliable statistical technique continues, and new advanced statistical models have recently been proposed. In particular, a hierarchical structure allows for additional levels where data are available, but no prior studies have applied this approach to suicide mortality. This approach may provide important insight into drivers of the anomalously high suicide rate among baby-boomers compared to the rates in small cohorts.

This study focuses on two objectives. The first is to determine the relationship between suicide mortality rate and relative cohort size (RCS) in Canada from 1926 to 2008. The second is to compare the impact of RCS on suicide rates in the province of Quebec to the impact in the rest of Canada.[5] This analysis included the most comprehensive period data available at this time in an attempt to uncover trends at the national and provincial levels and thereby provide a more complete and accurate profile of the changes that occurred over 83 years. Indeed, this study encompasses nearly four generations of Canadians from 1911 to 1991; it includes the GI generation, also called the Greatest Generation, which is composed of individuals born at the beginning of the 20th century through 1924, and all cohorts through the Y generation (born between 1981 and 1996). This extended time period includes the cohort of baby boomers with the high suicide rate. Cohort membership could strongly affect economic fortunes and social integration and regulation. Theoretical arguments regarding the advantages and disadvantages of cohort size are revisited with reference to Easterlin (1987 [1980]) and Preston (1984). Specifically, we use evidence from the literature to test the following hypotheses:

[4] Available upon request to the author.

[5] Canadian provinces and territories minus Quebec province.

Hypothesis 1. *Basic national cohort size effect*: Relatively large cohorts in Canada commit suicide at higher rates compared to relatively small cohorts.

Hypothesis 2. *National gender cohort size effect*: The relative effect of cohort size on suicide rates in Canada is significantly greater for males than for females.

Hypothesis 3. *Regional*[6] *suicide effect:* There is a significantly greater cohort effect on the suicide rate in the province of Quebec than in the rest of Canada.

Hypothesis 4. *Regional gender cohort size effect*: The relative cohort size effect on the suicide rate among males is significantly greater in the province of Quebec than in the rest of Canada.

A Hierarchical Age-Period-Cohort Cross-Classified Random Effect Model (HAPC-CCREM) was used to test these hypotheses. Our analysis was stratified by gender, and our findings are discussed within the socio-historical context of a changing Canadian society.

2. METHODS

2.1 Data

2.1.1 Dependent variable

The age-specific suicide rate by gender is our dependent variable. The data cover the period from 1926 to 2008, and the numbers of suicide deaths in Canada have been extracted from the publically available database Statistics Canada. For the analysis, the data were aggregated into five-year age and period intervals; we focused on ages 15-19 to 90+, thereby producing a Period x Age x Sex cross-table. The age- and sex-specific population estimates for Canada were derived from the census carried out by the Government of Canada using the series of population estimates produced by Statistics Canada. Vital statistics on suicide can be obtained back to the beginning of the 20th century, and the inclusion of specific provinces and territories varies by date of admission into the confederation[7]. Notably, this study is designed to examine suicide mortality. We do not consider an expanded definition of suicide, as surveys have consistently demonstrated that suicide attempts, suicidal "ideation" and suicidal conduct are separate concepts; additionally, recollections from survivors do not necessarily provide information relevant to suicide victims (Baudelot and Establet, 1984, p. 59). Consequently, only completed suicides are within the scope of this research.

Statistics on suicide have been the main tools utilized in analyses of this phenomenon since Durkheim's (1951 [1897]) study in the 19th century. Their validity is thoroughly debated (Brugha and Walsh 1978; McCarthy and Walsh 1975; 1973; Sainsbury and Jenkins 1982). Canada's official figures for suicide deaths are underestimates, but the discrepancy is not large enough to affect the validity of comparisons or hide real differences in suicide rates (Mao et al. 1990). For the period from 1950 to 1982, the years with the most substantial underreporting are 1977-1978, during which the average potential underreporting is estimated at 17.5% for women and 12% for men (Speechley and Stavraky 1991:38). Changes to the International Classification of Diseases (ICD), which underwent eight revisions during the time period of

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[6] The term *region (regional)* is used in this research to define the subdivision of Canada between the province of Quebec and the rest of Canada, as the more conventional term in research, *territory,* could have caused confusion with the *Northwest Territories, Nunavut, and Yukon,* which are three actual territories in the country.

[7] Figures from Quebec and Ontario were included in 1926, Newfoundland in 1950, and the Northwest Territories in 1956, while creation of Territories Nunavut date to 1999.

our study, were also considered. The changes from the 7th to the 8th revision very slightly affected suicide-data comparisons; an increase of 3% was observed according to WHO (1965), but the recently reported CIM-10 by Statistics Canada indicated no change in the number of deaths due to intentional self-harm (Geran et al. 2005:10, 33). Past analyses have thus been based on a negatively biased estimator that underestimates suicide rates, usually with no adjustments for the factors discussed above; the true rates would be difficult and work-intensive to define. Hence, we did not adjust the official data on suicide mortality in this research.

2.1.2 Independent variables

Measuring relative cohort size (RCS)
Our main predictor, or independent variable, is the relative cohort size (RCS) as a proportion of the total population. However, the analysis is complex, and the *appropriate* operationalization of the RCS presents further difficulties. Indeed, variations have been noted in the literature (Ahlburg and Schapiro 1984; Easterlin [1980] 1987; Holinger 1987; Leenaars and Lester 1994; Pampel 1996; Preston 1984; Stockard and O'Brien 2002a), including choices with partial influence on the outcomes (Leenaars and Lester 1996:47). There are two principal elements by which to calculate the indicator.

First, RCS can be a *variable* or a *fixed measure*. The first method allows the RCS value to change as a cohort ages over time[8]. In this study, we operationalized RCS as a *fixed* measure: it is the proportion as a percentage of the *population* that was in a five-year cohort when that cohort was young (i.e., 15-19 year olds). The measure is constant for a particular cohort across all age groups and periods by gender (each cohort has only a single value for RCS) and was used in previous analyses of suicide and violent mortality (O'Brien 1989; O'Brien et al. 1999; Savolainen 2000; Slack and Jensen 2008; Stockard and O'Brien 2002a, 2002d, 2006). This *fixed* operationalization was preferred because it appears to be the most consistent with the concepts of Ryder (1965), which emphasize the importance of historical experiences and social changes (particular events in time) faced by cohorts over time that last throughout a lifetime. The measure focuses on the age at which birth cohorts enter adulthood, a time when individuals are more likely to enter the job market, enter university, leave home, potentially start a family (bear children), get married, etc.[9]

Second, the denominator of the indicator is fundamental because it corresponds to the advantages and disadvantages associated with cohort age, the number of dependents, and social and economic conditions. Both demographers who specified cohort-size paradigms used different methods to compute relative size. Easterlin's conceptualization focused on comparing the size of a cohort to the size of the parents' cohort (ratio of the number of individuals aged 15-29 to those aged 30-64) because his theory mainly focused on competition for resources among the active population in the labor market. Preston, on the other hand, used the standard demographic method of taking the percentage of the total population for each year (O'Brien 1989:64). Refer to Equation 1 and Equation 2 for examples.

Equation 1: Example of Easterlin's RCS operationalization

$$RCS = \frac{P_g^{15-19}}{\sum P_g^{15-64+}}$$

8 For example, when the cohort was aged 18-20, RCS would be calculated as the percentage of the population 18-62 aged 18-20; when the cohort was aged 21-23, RCS would be calculated as the percentage of the population 18-62 that was 21-23; and so on O'Brien, R.M., J. Stockard, and L. Isaacson. 1999. "The enduring effects of cohort characteristics on age-specific homicide rates, 1960-1995." *American Journal of Sociology* 104:1061-1095.

9 "tap the effects of a relatively large number of new entrants into families, schools, and the job market on members of a cohort" ibid.

and

Equation 2: Example of Preston's RCS operationalization

$$RCS = \frac{P_g^{15-19}}{\sum P_g^{15-90+}}$$

where RCS = Relative cohort size
P = Population
g = Gender

For our study, we calculated RCS values using Preston's conceptualization on the basis of the total population (each male five-year cohort based on the male population and so on for females - refer to table 1). This choice seemed more appropriate because economic and social resources are consumed by the

Table 1
Cohort number and relative cohort size by age and year, Canadian males, 1926-2008[10]

Year	Age																
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90+	
1926	**1** **13.958**																
1931	**2** **13.731**	**1** **13.958**															
1936	**3** **13.524**	2 13.731	**1** **13.958**														
1941	**4** **12.687**	3 13.524	2 13.731	**1** **13.958**													
1946	**5** **11.538**	4 12.687	3 13.524	2 13.731	**1** **13.958**												
1951	**6** **10.726**	5 11.538	4 12.687	3 13.524	2 13.731	**1** **13.958**											
1956	**7** **11.205**	6 10.726	5 11.538	4 12.687	3 13.524	2 13.731	**1** **13.958**										
1961	**8** **12.916**	7 11.205	6 10.726	5 11.538	4 12.687	3 13.524	2 13.731	**1** **13.958**									
1966	**9** **14.11**	8 12.916	7 11.205	6 10.726	5 11.538	4 12.687	3 13.524	2 13.731	**1** **13.958**								
1971	**10** **14.228**	9 14.11	8 12.916	7 11.205	6 10.726	5 11.538	4 12.687	3 13.524	2 13.731	**1** **13.958**							
1976	**11** **13.661**	10 14.228	9 14.11	8 12.916	7 11.205	6 10.726	5 11.538	4 12.687	3 13.524	2 13.731	**1** **13.958**						
1981	**12** **11.504**	11 13.661	10 14.228	9 14.11	8 12.916	7 11.205	6 10.726	5 11.538	4 12.687	3 13.524	2 13.731	**1** **13.958**					
1986	**13** **9.59**	12 11.504	11 13.661	10 14.228	9 14.11	8 12.916	7 11.205	6 10.726	5 11.538	4 12.687	3 13.524	2 13.731	**1** **13.958**				
1991	**14** **8.942**	13 9.59	12 11.504	11 13.661	10 14.228	9 14.11	8 12.916	7 11.205	6 10.726	5 11.538	4 12.687	3 13.524	2 13.731	**1** **13.958**			
1996	**15** **8.881**	14 8.942	13 9.59	12 11.504	11 13.661	10 14.228	9 14.11	8 12.916	7 11.205	6 10.726	5 11.538	4 12.687	3 13.524	2 13.731	**1** **13.958**		
2001	**16** **8.651**	15 8.881	14 8.942	13 9.59	12 11.504	11 13.661	10 14.228	9 14.11	8 12.916	7 11.205	6 10.726	5 11.538	4 12.687	3 13.524	2 13.731	**1** **13.958**	
2006	**17** **8.535**	16 8.651	15 8.881	14 8.942	13 9.59	12 11.504	11 13.661	10 14.228	9 14.11	8 12.916	7 11.205	6 10.726	5 11.538	4 12.687	3 13.524	2 13.731	**1** **13.958**

Note: Values expressed in percentage (%)
RCS Preston Total population (15-90+)

entire population, as opposed to only the adult or the active population (i.e., 15-64). For instance, an elderly population will increase funding for welfare, old-age pensions, healthcare, etc., at the expense of adults and children (Leenaars and Lester 1996:52). Likewise, in a population with large numbers of

10 To save space, only the table containing the Canadian male cohort numbers and relative cohort sizes is presented. Other tables available upon request to the author.

children, resources will be directed into child-assistance payments, family-aid programs, school and day care, at the expense of seniors and adults. Therefore, each segment draws resources from every other segment. RCS results are presented accordingly. Our results are representative of this operationalization. We thus undertook a sensitive analysis as suggested in literature[11], using Easterlin's measure for the active population (not presented[12]).

In our analysis, gender is a dummy variable integrated in the models along with region, which denotes either the province of Quebec or the rest of Canada. The other variables beside RCS[13] are the three APC analysis dimensions of age, period and cohort.

2.2 Statistical estimation: HAPC-CCREM

The APC approach distinguishes three dimensions of time-related variation (age, period, and cohort effects) and is a central element of a cohort analysis. Though, APC analysis is impeded by the "identification problem": the fundamental problem that the three variables are collinear by definition (Cohort = Period – Age).[14] This problem is well documented in the APC literature, and different methods have been proposed to produce reliable and stable coefficient estimates over the years (Bell 2014; Chauvel 2011a, 2011c; Holford 1983; Mason et al. 1973; O'Brien et al. 1999; Pullum 1978; Yang, Fu and Land 2004). In the APC family of models, the most used model is probably the Conventional Linear APC Model, which imposes arbitrary additional constraints.[15] However, other approaches have been recently proposed.

Our analysis was conducted using the HAPC-CCREM[16] developed by Yang and Land (2006), which is well suited to testing our hypotheses regarding the impact of RCS on *S*, the suicide mortality rate (five-year age groups and periods). Extensive technical algebraic descriptions can be found in the developer's studies (Yang 2008; Yang and Land 2006). HAPC-CCREM is a multilevel model (also called a random-effect, hierarchical linear, or mixed model in the literature) with a cross-classified structure. Age is specified as an individual-level determinant of the suicide rate in the fixed part of the model (potentially non-linear) (Level 1). Individuals are nested within both cells of the cross-classified period and cohort (no exact nesting). Thus, the structure treats period and cohort as context in competition in the random part of the model (Level 2). Paraphrasing Yang et Land (2006) and using RCS as an illustration, a level-1 or "within-cell" model takes the following form:

$$S_{ijk} = \beta_{0jk} + \beta_1 Age_{ijk}$$
$$+\beta_2 RCS_{ijk} + \sum \beta_m * X_{mijk} + e_{ijk}$$

[11] Leenaars, A.A.and D. Lester. 1996. "Testing the cohort size hypothesis of suicide and homicide rates in Canada and the United States." *Archives of Suicide Research* 2(1):43-54.

[12] Available upon request to the author.

[13] National total fertility rate is not included in the assessment of the Easterlin and Preston theories due to its association with the demographic cycle captured by the RCS.

[14] Exact collinearity: A=P-C; C=P-A; and P=C-A.

[15] Typically one (single identification) or more (over-identification) parameters are constrained to be equal.

[16] Not to be confused with the same author's "Intrinsic Estimator", which is based on the conventional linear model (CGL) and does not allow for the inclusion of covariates (exogenous independent variables) in the regression. IE was also applied to a study of suicide in Canada by Thibodeau, L. 2015c. "Suicide Mortality in Canada and Quebec, 1926-2008: an Age-Period-Cohort Analysis." *Canadian Studies in Population* 42(3-4):1-23. and in the United States by Phillips, J.A. 2014. "A Changing Epidemiology of Suicide? The Influence of Baby Boomers on Suicide Rates in the United States." *Social Science & Medicine* 114:151-160.

A level-2 or "between-cell" model takes the form:

$$\beta_{0jk} = \gamma_0 + u_{0j} + v_{0k}$$

and a combined model the form:

$$S_{ijk} = \gamma_0 + \beta_1 Age_{ijk} + \beta_2 RCS_{ijk}$$
$$+ u_{oj} + v_{0k} + e_{ijk}$$

where *i* refers to individuals within cohort *j* and period *k;*
j = 17 birth cohorts*;*
k = 17 time periods (five years[17]);

where *i* refers to individuals within birth cohort *j* and year *k*; *X* to the *m* control variable, and *e* to a normally distributed error with a mean of zero and variance of σ^2. Level-2 γ is the model intercept or grand-mean outcome; u_{oj} is the residual random effect of cohort j on β_{0ik} averaged over all periods (assumed normally distributed with mean 0 and variance τ_u); and v_{0k} is the residual random effect of period *k* on β_{0ik} averaged over all cohorts (assumed normally distributed with mean 0 all over variance τ_v). The slope coefficients β_0 through β_m are treated as fixed.

The analysis was undertaken in four steps. The first step (Model 1), used to test our first hypothesis, is a cross-classified version of the HAPC random-effects model that has RCS, age and gender as drivers of the suicide rate in Canada. The second step (Models 2 and 3), used to test Hypothesis 2, examined whether modeling by gender revealed significant differences in the impact of relative cohort size on suicide mortality. The third step (Model 4) tested whether controlling for region (the province of Quebec or the rest of Canada) influenced suicide mortality coefficients (test of Hypothesis 3). Finally, our fourth step (Models 5, 6, 7 and 8) evaluated the effect of RCS on suicide mortality in each *region* (Quebec and rest of Canada) by gender to test our last hypothesis (4). All models for this study were estimated using StataSE 10.1 xtmixed programs.

3. RESULTS

Table 2 reports empirical estimates to test our hypotheses regarding the impact of relative cohort size on suicide mortality in Canada using the HAPC-CCREM. Model 1 estimates the general relationships between the level-1 independent variables, age, gender, and RCS, and suicide mortality. It shows a significant positive effect of RCS (0.394), meaning that as cohort size increases, the suicide rate in Canada increases. The estimates for random effects in terms of the residual components at level 2 indicate significant positive period and cohort effects when controlling for the age effect. Thus, the suicide rate varies significantly by time period and birth cohort in Canada, independent of the age effect. The results of Model 1 also show that males commit suicide at a substantially and highly significantly higher rate

[17] The last period, 2006-2008, is 3 years long.

compared to females (13.402). The results of Models 2 and 3 show that, as expected, the RCS is more significant in Canada for males than for females. Indeed, the estimated coefficient is 0.9 for males but is not significant for females. To test whether significant differences emerged between suicide rates in the province of Quebec and those in the rest of Canada, Model 4 used a *region* regressor. After adjusting for time period and birth-cohort variations, the suicide rate increases by 2.221 in Quebec compared to the rest of Canada (2.221, CI= [1.117, 3.325]). Therefore, it is important to estimate the effect of RCS stratified by gender and region.

Table 2
HAPC-CCREM model parameter estimates of suicide mortality, Canada

	Canada							
Variables	**Model 1**		**Model 2**		**Model 3**		**Model 4**	
	β	**SE**	**β^{male}**	**SE**	**β^{female}**	**SE**	**β**	**SE**
Fixed Effects								
Constant	-4.674		-0.695		3.794		0.737	
RCS[a]	0.394*	0.216	0.900***	0.326	-0.051	0.138	-0.169	0.201
Age	0.112***	0.020	0.166***	0.027	0.066***	0.014	0.129***	0.022
Gender (Male 1, Female 0)	13.402***	0.538					14.139***	0.453
Region (Quebec 1, rest of Canada 0)							2.221***	0.563
Random Effects								
Period	4.133**		6.580**		1.856**		4.143**	
Cohort	1.682**		5.164		2.359		3.248**	
Residual	4.929		2.240		0.969		5.870	
Goodness-of-fit (BIC)	2142.957		1131.616		857.4767		4509.017	

Note: *p< .10, **p< .05, ***p< 0.01

[a] Total population 15-90+

Table 3 presents the parameter estimates and model fit statistics for each *region* to compare the gender-specific impact of RCS on suicide mortality in the province of Quebec to the same impact in the rest of Canada to test Hypothesis 4 (Models 5 to 8). Beyond the national trends, Model 5 and Model 7 indicate a significant positive impact of RCS: males of relatively large cohorts in Quebec and in the rest of Canada commit suicide at higher rates compared to those of relatively small cohorts. However, the relationship appears to be stronger in Quebec (1.344) than in the rest of Canada (0.788). Examining Models 6 and 8 and focusing on the female suicide rate, the estimated individual-level coefficients for both RCS and age are not significant in Quebec, although, independent of the age effect, the suicide rate for females in the rest of Canada varies by time period (1.987). The Bayesian Information Criterion (BIC) assesses the relative fit of different models. Lower values of BIC indicate better fit, and the female models overall appear to have better fits.

Table 3
HAPC-CCREM model parameter estimates of suicide mortality, Quebec and rest of Canada

Variables	Quebec				Rest of Canada			
	Model 5		Model 6		Model 7		Model 8	
	β^{male}	SE	β^{female}	SE	β^{male}	SE	β^{female}	SE
Fixed Effects								
Constant	-2.170		3.511		-0.462		3.476	
RCS[a]	1.344***	0.431	0.048	0.169	0.788***	0.300	-0.041	0.135
Age	-0.003	0.048	0.034	0.021	0.212***	0.024	0.072***	0.013
Random Effects								
Period	13.179**		2.630**		5.092**		1.987**	
Cohort	6.948		3.049		4.901		2.278	
Residual	3.168		1.248		2.074		0.951	
Goodness-of-fit (BIC)	1243.896		944.446		1107.464		849.307	

Note: *p< .10, **p< .05, ***p< 0.01

[a] Total population 15-90+

4. DISCUSSION

In this paper, we tested four hypotheses to assess the prominent demographic paradigm of Easterlin ([1980] 1987) and the counter-theory of Preston (1984), who both proposed an explanation for the effect of cohort size on suicide mortality. For the GI through the Y generations in Canada, our findings support our hypotheses in a manner that is overall consistent with Easterlin's view. A sensitivity analysis using Easterlin's RCS measure (on the total active population aged 15-64)[18] did not change the direction or strength of our observed associations discussed here, which are based on the total population (15-90+).

4.1 Canada's larger cohort and suicide: encountering Easterlin's theory

The national-level analysis in Model 1 reveals a significant positive relationship: large cohorts commit suicide at higher rates than small cohorts (Hypothesis 1 is supported). Furthermore, we explored the effect of cohort size on suicide mortality by gender, as previous literature has consistently shown a higher suicide rate for males and life experiences and expectations differ by sex. As expected, Models 2 and 3 show a significantly greater effect of cohort size on suicide for males than for females in Canada (Hypothesis 2 is supported). In fact, our results indicating a stronger and more positive cohort size effect for males than for females concur with prior studies (Leenaars and Lester 1996; Pampel 2001; Stockard and O'Brien 2006). The theories of Easterlin and Preston tested in this study are founded on the density of the cohort and the available labor market earnings and the size of the labor force and do not distinguish between genders. It has been proposed in previous analyses that "males might be more likely than females to be negatively affected by larger cohort sizes because of their historically greater involvement with the labor market" (Pampel 2001), and women generally show stronger social integration than men as a result of role differences between the sexes, affording women greater protection from suicidal impulses (Krull and Trovato 1994; Travis 1990). Our finding of a greater cohort size effect for males in Canada is related to the large birth cohorts of the baby boomers, individuals born after World War II through the mid-1960s. These cohorts are particularly large compared to previous and subsequent cohorts, and individuals in these

18 Tables available upon request to the author.

cohorts came of age during substantial changes and shared enduring characteristic behaviors. As mentioned previously, many studies reported that males of this generation commit suicide at higher rates; our work goes a step further by indicating that the demographic size of these cohorts played a detrimental role.

How can we make sense of this? Our results in Canada correspond to Easterlin's theory that cohort size crucially shapes personal welfare: "for those fortunate enough to be members of a small generation, life is - as a general matter - disproportionately good; the opposite is true for those who are members of a large generation" (Easterlin 1987 [1980]:3-4). Large cohorts face competition for increasingly limited resources and deprivation that may persist throughout their lives. Scarcity includes a shortage of teachers and schools when large cohorts are young, labor-market competition and unemployment in early adulthood, low pay and slow promotion during adulthood, and finally insufficient health care and meager public retirement benefits in old age (Easterlin 1987 [1980]). In each life stage, large cohorts endure the lasting negative consequences of their demographic. Consequences of scarce resources and deprivation include social disruption and psychological stress due to low relative incomes, as well as difficulties achieving personal or professional goals. Suicide is a response to these difficulties among males (Easterlin 1987 [1980]:106). Hence, according to Easterlin, the suicide rate would vary with stress levels in association with generation size; smaller cohorts experience greater economic success, more stable lives and more satisfying family dynamics, and thus lower rates of suicide. The author has supported this theory in previous work (Keyfitz 1972; Ryder 1965:845), which suggested implications for educational, labor-market and bureaucratic structures.

Furthermore, Easterlin anticipated that the large cohort of the baby boomers would face *social deteriorations,* including increasing likelihoods of late marriage, low fertility, illegitimacy, and divorce. These patterns were observed in Canada and were linked to this generation's increased risk of suicide. Upon reaching working age, the baby boomers encountered a societal transformation resulting from modernization. Consistent with Easterlin's theory, the female presence in the labor force increased in the early 1960s (Rosin 2012; Sangster 2010; Statistics Canada 2012c), leading to new competition between male and female baby boomers, notably for education and for jobs. Females took advantage of their opportunities, and gender relationships were redefined. Of interest in the context of an APC analysis, our study found significant period effects for females at the national and provincial levels. These results agree with a prior analysis by Thibodeau (2015c); thus, the interpretations suggested are in keeping with the Durkheim theory and *amonie* arising from modernization.

In around the same period, the influence of religion was greatly reduced and secularization increased. Subsequently, a progressive lifestyle and new family structures emerged (Kempeneers 1992)[19], and views on marriage changed to regard the practice as more disposable, with a general decreasing aspiration to marry. As Easterlin anticipated, baby boomers experienced late marriage (Duchesne et al. 1999:10; Le Bourdais and Marcil-Gratton 1996:415; Ram 1990:80), and the increasing prevalence of non-marital-births was associated with a higher suicide rate (Pampel 2001; Stockard and O'Brien 2002d, 2006). The fertility rate declined below the replacement level of approximately 2.1 children per woman (Statistics Canada 2008), weakening the protection that fertility offers against suicide. Indeed, male suicide is negatively correlated with female fertility (Easterlin 1987 [1980]:105; 1975), and Durkheim demonstrated lower suicide rates when children were present in families in the 19th century; the number of children also mattered (Durkheim 1951 [1897]:193). Finally, considerable evidence in the literature indicates that suicide rates vary directly with the incidence of marital dissolution (Leenaars, Yang and Lester 1993:919; Stack 2000; Trovato 1986, 1987:201, 1988, 1992) and large cohort and the large cohorts of the baby boomers were the first cohorts to divorce and remarry in large numbers during their young adulthood.

19 Alongside the traditional nuclear family unit, it became more common to encounter single parent families, reconstituted /blended /step families, two parents of the same sex, childless families, grandparent families, etc.

Moreover, a recent study showed that the pattern persists throughout life, as these cohorts continued to experience increased divorce rates between 1990 and 2010, a phenomenon known as the *gray divorce revolution* (Brown and Lin 2012:3). A detrimental cohort size effect was observed in Canada.

4.2 Beyond a national assessment: distinctive traits in Quebec

As many studies (Langlois and Morrison 2002:14; Sakinofsky et al. 1975; Sakinofsky and Webster 2010:357) have indicated, suicide rates are not evenly distributed throughout the nation, and Model 4 revealed the hypothesized statistically significant effect of the region on suicide mortality over the years covered by our study. The suicide rate in Quebec is 2.221 times greater than that in the rest of Canada (Hypothesis 3 is supported). Therefore, national-level findings suggest the need for a refined investigation in Quebec and the rest of Canada, considering gender. The most notable feature of the results of Models 5 to 8 is the different levels of the effect of RCS on the suicide mortality rate. Males of relatively large cohorts in *la belle province*, as expected, commit suicide at higher rates than those in the rest of Canada (Hypothesis 4 confirmed). The RCS effect on male suicide rates is stronger in Quebec (1.344) than in the rest of Canada (0.788). Our analysis also uncovered a greater period effect for males in the province of Quebec (coefficient of 13.179) compared to the rest of Canada (coefficient of 5.082), in agreement with work by Thibodeau (2015c) that specified a 25-year distinctive effect in the past French colonies[20]. Therefore, we suggest that cohort size and period effects might not be mutually exclusive; rather, we suggest reviving the theory of Ryder (1965:845) regarding the importance of cohort membership and events experienced within the same time interval. Indeed, baby boomers form a large demographic contingent and grew up during a highly unstable period. While adverse conditions occurred throughout Canada, Quebec was especially badly disrupted. Social and cultural norms changed profoundly and rapidly at the beginning of the 1960s in what is known as the Quiet Revolution, or *La révolution tranquille*. As a consequence of the Duplessis' regime of *retour à la terre* for 20 years, the province was notably behind the rest of Canada in terms of modernization (Krull and Trovato 1994:1124). This revolution is notable for the severe decline of the Catholic Church and clergy, increased secularization, the transition from an agricultural to an industrialized society and the drastic change in gender roles. The changes of the 1960s resulted in increased suicide rates in Quebec, as suggested by our results and those of previous analyses (Krull and Trovato 1994; Mao et al. 1990:324; Sakinofsky and Webster 2010:358; Thibodeau 2015c). Our results and previous literature seem to indicate a net male cohort effect in Quebec and, to a lesser extent, in the rest of Canada, which appears to be related to the period effect size of their demographic (cohort).

4.4 Limitations

Possible limitations of this research relate to the methodological approach. The identification problem leads to severe criticisms of the use of APC models, and the HAPC-CCREM is no exception. Recent work by Bell and Jones (2014) noted some concerns, mainly regarding the application of the technique, because the assumptions made must be appropriate for the project at hand (Bell and Jones 2014:352). Other APC methodologies can be applied to investigate effects of cohort size on suicide mortality. Additionally, dummy variables could not be used for all of the time periods (or in a set of terms) because the number of observations was insufficient. Further research to estimate random effects for cohort and RCS impacts in specific age groups and time periods in Canada is desirable. Methodological limitations also prevented us from using standardized rates because suicide rates by age groups are required for APC modeling. Secondly, direct measurement of some characteristics of the large cohorts that are believed to be detrimental could not be integrated into the analysis. Like many other countries, Canada lacks data on Durkheim's elements of social integration measured by five-year age groups for each group for lengthy

[20] "The rest of Canada showed a decrease in the net period effect at the beginning of the 1970s, while rates in Quebec continued to increase until 1981-1985 and thereafter oscillated until the end of the century (1996-2000), when they began to decrease".

periods, such as marital status, number of children, education, etc. The economic indicators that are generally available for long historical periods raised two concerns: i) data on the unemployment rate and GDP per capita (by sex and age) are not currently available from 1926 in Quebec and the rest of Canada; and ii) most fundamentally, numerous economic indicators have long-term impacts (pending, leading, coincidental or lagging), with effects on suicide that can persist (lag) up to 5 years (Brenner 1976; Thibodeau 2015a). This effect was found in the relationship between unemployment rates and suicide in Canada (Statistics Canada and Adams 1981; Thibodeau 2015a). Incorporation of an appropriate time lag (a single value for each cohort) is beyond the scope of this study; similar limitations were encountered in other works (Pampel 1996, 2001; Trovato 1988:39). Finally, patterns may not be homogenous throughout the rest of Canada. Therefore, an investigation of the effect of relative cohort size in other provinces could provide valuable data.

5. CONCLUSION

In summary, our findings indicate a significant impact of cohort size on suicide mortality in Canada and support Easterlin's theory that large cohorts commit suicide at higher rates than relatively small cohorts. This relationship is specific to males in Quebec and in the rest of Canada because no cohort size effect was observed for females. Additionally, although a significant positive cohort size effect was observed for males in Quebec and the rest of Canada, the effect in *la belle province* was significantly stronger. We conclude that the cohort size effect goes beyond temporal variability in fertility and powerfully influences individuals' life experiences and social integration. Our results offer insight into the very high suicide rates among baby boomers. However, it is possible, as Easterlin suggested (1987 [1980]:110-111), that baby boomers' high suicide rates were an exception attributable to unique historical and demographic conjunctions. Still, close monitoring of the situation is essential as the baby boomers enter their senior years in large numbers, as seniors are vulnerable to suicide[21]. A *Being and Time*, published almost a century ago, made a point relevant to this case: "the inescapable fate of living in and with one's generation completes the full drama of individual human existence" (Heidegger 1962 [1927]).

[21] Durkheim's Durkheim, É. 1951 [1897]. *Suicide, a study in sociology*. Glencoe, Illinois: The Free Press. Theory of the increases of suicide rates with age to reach its highest point at old age.

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