TITRE:

Public and Private Pharmaceutical Spending as Determinants of Health Outcomes in Canada

NOMS DES AUTEURS ET AFFILIATIONS:

Auteur	Affiliation #1	Affiliation #2
Pierre-Yves Crémieux, Ph.D.	Analysis Group, Boston, U.S.A. and Montreal, Canada	Dept. of Economics, Université du Québec à Montréal, Montréal, Canada
Marie-Claude Meilleur, M.A.	Analysis Group, Boston, U.S.A. and Montreal, Canada	
Pierre Ouellette, Ph.D.	Dept. of Economics, Université du Québec à Montréal, Montréal, Canada	
Patrick Petit, M.Sc.	Analysis Group, Boston, U.S.A. and Montreal, Canada	
Martin Zelder, Ph.D.	Analysis Group, Boston, U.S.A. and Montreal, Canada	
Ken Potvin, M.Sc.	Rx&D, Ottawa, Canada	

COORDONNÉES DU PRÉSENTATEUR:

Pierre-Yves Crémieux, Analysis Group, 111 Huntington Avenue, Tenth Floor, Boston, MA 02199, Tel: 617-425-8135 Fax: 617-425-8001. Email: pcremieux@analysisgroup.com

RÉSUMÉ ET TEXTE:

Voir ci-bas.

DISPONIBILITÉ:

M. Crémieux n'est pas disponible pour agir à titre de président de session ou de commentateur.

CHAMPS D'EXPERTISE DE M. CRÉMIEUX:

Économie de la santé, économie du travail, pharmacoéconomie.

PUBLIC AND PRIVATE PHARMACEUTICAL SPENDING AS DETERMINANTS OF HEALTH OUTCOMES IN CANADA[+]

by

Pierre-Yves Crémieux, Ph.D.,[1,2] Marie-Claude Meilleur, M.A.,[1] Pierre Ouellette, Ph.D.,[2] Patrick Petit, M.Sc.,[1] Martin Zelder, Ph.D.,[1] Ken Potvin, M.Sc.[3]

[1] Analysis Group / Economics, Boston, U.S.A. and Montreal, Canada
[2] Dept. of Economics, Université du Québec à Montréal, Montréal, Canada
[3] Rx&D, Ottawa, Canada

Corresponding author:

Pierre-Yves Crémieux, Analysis Group / Economics, 111 Huntington Avenue, Tenth Floor, Boston, MA 02199, Tel: 617-425-8135 Fax: 617-425-8001. Email: pcremieux@analysisgroup.com

First submitted: December 2002
Revised: November 2003

+ We would like to thank the following individuals for their invaluable comments on various parts of this manuscript: Jim Adams (Hoffmann-La Roche Limited, Mississauga, Canada), Ed Wang (Wyeth-Ayerst Canada Inc., Markham, Canada), Michael Ford (Wyeth-Ayerst Canada Inc., Markham, Canada), Jean-Pierre Grégoire (Merck Frosst Canada Ltd., Kirkland, Canada), Christopher J. Longo (Eli Lilly Canada Inc., Scarborough, Canada), Ashish Pradhan (Bristol-Myers Squibb Pharmaceutical Group, St.-Laurent, Canada), as well as all other members of Rx&D's Health Economics Working Group. This project was funded by Rx&D, Canada's Research-Based Pharmaceutical Companies.

ABSTRACT

Canadian per capita drug expenditures increased markedly in recent years and have become center stage in the debate on health care cost containment. To inform public policy, these costs must be compared with the benefits provided by these drugs. This paper measures the statistical relationship between drug spending in Canadian provinces and overall health outcomes. The analysis relies on more homogenous data and includes a more complete set of controls for confounding factors than previous studies. Results show a strong statistical relationship between drug spending and health outcomes, especially for infant mortality and life expectancy at 65. This relationship is almost always stronger for private drug spending than for public drug spending. The analysis further indicates that substantially better health outcomes are observed in provinces where higher drug spending occurs. Simulations show that if all provinces increased per capita drug spending to the levels observed in the two provinces with the highest spending level, an average of 584 fewer infant deaths per year and over six months of increased life expectancy at birth would result.

Keywords: Health; Drugs; Infant Mortality; Life Expectancy; Canada.

JEL Classification: I10, I12, I18, H51.

INTRODUCTION

Driven by technological innovation [1] increased expectations, and an aging population, Canadian per capita drug expenditures increased markedly in the early 1990s. This increase occurred despite cost containment efforts and the rehabilitation of public finances over the same period. The sustained growth of pharmaceutical spending in the face of such a pervasive cost-control effort is puzzling to many, and pharmaceuticals have become center stage in the debate on health care cost containment.

Reasons for increased pharmaceutical costs have been extensively discussed in the literature [2]. Central to this discussion in Canada has been the "cost driver" analysis project conducted by the Patented Medicine Prices Review Board for the Federal/Provincial/Territorial Working Group on Drug Prices. The Working Group found that changes in utilization and the availability of newer therapies were the major cost drivers, and that price changes (at the individual drug level) did not play a significant role in driving expenditures [3]. This growth in pharmaceutical product utilization may be the result of a more outpatient-focused strategy for containing costs, since it is increasingly possible to substitute innovative pharmaceutical therapies for more standard types of health care, such as surgery (e.g., for stomach ulcers, or for prostate cancer) or care from specialists (e.g., selective serotonin reuptake inhibitors prescribed by family practitioners for depressed patients instead of tricyclic antidepressants prescribed by psychiatrists).

In the public policy debate on the surge in pharmaceutical costs, a focus on both costs and benefits is necessary. Pharmaceuticals increase life expectancy (e.g., leukemia, lymphoma and HIV/AIDS) and increase quality of life (e.g., depression, pain, and anemia). Consequently, a decrease in the level or quality of pharmaceutical products available may have negative consequences on patients. Furthermore, costs may increase elsewhere in the health care system if more expensive non-pharmaceutical treatments are substituted for drug treatments. Hence, while the well-studied cost of pharmaceutical products is worthy of concern, determining the level of benefits resulting from the use of pharmaceutical products is also central to guiding policy decisions.

This study measures the health outcomes benefits of pharmaceutical use. It relies on standard measures, infant mortality and life expectancies at birth and at age 65, as proxies for overall health. Since improved quality of life and substitution away from other forms of health care may result from the use of pharmaceuticals, but are not considered in this analysis, this study may understate the true benefit derived from pharmaceutical use. However, it provides a useful lower bound on the effect of pharmaceuticals on health outcomes.

DATA

The data were available from Statistics Canada and the Canadian Institute for Health Information (CIHI). Analyses were conducted separately for males and females. Table 1 presents definitions and sources for the variables used in the analysis. While spending data are available for the period 1975-2000, complete provincial data are not available for the health outcomes measures used for 1999 or 2000. The analysis begins in 1981 because values for some of the explanatory variables were not consistently collected at the provincial level prior to that date. Finally, no data were available prior to 1986 for life expectancy at age 65.

[Table 1]

The use of Canadian data ensures uniformity in data definition and collection and in the (unmeasured) characteristics of the studied population, providing advantages over previous studies that relied on cross-country data [4] [5] [6] [7]. This alleviates concerns regarding the danger of such international comparisons, given inter-country differences in methodology and data-gathering [8]. In addition, the use of a single monetary unit eliminates the delicate question of international monetary equivalency [9]. Yet, Canadian regional differences are strong enough to allow for a critical examination of the relationship between spending and health outcomes, and in this respect measured variations fully reflect underlying differences among regions.

For the purpose of this analysis, Canada is divided into five regions: the Atlantic Provinces, Québec, Ontario, the Prairies, and British Columbia. Besides reflecting geography, this categorization also captures differences in population patterns.

Indicators of health outcomes are infant mortality and life expectancy at birth and at 65. These are commonly used proxies because of their central significance as well as the regularity and care with which such data are collected [10] [11] [12]. Although less often reported than life expectancy at birth and only available since 1986, life expectancy at age 65 is particularly interesting in the context of this research since it is an outcome measure purged of infant mortality and most accidental deaths. In addition, individuals 65 and over are by far the main users of health care [13] and drugs [14] and their life expectancy may thus better reflect the health care system's ability to extend life.

Determinants of health outcomes include non-drug healthcare spending, pharmaceutical spending, economic variables, social and demographic variables, lifestyle variables, and nutritional variables. Increases in non-drug health spending are expected to improve health outcomes. These are categorized as spending on hospitals, physicians, institutions other than hospitals, professionals other than physicians, or capital, and are consistent with other measures used in the literature [5] [11] [10] [15] [16] [17]. In

Canada these are primarily financed through Canada's public health insurance system with the exception of practitioners other than physicians.

As discussed earlier, drug spending also may positively affect health outcomes. In contrast to other major categories of health care (besides "other professionals"), private drug spending constitutes a substantial share of total drug spending. At the national level, prescription drugs represent more than 75 percent of total drug spending [18]. Three qualifications should be noted, however. First, drug spending figures do not fully reflect actual spending on prescription drugs because they do not include the cost of drugs dispensed in hospitals, which is included in "hospital" spending. Second, because measured "drug" spending also includes pharmacy markups and professional fees as well as "personal health products," it overstates actual retail drug spending. Finally, the data do not permit further disaggregation of drug spending according to type of drug (e.g., antidepressant, anti-ulcer, etc.).

Per capita income may affect health outcomes through greater tax revenues available to provincial governments. Direct income may also help satisfy basic needs such as shelter, food, or clothing, and the private purchase of other products and services intended to maintain health and not included in health spending measures (e.g., exercise equipment or activities). Poverty rates may add a nonlinear effect on health that may manifest itself most strongly in differences in life expectancy. Since prenatal care is provided in large part

free of charge, poverty may have a differential impact across provinces because of differences in social programs and health coverage.

Lower population density may increase the cost of providing care to citizens, as spending translates into lower accessibility and fewer health care procedures in a less dense population. At the same time, the increased stress, pollution, exposure to communicable infectious diseases, accidents, and criminality associated with higher density can negatively influence health outcomes. Thus, the final impact of population density on health outcomes is an empirical question. Different types of density indicators are used in the literature: population per square mile [16], urbanization level [l5] [17] [19] and the percentage of population in cities of more than 100,000 [20]. Following common practice [10] density of population will be expressed as population per square kilometer of total provincial territory.

Excessive tobacco and alcohol consumption have documented harmful effects on health outcomes. Tobacco consumption is associated with various forms of cancer, as well as cardiovascular and respiratory diseases. Maternal tobacco consumption is linked to increased risks of miscarriage, birth complications [21], low birth weight babies [22], Sudden Infant Death Syndrome [23], and slower fetal growth [22]. Excessive alcohol consumption can damage the liver, and lead to cardiovascular disease, fetal injury, and to life-threatening injuries such as road accidents. With regard to infant mortality, the most relevant alcohol and tobacco consumption measure would be, of course, that

of the mother during pregnancy. Hence, the infant mortality regressions contain a variable measuring female tobacco spending, but omit the alcohol-spending variable, which is not available separately for males and females. While the health impacts of tobacco and alcohol on life expectancy may lag actual consumption, lagged alcohol and tobacco consumption values were not used in the analysis because of limited time-series.

Nutritional spending can have mixed effects on health outcomes, depending on the type of spending that occurs. Expenses on food and beverages with health-enhancing properties can be inputs to better health, but excessive food consumption, especially of fatty foods, can lead to obesity and cardiovascular diseases. Hence, the impact of nutritional spending on health outcomes is unclear.

Most explanatory factors used in this study are proxies based on spending measures and not the true underlying factors. For example, drug expenditures are only a broad measure of drug use in the population and provide no information on the quality or accessibility of drugs. In addition, interpreting the impact of other factors such as population density demands great care in the Canadian context, since most of the population is highly concentrated in the southern part of the country.

METHOD AND ESTIMATION

This research follows a two-step methodology. First, regression models describe the effect of non-drug health care spending and drug spending on six health outcomes—male and female infant mortality rates, male and female life expectancies at birth, and male and female life expectancies at age 65. These cross-sectional time-series linear models are estimated using Stata's feasible generalized least squares for panel data with correction for AR(1) autocorrelation of the error term within panels and for heteroskedasticity across panel. Provinces are equally weighted [7] [10]. As shown by Hamilton (1994), this model is asymptotically equivalent to a regression in difference, and therefore addresses the possible issues of unit root and spurious regression result typical of time series [24].

The models include privately funded pharmaceutical spending, publicly funded pharmaceutical spending, total (private and public) non-drug health care spending, and GDP per capita (all economic variables are expressed as per capita 1998 dollars). Social and demographic variables include the poverty rate and population density, lifestyle variables include per capita deflated alcohol expenditures and gender-specific tobacco product expenditures, and nutrition is captured by per capita deflated expenditures on food and nonalcoholic beverages (combined). All variables are transformed into natural logarithms. Regional variables capture otherwise unmeasured genetic and geographic influences on health. Since data on alcohol

consumption during pregnancy or gender-specific alcohol consumption measures were unavailable, total alcohol spending was omitted from infant mortality analyses. Gender-specific tobacco consumption was included in the appropriate life expectancy analysis and only female tobacco consumption was included in gender-specific infant mortality regressions.

Second, the simulated effect of alternative drug spending levels was derived based on the regression results. Specifically, the effect on health outcomes of maintaining per capita drug spending at the base-year level, at low level and or at high level were compared to observed health outcomes. "Base-year" per capita drug spending simulations are constructed by maintaining spending at its original (1981 or 1986) level. "Low-level" per capita drug spending is constructed by maintaining all provincial spending at the average of the two provinces with the lowest spending in each year. The "high-level" per capita drug spending is constructed in the same way, with the average per capita spending of the two highest spending provinces, for each year. In all cases, variables other than drug spending remain at their observed levels, and simulated health outcomes are estimated by using regression coefficients and the "base year," "low level," or "high level" drug spending. For each health outcome, the three simulated values (base-year, low-level, and high-level) are compared with the predicted health outcome i.e., the predicted values generated by the regression equations.

RESULTS

The Evolution of Drug Spending and Health Outcomes

Pharmaceutical spending is the second largest category of health care expenditures in Canada, and its share of overall health care costs rose from 8.8 percent in 1975 to 15.0 percent in 2000. It now represents $450 per capita, up from $152 in 1975 (in 1998 constant dollars). Factors influencing this trend include the ongoing introduction of new innovative medicines, shifts in demography (the age and gender distribution of the population), the growing prevalence of certain health conditions (e.g., cardiovascular diseases, respiratory illnesses, HIV/AIDS), consumer awareness, changes in health care professionals' prescribing practices, and to a lesser extent, price [3].

Coincident with observed growth in both health care and pharmaceutical spending, infant mortality receded by 2.7 percent annually for males and by 2.6 percent annually for females between 1975 and 1998 (Table 2). During the same period, life expectancy at birth grew by 0.4 percent (3.2 months) per year for males and by 0.2 percent (2.2 months) per year for females (Table 3). From 1986 to 1998, Canada's male and female life expectancies at 65 increased from 14.7 to 16.3 years and from 19.2 to 20.1 years, respectively (Table 4), with an average growth of 1.6 months per year for males and by almost one month per year for females.

[Table 2]

[Table 3]

[Table 4]

Regression Analysis

The regression results confirm the significance of overall health spending and pharmaceutical spending, as well as lifestyle and nutritional variables, as factors that enhance health outcomes (Table 5). Overall, the estimated models have high explanatory power, with R-squared values in five of the six regressions reaching 0.9 or better.

[Table 5]

The coefficients (except for the ones on the provincial/regional dummies) indicate the percentage impact on each health outcome of a one-percent increase in the corresponding explanatory variable. Sociodemographic variables have a limited impact on health outcomes. This stands in contrast with the US, where poverty has a negative impact on infant survival rates [11].

Lifestyle variables, often omitted from previous studies, have significant (and predictable) effects on health outcomes. The effect of female tobacco consumption on infant mortality is dramatic, while the effect on life expectancy remains strong, but smaller. Per capita alcohol spending is also negatively associated with both male and female life expectancies. Spending on food and nonalcoholic beverages has mixed effects on health; increases in

food/ beverage consumption may enhance (lower male infant mortality, higher male life expectancy at birth) or harm health (lower male life expectancy at 65, lower female life expectancies at birth and at 65). The opposite result found for different populations may be the result of the pattern of consumption rather than its level.

Increased per capita GDP is associated with increased life expectancy for both males and females, a finding compatible with the established relationship between increased wealth and longer life [25], [26]. However, an analogous health-enhancing effect of income is not found for infant mortality. Again, lifelong habits that affect life expectancy are more likely to be affected by poverty than infant mortality particularly in a rather rich country with universal health care.

Increases in both privately and publicly funded pharmaceutical expenses are significantly associated with decreases in infant mortalities and with increases in life expectancies. Except in the case of female life expectancy at birth, private drug spending has a greater estimated impact on health than publicly-funded drug spending does. These results for pharmaceutical expenses are robust to various specifications that included or excluded various cofactors, such as poverty rate, GDP per capita, population density, alcohol intake, etc. Finally, increases in non-drug health care spending are associated with statistically significant decreases in male infant mortality and increases in male life expectancy at birth, but effects on female health outcomes are

statistically insignificant, and higher non-drug spending is associated with *lower* male life expectancy at age 65. The latter result is likely due to reverse causation: greater non-drug spending is incurred on behalf of elderly males who are sicker, and thus have shorter life expectancy. Finally, a comparison of the coefficients for drug and non-drug spending reveals a general pattern: while non-drug spending has a larger effect than drug spending on infant mortality, drug spending generally has a larger impact on life expectancy than does non-drug spending.

Since lifetime health habits influence present-day health outcomes, further analyses were undertaken, replacing current explanatory factors with their lagged values. However, given limited data-availability, statistically sound conclusions could not be drawn from these analyses, despite the overwhelming majority of coefficients keeping the same sign.

Despite these differences between the impact of drug spending on various health outcomes, the principal finding of this analysis - that higher drug spending in Canada over the period 1981-1998 was associated with significant improvements in infant mortality rates and life expectancies - illustrates the general importance of drug spending for health outcomes. In addition to drug spending, of course, the analysis indicates that other factors are associated with improved health outcomes.

Selected simulations

Simulation estimates are derived from the statistical estimations underlying Table 5. This analysis indicates that substantial health outcome improvements could result from greater drug spending (Table 6). Were each province to have undertaken drug spending equivalent to the average of the two provinces with the highest expenditures, an average of 584 fewer deaths per year, or up to 10,509 fewer deaths during the first year of life would have been observed since 1981. In addition, life expectancy at birth would have been on average eight months higher every year than what it actually was for males, and five months higher for females. Finally, life expectancy at age 65 would have been on average four months higher every year than what it actually was for males, and one month higher for females (increases in life expectancy are not cumulative). All simulation results are as robust as the underlying coefficients; in the case of drugs, all p-values are at or below the 0.01 level.

While increasing drug expenditures further could result in fewer deaths, the observed increase from 1981 spending levels already has saved over 15,000 lives. These results show in concrete terms that the statistical link between drug spending and improved health outcomes goes beyond mere correlation and that there is a measurable positive relationship between drug spending and health outcomes.

[Table 6]

CONCLUSION

This paper advances the growing body of economic analysis that estimates the health benefits of pharmaceutical and health spending. Corresponding to recent findings regarding the health benefits of higher overall health spending in Canada [10], and the health benefits of higher drug spending in the US [11] and the OECD countries [12], this analysis detects substantial health benefits associated with increased spending on pharmaceuticals in Canada during the period 1981-1998. Specifically, it indicates that improved infant mortality rates and life expectancies for both genders have resulted from increased public and private drug spending.

These results demonstrate that increases in pharmaceutical spending, which have been especially rapid since the early 1990s, have been associated with substantial health benefits and that cost-controlling efforts through restrained drug spending must take these benefits into account. The benefits assessed here do not represent a complete description of how drugs impact the health of the population and the efficiency of the health system. However, they indicate that accurately qualifying these benefits is necessary to insure that pharmaceutical policy decisions do not have unintended negative impacts on health.

Table 1:
Definitions and Sources of the Variables Used in the Analysis

Variable	Definition	Source
Gender-specific infant mortality	Number of deaths of babies in the first year of life per 1,000 live births	Statistics Canada, 2001: *Décès: Tableaux Standards* *Naissances: Tableaux Standards* *Nombre de Décès, Canada et Provinces*, Matrix 0005 *Nombre de Naissances, Canada et Provinces*, Matrix 0004
Gender-specific life expectancy at birth	Average remaining years of life at birth	Statistics Canada, 2001: *Life Expectancies at Birth and at 65, calculations on request*
Gender-specific life expectancy at age 65	Average remaining years of life at age 65	
Public drug spending	Per capita province-specific drug spending from public sources of funding (1998 $)	Canadian Institute for Health Information: *National Health Expenditure Trends, 1975-2001*. Ottawa.
Private drug spending	Per capita province-specific drug spending from private sources of funding (1998 $)	
Non-drug health care spending	Per capita province-specific sum of all private and public spending for physicians, hospitals, professionals other than physicians, institutions other than hospitals, capital, and other health care spending (1998 $)	Statistics Canada, 2001: *Indices des Prix à la Consommation, Mensuels, Classification de 1992, Provinces*, Matrices 7441 to 7452 *Population par Année d'Âge, Groupes d'Âge et le Sexe, Provinces*, Matrices 6368 to 6377
Per capita income	Per capita provincial GDP (1998 $)	Statistics Canada, 2001: *Indices des Prix à la Consommation, Mensuels, Classification de 1992, Provinces,* Matrices 7441 to 7452 *Population par Année d'Âge, Groupes d'Âge et le Sexe, Provinces*, Matrices 6368 to 6377 *Produit Intérieur Brut Provincial*
Population density	Provincial population/square kilometer	Statistics Canada, 2001: *Population par Année d'âge, Groupes d'âge et le Sexe, Provinces*, Matrices 6368 to 6377
Poverty	Percentage of households using more than 54.7% of their pre-tax income on food, housing and clothing	Statistics Canada, 1999: *Aperçu des Statistiques sur la Santé 1999*
Alcoholic beverages spending	Per capita alcoholic beverages spending (1998 $)	Statistics Canada, 2001: *Dépenses Alimentation et Boissons Non-Alcoolisées, Produits du Tabac et Boissons Alcoolisées*, calculations on request *Indices des Prix à la Consommation, Mensuels, Classification de 1992, Provinces*, Matrices 7441 to 7452 *Population par Année d'âge, Groupes d'âge et le Sexe, Provinces*, Matrices 6368 to 6377
Gender-specific tobacco products spending	Per capita spending on tobacco products, for males and females (1998 $)	
Food and nonalcoholic beverages spending	Per capita food and nonalcoholic beverages spending (1998 $)	

Table 2:
Infant Mortality in Canada and Provinces
(deaths per 1,000 live births)

		Canada	NF	PE	NS	NB	QC	ON	MB	SK	AB	BC
Males	1975	**15.21**	18.50	15.02	19.07	19.03	13.27	14.37	16.19	17.74	16.31	15.95
	1980	**11.67**	13.66	16.39	12.96	11.69	10.72	10.68	11.60	12.65	14.03	12.62
	1985	**8.71**	13.88	1.89	8.55	9.40	7.59	8.06	12.31	11.04	8.99	9.22
	1990	**7.53**	11.26	6.89	6.56	7.98	7.03	6.76	8.99	8.81	8.88	8.35
	1995	**6.73**	8.38	3.34	5.16	5.21	6.19	6.42	8.05	10.89	7.75	6.41
	1998	**5.72**	6.93	8.17	3.82	7.63	5.95	5.33	7.50	8.84	5.44	4.55
	Average Annual (%) Change	**-2.7**	-2.7	-2.0	-3.5	-2.6	-2.4	-2.7	-2.3	-2.2	-2.9	-3.1
Females	1975	**12.07**	15.99	23.68	13.11	11.90	10.16	11.21	13.87	17.90	13.41	12.87
	1980	**9.18**	9.90	5.43	8.77	10.08	8.79	8.32	11.41	9.88	11.02	9.34
	1985	**7.15**	9.56	6.31	7.14	9.78	6.89	6.43	7.50	10.99	7.03	6.88
	1990	**6.10**	9.38	4.95	6.02	6.44	5.41	5.74	6.86	6.41	7.16	6.69
	1995	**5.52**	7.31	5.84	4.52	4.34	4.69	5.45	7.20	7.31	6.30	5.52
	1998	**4.84**	5.43	7.79	5.37	5.24	5.25	4.72	5.86	5.37	4.18	3.94
	Average Annual (%) Change	**-2.6**	-2.9	-2.9	-2.6	-2.4	-2.1	-2.5	-2.5	-3.0	-3.0	-3.0

Table 3:
Life Expectancy at Birth in Canada and Provinces
(in years)

		Canada	NF	PE	NS	NB	QC	ON	MB	SK	AB	BC
Males	1975	**70.0**	70.8	70.0	69.4	69.8	69.1	70.5	70.6	71.3	71.0	70.5
	1980	**71.6**	72.0	72.4	70.7	70.9	70.8	72.1	72.3	72.5	71.8	72.5
	1985	**72.8**	72.5	72.8	72.1	72.8	72.1	73.6	73.0	73.6	73.6	74.2
	1990	**73.8**	73.1	73.1	73.5	74.0	73.4	74.9	74.5	74.9	74.8	75.1
	1995	**75.3**	74.4	74.1	74.9	74.2	74.6	75.8	74.8	74.9	75.8	76.2
	1998	**76.1**	74.8	75.0	75.1	74.9	75.3	76.6	75.2	75.6	76.4	77.0
	Average Annual Change (%)	**0.4**	0.2	0.3	0.4	0.3	0.4	0.4	0.3	0.3	0.3	0.4
Females	1975	**77.3**	77.2	77.3	77.3	77.1	76.5	77.7	77.8	78.1	77.9	78.0
	1980	**78.8**	78.1	79.7	78.1	78.6	78.5	78.9	78.8	79.9	78.9	79.9
	1985	**79.6**	79.1	80.6	78.9	80.1	79.7	79.9	80.0	80.2	80.2	80.6
	1990	**80.4**	79.3	80.5	79.9	80.7	80.7	80.9	80.5	81.2	81.2	81.1
	1995	**81.3**	80.6	81.5	80.8	81.5	81.3	81.2	80.5	81.6	81.5	81.9
	1998	**81.5**	80.1	79.9	80.4	81.1	81.3	81.6	80.8	81.6	81.9	82.1
	Average Annual Change (%)	**0.2**	0.2	0.1	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2

Table 4:
Life Expectancy at Age 65 in Canada and Provinces
(in years)

		Canada	NF	PE	NS	NB	QC	ON	MB	SK	AB	BC
Males	1986	**14.7**	14.6	15.3	14.4	14.7	14.2	15.1	15.1	15.9	15.7	16.1
	1990	**15.4**	14.4	15.5	15.1	15.5	15.0	15.8	15.8	16.4	16.2	16.6
	1995	**16.2**	15.1	15.4	15.3	15.6	15.7	16.2	15.9	16.7	16.7	17.2
	1998	**16.3**	14.7	15.6	15.6	15.2	15.6	16.4	16.0	16.5	16.7	17.4
	Average Annual Change (%)	**0.9**	0.1	0.2	0.7	0.3	0.8	0.7	0.5	0.3	0.5	0.7
Females	1986	**19.2**	18.3	19.5	18.9	19.3	18.9	19.1	19.7	20.3	19.6	20.2
	1990	**19.6**	18.4	19.4	19.2	19.9	19.8	19.8	20.0	20.5	20.4	20.2
	1995	**20.1**	19.3	20.4	19.8	20.1	20.0	19.9	20.0	21.0	20.3	20.6
	1998	**20.1**	18.8	19.2	19.4	19.8	20.0	20.0	20.0	20.7	20.6	20.6
	Average Annual Change (%)	**0.4**	0.2	-0.1	0.2	0.2	0.5	0.4	0.1	0.2	0.4	0.2

Table 5:
Results of the Regression Analysis (Variables in Logarithms)
(p-values are in brackets and statistically significant variables appear in bold)

Variable	Male Infant Mortality	Female Infant Mortality	Male Life Expectancy at Birth	Female Life Expectancy at Birth	Male Life Expectancy at 65	Female Life Expectancy at 65
Sample Size (Degrees of Freedom)	180 (167)	180 (167)	180 (166)	180 (166)	130 (116)	130 (116)
R-Squared	.90	.75	.93	.90	.98	.93
Constant	**16.989 (<0.01)**	4.735 (0.10)	**3.877 (<0.01)**	**4.520 (<0.01)**	**4.456 (<0.01)**	**6.157 (<0.01)**
Sociodemographic Variables:						
•Poverty Rate	-0.035 (0.52)	0.028 (0.74)	-0.001 (0.60)	-0.004 (0.05)	0.010 (0.12)	-0.003 (0.57)
•Density	**-0.084 (0.01)**	**-0.107 (<0.01)**	-0.001 (0.47)	0.001 (0.10)	0.003 (0.48)	**0.008 (<0.01)**
Lifestyle Variables:						
•Spending on Tobacco Products, Males	-	-	**-0.008 (<0.01)**	-	**-0.034 (<0.01)**	-
•Spending on Tobacco Products, Females	**0.156 (0.01)**	**0.160 (0.04)**	-	**-0.005 (0.03)**	-	-0.002 (0.57)
•Spending on Alcoholic Beverages	-	-	**-0.022 (<0.01)**	**-0.017 (<0.01)**	**-0.045 (0.01)**	**-0.086 (<0.01)**
Nutritional Variables:						
•Spending on Food and Nonalcoholic Beverages	**-1.617 (<0.01)**	-0.038 (0.93)	**0.029 (<0.01)**	**-0.022 (0.03)**	**-0.301 (<0.01)**	**-0.415 (<0.01)**
Health and Economic Variables:						
•Public Drug Spending per Capita	**-0.108 (<0.01)**	**-0.143 (0.01)**	**0.011 (<0.01)**	**0.009 (<0.01)**	**0.029 (<0.01)**	**0.012 (<0.01)**
•Private Drug Spending per Capita	**-0.169 (<0.01)**	**-0.161 (0.01)**	**0.015 (<0.01)**	**0.006 (<0.01)**	**0.054 (<0.01)**	**0.018 (<0.01)**
•Total Non-Drug Health Care Spending per Capita	**-0.510 (<0.01)**	-0.250 (0.13)	**0.017 (0.01)**	0.001 (0.89)	**-0.051 (<0.01)**	-0.012 (0.32)
•GDP per Capita	0.128 (0.25)	-0.024 (0.89)	**0.013 (0.02)**	**0.009 (0.04)**	**0.084 (<0.01)**	**0.030 (<0.01)**
Regional Variables*:						
•Atlantic Provinces	-0.041 (0.53)	**0.173 (0.03)**	**0.010 (<0.01)**	**-0.006 (<0.01)**	**-0.016 (0.04)**	**-0.058 (<0.01)**
•Ontario	-0.064 (0.27)	**0.188 (0.02)**	**0.015 (<0.01)**	**-0.006 (<0.01)**	-0.007 (0.46)	**-0.055 (<0.01)**
•Prairies	**0.141 (<0.01)**	**0.146 (0.03)**	**0.011 (<0.01)**	0.002 (0.23)	**0.060 (<0.01)**	**0.016 (<0.01)**
•British Columbia	**0.181 (<0.01)**	**0.142 (0.01)**	**0.019 (<0.01)**	**0.010 (<0.01)**	**0.116 (<0.01)**	**0.053 (<0.01)**

* Quebec is the reference province.

Table 6:
Estimated Lives Saved/Months of Life Gained From Actual Pharmaceutical Spending, Compared to Hypothetical Alternative Spending Levels (1981 - 1998)*

Health Outcomes	Gender	Base-year Drug Spending	Low-level Drug Spending	High-level Drug Spending
Lives Saved*	Male	449	311	-326
		(8,087)	(5,595)	(-5,871)
	Female	404	277	-258
		(7,280)	(4,989)	(-4,638)
Life Expectancy at Birth (Months of life gained)	Male	12.0	7.2	-8.4
	Female	8.4	4.8	-4.8
Life Expectancy at 65 (Months of life gained)	Male	4.8	3.6	-3.6
	Female	2.4	2.4	-1.2

* The cumulative number of lives saved from 1981 is provided in brackets. For Life Expectancy at 65, simulations start in 1986.

REFERENCES

[1] Newhouse JP. An Iconoclastic View of Health Cost Containment. *Health Affairs* 1993; Supplement: 152-171.

[2] Berndt ER. The U.S. Pharmaceutical Industry: Why Such Growth in Times of Cost Containment? *Health Affairs* 2001; **20**: 100-114.

[3] Federal/Provincial/Territorial Working Group on Drug Prices. *Cost Driver Analysis of Provincial Drug Plans: Ontario, 1992/93-1998/99*. Federal/Provincial/Territorial Health Ministers' Meeting, 2001. < http://www.pmprb-cepmb.gc.ca/PDF/studies/99-00/on-e.pdf > [3 December 2002].

[4] Newhouse JP. Medical-Care Expenditures: A Cross-National Survey. *Journal of Human Resources* 1977; **12**: 115-125.

[5] Leu RE. The Public-Private Mix and International Health Care Costs. In: Culyer AJ, Jonsson B (Eds). *Public and Private Health Services*. Basil Blackwell: Oxford, 1986: 41-63.

[6] Parkin D, McGuire A, Yule B. Aggregate Health Care Expenditures and National Income – Is Health Care a Luxury Good? *Journal of Health Economics* 1987; **6**: 109-127.

[7] Hitiris T, Posnett J. The Determinants and Effects of Health Expenditure in Developed Countries. *Journal of Health Economics* 1992; **11**: 173-181.

[8] Organization for Economic Co-operation and Development. *OECD Health Data 2000: A Comparative Analysis of 30 Countries*. Paris: 2000. < http://www1.oecd.org/els/health/ software/ > [28 August 2002].

[9] Gerdtham U-G, Jönsson B. Conversion Factor Instability in International Comparisons of Health Care Expenditure. *Journal of Health Economics* 1991; **10**: 227-234.

[10] Crémieux PY, Ouellette P, Pilon C. Health Care Spending as Determinants of Health Outcomes. *Health Economics* 1999; **8**, 627-639.

[11] Crémieux PY, Ouellette P, Meilleur M-C, Leong S, Greenberg P, Birnbaum H. Pharmaceutical Spending and Health Outcomes: A State Level Analysis. In: Sorkin A, Summers K, Farquhar I (Eds). *Investing in Health: The Social and Economic Benefits of Health Care Innovation*, Vol. 14. Elsevier Science, 2001: 59-76.

[12] Miller RD, Frech HE III. Is There a Link between Pharmaceutical Consumption and Improved Health in OECD Countries? *Pharmacoeconomics* 2000; Suppl. 1: 33-45.

[13] Régie de l'assurance-maladie du Québec. *Nombre de participants, nombre de services médicaux et leur coût par participant selon le sexe, le groupe d'âge et le type de service, rémunération à l'acte, médecine et chirurgie, Québec, 2000*. Québec: 2002. < http://www.ramq.gouv.qc.ca/crc/sta/ pdf/2000/tab213.pdf > [28 August 2002].

[14] Régie de l'assurance-maladie du Québec. *Nombre de participants et d'ordonnances, nombre d'ordonnances par participant, coût brut des ordonnances et par participant, coût RAMQ des ordonnances et par participant selon le sexe, le groupe d'âge et la catégorie de personnes assurées, régime d'assurance médicaments, Québec, 2001*. Québec: 2002. < http://www.ramq.gouv.qc.ca/crc/sta/pdf/2001/tab509.pdf > [28 August 2002].

[15] Newhouse JP, Phelps CE. Price and Income Elasticities for Medical Care Services. In: Perlman M (Ed). *The Economics of Health and Medical Care*. John Wiley and Sons: New York, 1974; 139-161.

[16] Cochrane AL, St.Leger AS, Moore F. Health Service 'Input' and Mortality 'Output' in Developed Countries. *Journal of Epidemiology and Community Health* 1978; **32:** 200-205.

[17] Gerdtham U-G, Søgaard J, Jönsson B, Andersson F. A pooled cross-section analysis of the health care expenditures of the OECD countries. *Developments in Health Economics and Public Policy* 1992; **1**: 287-310.

[18] Canadian Institute for Health Information. *The Evolution of Public and Private Health Care Spending in Canada, 1960-1997*. Ottawa, 1999.

[19] Gerdtham U-G, Søgaard J, Jönsson B, Andersson F. An econometric analysis of health care expenditure: a cross-section study of the OECD countries. *Journal of Health Economics* 1992; **11**: 63-84.

[20] Kleiman E. The Determinants of National Outlay on Health. In: Perlman M (Ed). *The Economics of Health and Medical Care*. John Wiley and Sons: New York, 1974; 66-81.

[21] U.S. Department of Health and Human Services. *Reducing the Health Consequences of Smoking: 25 Years of Progress. A Report of the Surgeon General*. Maryland: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 1989.

[22] U.S. Department of Health and Human Services. *The Health Consequences of Smoking: Nicotine Addiction. A Report of the Surgeon General.* Maryland: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, Center for Health Promotion and Education, Office on Smoking and Health, 1988.

[23] Southall DP, Samuels MP. Reducing the Risks in Sudden Infant Death Syndrome. *British Medical Journal* 1992; **304**: 265-266.

[24] Hamilton, James D. Time Series Analysis. Princeton: Princeton University Press, 1994.

[25] Senn S, Wilkinson RG, Sutton GC, Gravelle H. Mortality and Distribution of Income. *British Medical Journal* 1998; **316**: 1611-1612.

[26] Wolfson M, Rowe G, Gentleman J, Tomiak M. Career Earnings and Death: A Longitudinal Analysis of Older Canadian Men. *Journal of Gerontology* 1993; **48**: s167-s179.