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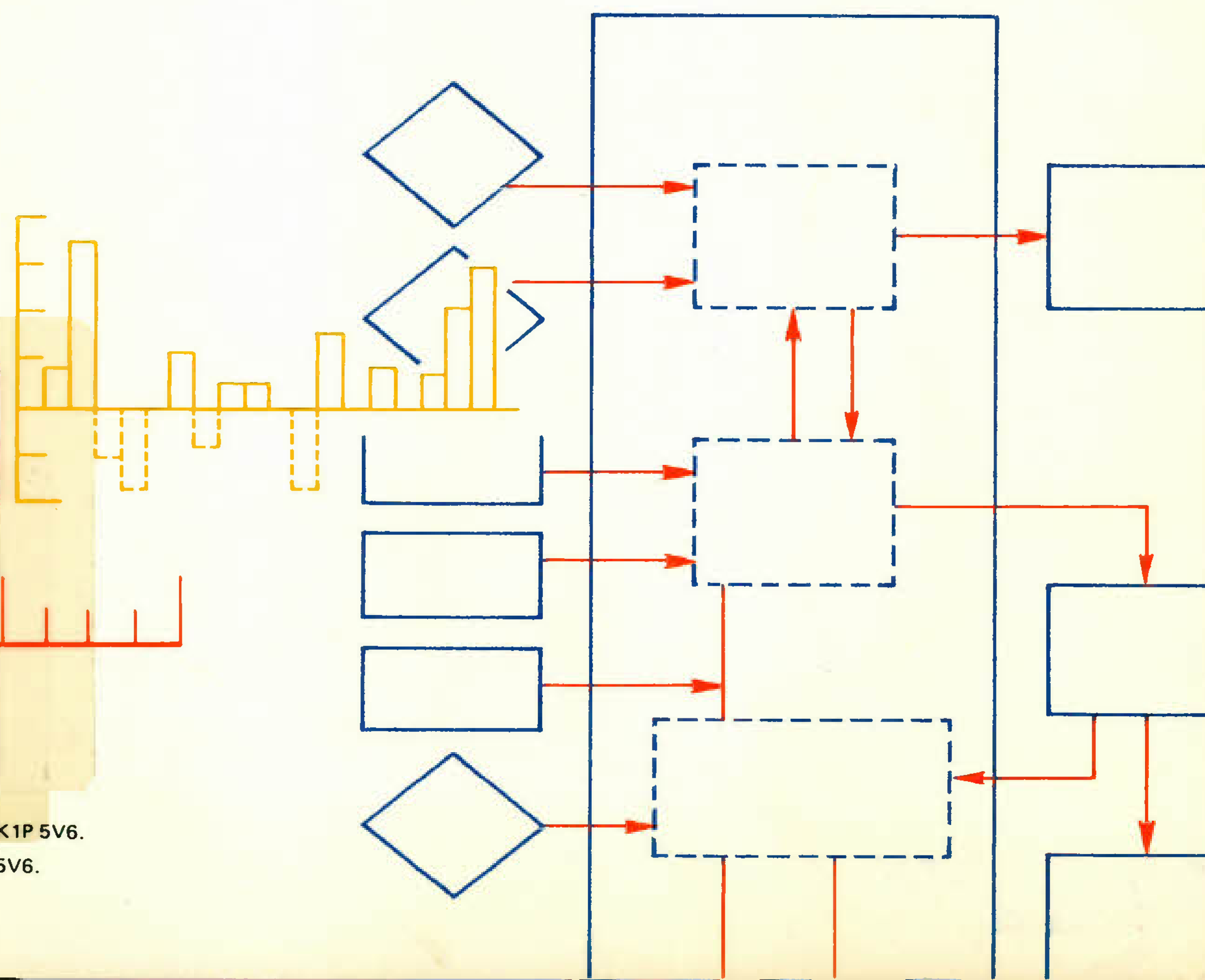

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DISCUSSION PAPER NO. 205

Provincial Variations in the Productivity of Physicians in Canada, 1974-76

by Ludwig Auer and John Menic

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RÉSUMÉ

La présente étude a été préparée aux fins de la rédaction du chapitre 6 du Dix-septième Exposé annuel du Conseil économique et du chapitre 7 de l'étude entreprise par le Conseil sur le fédéralisme fiscal. Elle fait partie d'un projet de recherche de plus grande envergure sur l'évolution de la productivité dans les services de santé.

En 1975, l'achat de services de santé a coûté environ 12 milliards de dollars aux Canadiens. Le sixième environ de cette somme a servi à défrayer le coût des services de médecins. Dans le présent document, nous nous proposons de comparer les services offerts par les médecins dans les diverses provinces, de déterminer dans quelle mesure leur productivité varie d'une province à l'autre, d'identifer et, si possible, de quantifier certains des facteurs expliquant ces variations.

À cette fin, nous examinons d'abord les mesures de la production. En comparant l'espérance de vie dans divers pays, on peut démontrer qu'elle est clairement reliée à la disponibilité de médecins et de services de santé par habitant. Dans le cas des comparaisons interprovinciales, le lien est beaucoup plus ténu. Au lieu de mesurer la production en fonction des répercussions que les services médicaux exercent sur l'état de santé, nous la mesurons ici au moyen d'un indice des services médicaux. Cet indice se fonde sur 116 activités différentes dans chacune des 18 spécialités médicales étudiées, et il est calculé

sur une base annuelle pour chacune des provinces entre les années 1974 et 1976.

D'après les résultats de notre analyse, les écarts de productivité ainsi mesurés peuvent atteindre jusqu'à 30 % d'une province à l'autre. Quant à la production par médecin, elle oscille entre 13 % au-dessus de la moyenne canadienne à Terre-Neuve et 10 % en dessous de la moyenne en Colombie-Britannique. Dans les autres provinces, elle se situe entre ces deux limites, le Manitoba, la Nouvelle-Écosse et l'Alberta se trouvant au-dessus de la moyenne et le Québec, en dessous de la moyenne. Le rendement supérieur calculé pour Terre-Neuve est en grande partie attribuable à un niveau de production plus élevé des médecins, qu'ils soient généralistes ou spécialistes. Toujours d'après nos résultats, le rendement inférieur observé en Colombie-Britannique, en Alberta et au Manitoba serait imputable non seulement à la production moins élevée des omnipraticiens et des spécialistes, mais aussi à celle des chirurgiens et des anesthésistes.

Ces différences de productivité sont presque exactement à l'opposé des variations provinciales de la productivité des industries productrices de biens. Il en ressort que la production des médecins exerçant leur profession dans certaines provinces à revenu élevé est inférieure à celle de leurs collègues des provinces à faible revenu.

Quant à la relation entre la productivité et les revenus, il appert que la rémunération des médecins dans la région de l'Atlantique est trop faible à Terre-Neuve et trop élevée en Nouvelle-Écosse. Dans les provinces centrales, les revenus bruts semblent trop élevés au Québec, alors que les gains nets et le revenu net se rapprochent des niveaux de la productivité. De toutes les provinces, c'est en Ontario que les estimations des revenus sont les plus rapprochées de celles de la productivité. Dans les quatre provinces de l'Ouest, la rémunération des médecins de la Saskatchewan semble être inférieure au niveau estimatif de la productivité, tandis qu'elle leur est supérieure en Alberta. Le revenu des médecins en Colombie-Britannique est nettement au-dessus du niveau de la productivité calculé; leur revenu net toutefois est à peu en ligne avec le niveau de leur productivité.

Il n'existe pas de mesure de qualité applicable à tous les services médicaux. Certains déterminants de la qualité peuvent toutefois être quantifiés à l'aide de certains indicateurs, tels que les taux de mortalité postopératoire et la durée de l'hospitalisation postopératoire. Même si les médecins de Terre-Neuve et de la Saskatchewan sont rémunérés à des taux inférieurs à leur productivité estimative, rien n'indique que leurs services sont de qualité inférieure. Nous ne pouvons pas conclure non plus que ces services sont d'une qualité supérieure en Nouvelle-Écosse et en Alberta même si les médecins y sont rémunérés à des taux supérieurs à ceux de leur productivité.

Les programmes fédéraux et provincaux de financement des régimes d'assurance-santé ont pour objectif principal d'offrir des services de santé "également accessibles" aux Canadiens de toutes les provinces. Si l'on classifie les provinces selon les services médicaux offerts par habitant, on constate que la région de l'Atlantique se retrouve de 10 à 25 % en dessous de la moyenne nationale tandis que le Québec, l'Ontario et la Colombie-Britannique se situent de 5 à 10 % au-dessus de cette moyenne.

ABSTRACT

This study provided background material for Chapter 6 of the Seventeenth Annual Review of the Economic Council and for Chapter 7 of the Council's study of Fiscal Federalism. It is part of a more comprehensive analysis of productivity performance in the health-service industries.

In 1975 Canadians spent about 12 billion dollars on all health services. Roughly one sixth of this expenditure went for physicians' services. The objective of this paper is to compare physicians' services among the provinces, to determine if and how much the physicians' productivity differs among them, and to identify and, where possible, quantify some of the underlying reasons for such differences.

In approaching these objectives, measures of output are reviewed first. It is shown that in international comparisons variations in life expectancy are clearly associated with physicians and health services per capita. In provincial comparisons the link is much more tenuous. Instead of measuring output in terms of the impact which physicians have on the status of health, it is measured here by an index of physicians' services. This index is based on 116 different activities in each of 18 medical specialties, and calculated annually for each of the provinces over the years 1974-76.

Results of the analysis show that productivity so measured varies by as much as thirty per cent among the provinces. Overall, output per physician ranges from 13 per cent above the Canadian average in Newfoundland to 10 per cent below the Canadian average in British Columbia. The figures in other provinces fall somewhere inbetween with Manitoba, Nova Scotia, and Alberta below and Quebec above average. Much of Newfoundland's stronger performance can be shown to come from greater output of general practitioners and medical specialists. British Columbia's, Alberta's, and Manitoba's weaker performance are shown to come not only from general practitioners and medical specialists but from surgical specialists and anesthesists as well.

These variations in productivity performance are almost the exact opposite of the provincial variations in productivity for the goods-producing industries. The implications are that physicians in some of the high-income provinces have a lower output than their counterparts in some of the low-income provinces.

When productivity performance is compared with physicians' incomes it appears that in the Atlantic Region physicians of Newfoundland are underpaid while those of Nova Scotia are overpaid. In the central region Quebec's gross payments seem to be out of line but net earnings and net income are close to productivity. Ontario's income estimates are very close to the productivity estimates, closer than for any other province. Among the four western provinces Saskatchewan's physicians appear to be paid less than estimated productivity while Alberta's are paid more. Payments of physicians in British Columbia are well above estimated productivity but their net income is almost the same as productivity.

No comprehensive measures of the quality of physicians' services exist. Several aspects of quality, however, can be quantified by using postoperative mortality rates and length of postoperative hospital stay, as well as some other indicators. Although physicians of Newfoundland and Saskatchewan were paid below estimated productivity there is no convincing evidence that the quality of their services was inferior. Nor is there any clear evidence that the quality of physician's services in Nova Scotia and Alberta, where physicians are found to be paid above estimated productivity, is superior.

Federal and provincial programs for financing health insurance programs have the central objective of providing "equal access" of health services to all Canadians irrespective of province of residence. A provincial ranking of physician services per capita puts the Atlantic Region 10 to 25 per cent below the national average and Quebec, Ontario and British Columbia 5 to 10 per cent above the national average.

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Introduction

In its recent Annual Review, "Climate of Uncertainty", the Economic Council showed that for nearly a decade now, Canada's production has scarcely improved. In search of the underlying causes it examined a variety of factors: the composition and skill of the labour force, the industrial structure, technical change, plant size, capacity utilization, capital and intermediate inputs, prices of energy and materials. It concluded that cyclical factors together with capital accumulation, changing labour-force composition and identifiable technical change, accounted for 33 per cent of the slowdown; structural shifts among industries for 9 per cent and that the price shock of the energy crisis accounted, possibly, for another 8 per cent. Thus one-half of the productivity slowdown was explained by identifiable factors while the other half -- the remainder of the productivity puzzle -- was thought to come from numerous factors, less readily identified and more difficult to measure.

Regional analysis substantiated these findings. It was found that the slowdown in productivity growth was widespread among the provinces and consistent with past experience. The fact that Alberta escaped it, was attributed to the boom in natural resource exploitation. It was more difficult to account for Quebec's experience. Unlike in the past, its rate of productivity growth declined less than that of Ontario and its economy recovered more strongly. Possibly this was because Quebec relies more on Canada's tariff-protected interprovincial trade and less on international trade.

Regional research also revealed sharp differences in service-sector productivity among the provinces. It supports the idea that productivity improvement in the service sector is both possible and desirable. As the service sector now comprises close to two-thirds of the economy, productivity improvement of this sector is, indeed, essential if the overall performance of the economy is to be raised significantly.

In manufacturing and other goods-producing industries output has been measured for many years by the dollar value of goods produced and the dollar value added. In the service industries, by contrast, output is not as readily defined and, if measured in traditional ways, success or failure of a policy directed at productivity improvement of the service sector might never be noticed. Output of the service industries is commonly measured by the total value of labour and capital inputs. In fact prior to 1961, it was measured by salaries and wages alone (Statistics Canada, 1971; p. 17). By that measure output per unit of labour input, or labour productivity could never change. It was constant by definition. Later when capital inputs, i.e., depreciation, were taken into account measured labour productivity would change only when capital inputs changed.

In recent years a variety of studies have dealt with improvements in productivity measurement of the service industries. Better measures have been obtained by disaggregating the outputs and inputs of a service industry into homogeneous categories and by attaching appropriate weights to each. A similar approach will be followed here.

Objectives

This study is part of a more comprehensive analysis of the performance of Canadian health services. In 1975 Canadians spent approximately 12 billion dollars on all health services. Not quite $2 billions, or roughly one-sixth of total health expenditures went for physicians' services. Here only the latter will be analysed.

The objectives of this paper are:

- to determine if and how much the productivity of physicians differs among the provinces,
- to identify and, where possible, quantify some of the underlying reasons for such differences, and
- to compare the provincial variations in productivity of physicians to provincial variations in incomes of physicians.

By necessity the coverage is limited. The focus will be on productivity in the delivery of services although aspects of quality of service will also be examined.

In approaching these objectives measures of output are reviewed first. Data and method of analysis are described next. Then follows the empirical analysis, showing how much the productivity performance differs among the provinces, how that compares to physicians' incomes and quality of service, and how much service is provided on a per capita basis. The analysis covers all the provinces but only the years 1974 to 1976.

Measuring the Output of Physicians

There are several main strands in the literature of health economics. One deals with measuring the real output of health services, another with the interaction of supply and demand, and a third with the impact of insurance programs on health services. While all of these have some implications for productivity analysis, literature on measuring productivity performance in the health services is quite sparse especially in the area of physician services. The following review reflects this situation. It ignores much of the literature on hospital services and concentrates on that of physician services even though both are interrelated and not easily disentangled.

To measure the real output of physicians would be very difficult if it meant evaluating the impact of their services on the status of a country's health, especially if health is defined very broadly. The World Health Organization (WHO), for example, defines health as "a state of complete physical, mental and social well-being and not just the absence of disease and infirmity" (WHO, 1975). Since it is not possible at present, to measure all these dimensions of health, it is expedient to rely on selected indicators.

One of these indicators is life expectancy. Although this indicator does not take into account the incidence of non-fatal diseases it is known to be closely associated with many forms of morbidity and debility and it is thought to provide a good indication of the range and intensity of health problems in different countries. Indeed for the purpose of international comparisons it is considered to be the most reliable indicator of health status presently available (World Bank, 1975; p. 677).[1] Based on a regression analysis of 75 countries, for example, access to physicians and nurses "explains" over four-fifths of the intercountry variations in length-of-life expectancy.[2] It implies that greater access to physicians and nurses lengthens a country's average life expectancy significantly. It also implies that an increase in the number of physicians and nurses will raise life expectancy at a diminishing rate until eventually a point is reached where further increases yield zero gains. This "critical" point is estimated to be in the neighbourhood of 150 physicians per 100,000 people. If it were not for certain reservations to such estimation procedures it would put Canada, with 177 physicians per 100,000 people, beyond this point of zero productivity. Among the provinces, however, only five would exceed this point while three of the four Atlantic provinces and two of the three Prairie provinces would not.

Estimates of this sort should be interpreted with great caution since they are based on cross-section data of many countries. It is doubtful that health care services around the globe are

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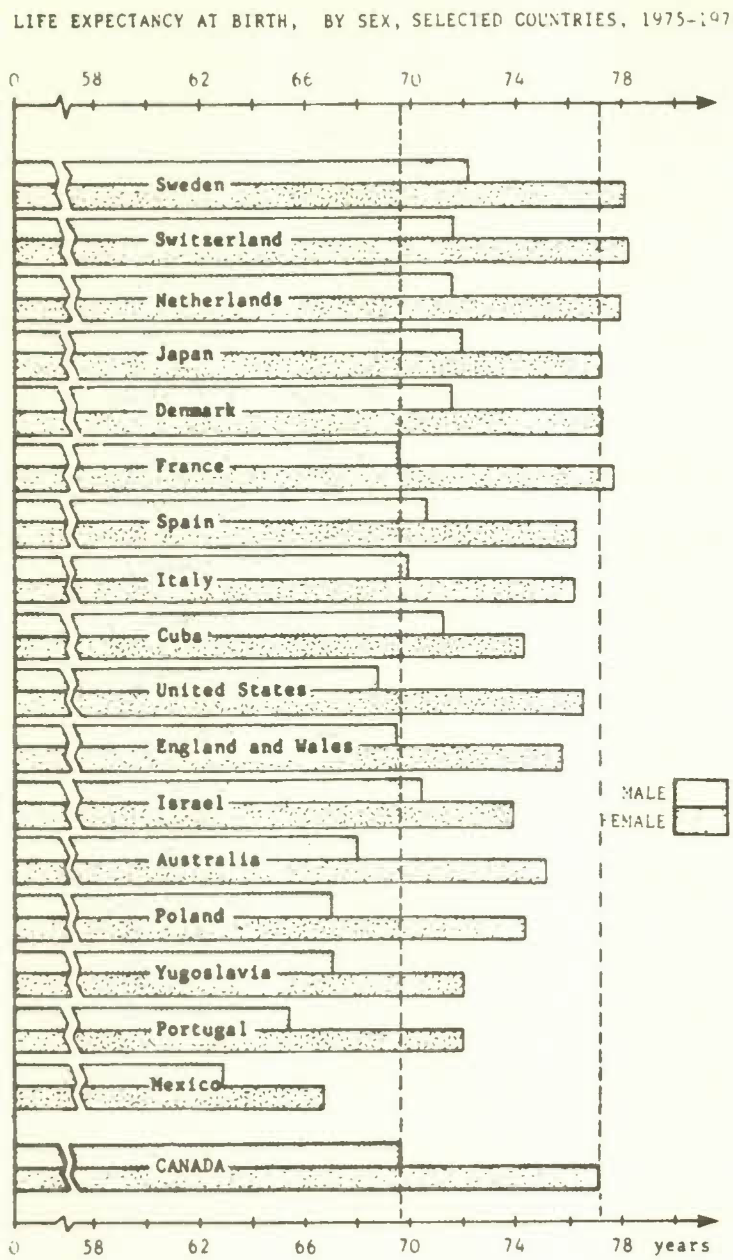
1 Bibliographical references are listed alphabetically at the end of the text. This reference, for instance, is listed under World Bank on page 65. The elevated numbers in the text refer to footnotes which are also listed at the end of the text. In this instance it refers to footnote 1 listed on page 61.

physicians in Canada in 1975, for example, only 25,881 were fee-practice physicians. The others, over one-third, were engaged in research, administration, or were retired. Since it is not very likely that this composition is the same in all countries such international comparisons of productivity, based on life expectancy, may not be very meaningful.

Yet there is little doubt that Canadian life expectancy could be extended further. Among the more industrialized countries Canada's life expectancy ranks about average. According to a recent ranking, for example, Canada placed eighth among 18 countries. As illustrated in Chart 1, Canada ranks lower than some of the Western-European countries but higher than the United States, England and Australia. For all 18 countries life expectancy is higher among females than males. Also life expectancy is linked to per-capita incomes. In Sweden -- one of the higher-income countries -- life expectancy is highest and in Mexico -- one of the lower-income countries -- it is lowest. Between these two countries life expectancy differs by about ten years. This ranking between income and life expectancy, however, holds only approximately true. Canada, Italy and Cuba, for example, rank above the United States even though per-capita incomes of all three are lower than in the United States. Evidently some other factors have a bearing on life expectancy.

Chart 1

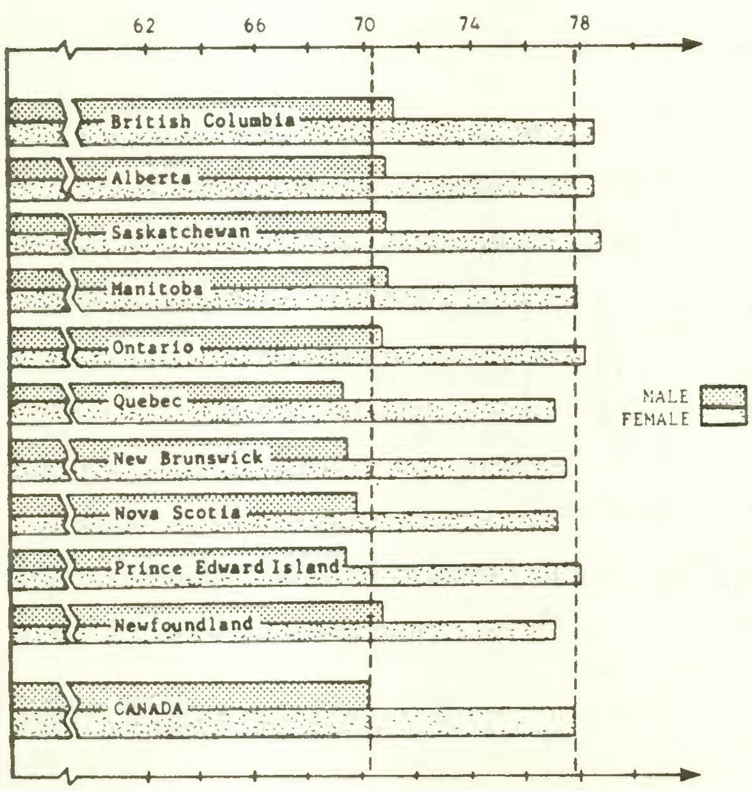


Source Ouellet, 1979, p. 12.

As in other countries around the world, life expectancy in Canada has steadily increased over the years, mainly because of a drop in infant mortality and lower death rates from infectious diseases. Life expectancy in Canada was around 60 years in 1931 and is well over 70 years today. While the trends are similar everywhere, some provinces continue to lead while others lag behind. As far back as 1930 residents of Saskatchewan, for example, have enjoyed a longer life expectancy than people in the rest of Canada. By 1976 females in Saskatchewan had not only Canada's highest life expectancy but -- with 78.8 years -- surpassed that of Switzerland and Sweden, the two countries with the highest life expectancy in the world today. For males the life expectancy was highest in British Columbia and lowest in the province of Quebec. Quebec has lagged behind the other provinces in life expectancy of both males and females. It has done so over the passed 30 to 40 years. Although this lag has been greatly reduced over the years, Quebec's life expectancy still falls 0.9 years short of the Canadian average (Chart 2).

Chart 2

LIFE EXPECTANCY AT BIRTH, CANADA AND PROVINCES, 1976



Source Ouellet, 1979, p. 13.

It would be of interest at this point to ask if the provincial variations in life expectancy are closely linked with access to health services. Following the pattern of the earlier global analysis of international statistics, provincial variations in life expectancy could be compared with provincial variations in health services. As provincial estimates of life expectancy are only available for Census years and not annually, an alternative health indicator is used here.

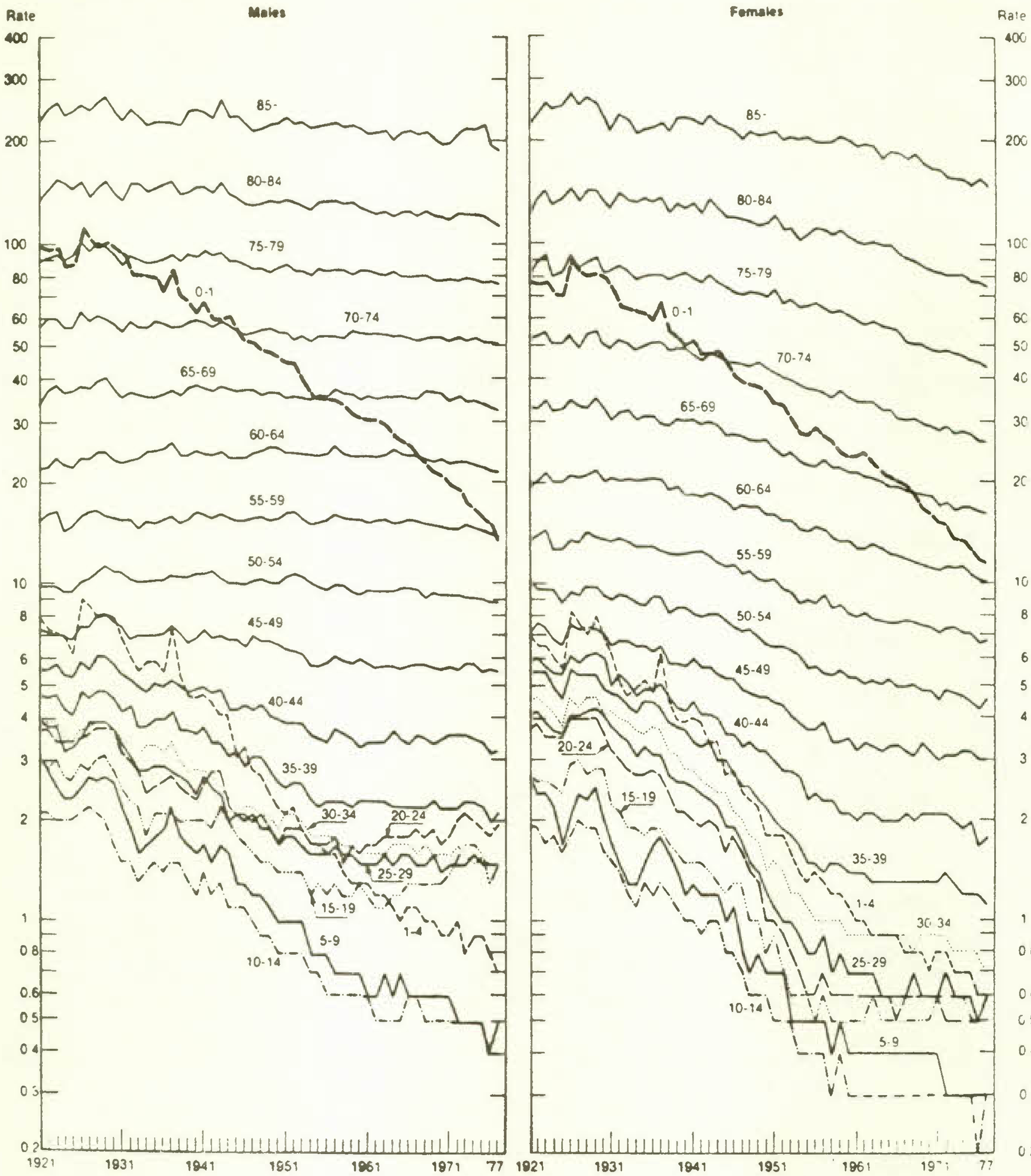
It is well known that a substantial part of the improvement in life expectancy over the past 50 years, has come from lower death rates among the younger age groups. Most strikingly, perhaps, infant mortality (babies up to one year old) has been greatly reduced (Chart 3). Part of this improvement has come from easier access to hospitals, the use of antibiotics and better instruments, and part of it has come from more extensive and better services of general practitioners and pediatricians. According to Dr. D.T. Wigle of the Canadian Bureau of Epidemiology, for example, there is little doubt that infant mortality is being reduced through better health-care delivery. Deaths from parasitic and inflammatory diseases, deaths from diseases of the digestive and the genitourinary systems, are preventable. Others, including a specific set of perinatal causes of death, are at least partially preventable.[3]

Since provincial records of infant mortality have been kept for many years, we can test if provincial variations in infant mortality are directly related to provincial health services.

Chart 3

Age-specific Death Rates by Sex, Canada, 1921-1977 [1]

(Per 1,000 population)



[1] Excludes Quebec 1921-1925

Source Statistics Canada. Vital Statistics, Vol. III, Deaths 1977, STATCAN Cat. No. 84-206 Annual, p. xv.

It is done by regressing provincial infant mortality rates on provincial numbers of physicians, nurses, and hospital beds per capita. Results of this analysis suggest that over the years 1966-75 these three variables "explain" about one-third, and the physician variable alone about one-fifth of the provincial variations in infant mortality. Although these estimates are statistically significant, they leave the larger proportion, i.e., up to four fifths of the provincial variations, unexplained. Moreover, if the same analysis is augmented by additional variables to capture some other provincial characteristics, the statistical significance of the three health-service variables diminishes while other provincial characteristics become highly significant.[4]

These results do not lend convincing support to the proposition that a further expansion of existing health services and a greater number of physicians per capita would further lengthen life expectancy in Canada. They are not out of line with the earlier finding, based on international comparisons, which suggested diminishing marginal returns to health services and physicians beyond the level attained by the highly industrialized countries. Nor do they run counter to the mainstream of the literature on health economics.

Economic efficiency depends on the competitive interplay of the market forces of supply and demand. Consumers are served best when the economy produces goods and services at minimum cost and when the system allocates them among consumers according to their real desires. The health sector is no exception. While it resembles other sectors of the economy in many ways, it has one shortcoming that is more pronounced than elsewhere, a lack of consumer information. Many times the consumer, as a patient, has only a vague notion of his ailment and little or no knowledge of a possible cure. Hence the argument that his sovereignty as a consumer is jeopardized (Migué and Bélanger, 1974, p. 4). The patient depends on the physician's advice but he seems to be a poor judge of the quality of his services. It has been shown, for example, that there is a wide range of competence among physicians and that their ability to attract patients has, at times, little or no connection with their technical knowledge or ability (Peterson, 1963).

Also from the economic point of view of profit maximization, it is clear that fee-for-practice physicians, as producers and suppliers of health services, are not strongly motivated to minimize costs to individual patients or to society as a whole. According to Evans, for example, the dependence of patients on physicians and the ability of physicians to create the demand for their services has led to less than optimal delivery of health services, and there is no easy solution to this problem. Increasing the number of physicians would not necessarily strengthen the market competition and lower physicians' fees. If it should lessen their workload and lower their incomes, physicians would compensate for it by raising their fees.

Moreover, a greater number would probably strengthen the interaction among physicians and specialists, thereby raise the demand for their services, and increase their fees and their incomes even further (Evans, 1974, 1975, 1976).

Findings of other writers in the field lend support to this point of view. Vayda has shown that (age-standardized) surgical rates for diverse elective and discretionary operations -- such as hysterectomy and cholecystectomy -- were in 1968 two to seven times as high in Canada as in England and Wales, that these rates increased significantly between 1968 and 1973, while those of non-elective procedures (on average) did not change very much, and that the rates of elective surgery were positively correlated with the number of physicians performing surgery (Vayda, 1973, 1975, 1976). In a subsequent study, Mindell, Vayda and Cardillo found, however, that the rates of certain elective procedures had peaked during the past decade and were on the decline. Thus between 1968 and 1978, the rates of hysterectomies peaked during the years 1971-72 and then, with the exception of Newfoundland, declined. Similarly, the rate of cholecystectomies peaked and declined in all provinces. Some of the other elective and discretionary surgery had diverging trends but overall, the rate of all surgery decreased to the point where it was lower in 1977 than in 1968 (Mindell, Vayda and Cardillo, 1980).

This rise and decline of surgery per capita occurred during a period of increasing numbers of physicians (per capita). If physicians would freely create the demand for their services a continuous increase in cases of surgery could have been expected. It did not happen. It might be that the rise during the early seventies was simply in response to a backlog of earlier years, or it could be that Evans and others were effective in putting their message across and that the publicity from the media helped lowering the rates of elective surgery. Whichever the case, it does not explain the continuous rise in the number of physicians especially when their positive impact on the status is not readily demonstrated. According to a recent U.S. study the impact on the status of health might even be negative. In this study it was observed that under prepaid care poor families, after one year of enrolment in the program, appeared sicker than the control group without prepaid medical care. The study went so far as to conclude that "free" health care may not be an effective way to improve health (Diehr, 1979).

Quite likely much of the concern about the impact of health care has come from the ever rising costs of health care services. This concern seems to be common among countries of the western world. To wit, a recent article of The Economist states:

> "Health services throughout the developed world are sick. Insatiable demand for health care is coutstripping supply, despite a vast increase in its share of national budgets and family incomes. This year Americans will spend nearly one in every 10 dollars they earn on their health, compared with one in every 15 at the start of the 1970's. Yet life expectancy in the United States is only inching up.

> So it is throughout the rich, industrialized western world. In all the industrialized democracies, a baby's life expectancy is now about 72-76, whether its parents pay 5 per cent of national income (Japan) or nearly twice as much (United States, Sweden) for the privilege.
>
> In almost all, health spending is eating further and further into national income, without a corresponding rise in general health, or even human happiness about the quality of medical services." (The Economist, November 1980)

The rise in health care costs, at a rate exceeding the growth of national incomes, is attributed to a variety of factors and not just the ever-increasing number of physicians. Members of an affluent society are less prepared to suffer minor ailments without drugs or other medical aid. Medical research continues to push out the frontiers of curable disease, creating new customers for new treatments (heart valve implants). New cures for old diseases come with bigger and bigger technological price tags[5] e.g., the CAT body scanner.[6] Health services are the victims of their own success. The elderly whose lives they have extended require more routine medical care than the young so that a small increase in their number can mean a large increase in health care costs. Not only are physicians pushing out the frontiers of curable disease, but health insurance programs make it possible to reach down to the poorer levels of society. On the other side of the income scale the better-off are wiping out part of the gain to general health as they encounter diseases of affluence, sedentary work, and lack of exercise. As well, smoking and drinking,[7] environmental pollution,[8] and even social change (women suffer in ever greater numbers from coronary disease and lung cancer, traditionally "male" diseases) add their toll.

This listing of factors is not based on a quantitative analysis of their relative importance. It merely underlines the fact that many factors -- and not any single one -- have contributed to the rise in health expenditures.

Over the past two decades, efforts by the Canadian government have been directed at providing adequate health services to all Canadians, irrespective of province of residence or level of income. Although the U.S. study of free access to health care, mentioned earlier (Diehr, 1979), might leave a different impression, there is clear evidence that lower-income people tend to consume more health services than others because their needs are greater. This is not only demonstrated by the inverse relationship between income and use of health services[9] but also by the link between income level and mortality rate.

A study by Wigle (1980) shows that life expectancy varies with income level: the lower the income, the shorter the life expectancy. Ranked by income quintiles, the differences in life expectancy between the highest and lowest income levels are found to be approximately 6 years for males and 3 years for females. Differences are evident in all age groups. Among the 35-64 year old, for example, tuberculosis and diseases of the circulatory system of both sexes account for most of the difference. Among the newborn, perinatal morbidity and mortality, congenital anomalies and diseases of the respiratory system are the main causes.

From the preceding analysis and the brief review of the literature it is apparent that physicians' services are not solely a function of physician-induced demand. Also it is apparent that life expectancy and infant mortality are not only determined by the accessibility of physicians' services. Other factors are involved: the greater demand for health services in a more affluent society, technological advances in the diagnosis and treatment of individual ills, treatment of a wider range of ills, more intensive treatment of the elderly, lengthening of the lifespan and the concomitant expansion of the needs of the elderly, "free" access to health services, changes in the structure of society, occupational hazards, and environmental pollution; to name the more important. Given these factors, an ideal estimate of the output of physicians should account for the impact of all of them, for that of physicians as well as that of other factors. While such an accounting framework could probably be developed,[10] it is beyond the scope of this study and not attempted here.

The focus of the present study is far more limited. Instead of measuring output in terms of the impact physicians have on life expectancy or the status of health, it will be measured here in terms of the services performed by physicians. This means of course, measuring the output by some aggregate index of inputs. It is based on the implicit assumption that physicians' services and the real output are fairly closely linked. Even if this link should not be very close and even if provincial variations in the status of health should not be closely associated with the provincial variations in the delivery of physicians' services, it will be useful to know:

- what services physicians are currently providing in each of the provinces;

- how much these services cost; and

- how their costs per unit of service differ from one province to the next.

This information would be useful because it would help explain why provincial expenditures vary so much among the provinces, when life expectancy varies so little (Table 1).

To arrive at provincial measures of physicians' performance, a two-step procedure is followed. First, the output of physicians is standardized by taking into account the provincial variations in medical specialization. Second, the output of physicians

Table 1

Percentage Variations in Life Expectancy and
Per-Capita Expenditures on Physicians' Services, 1975

	Life Expectancy		Per Capita Expenditures on Physicians' Services
	Males	Females	
	(per cent)		
Newfoundland	101	99	54
Prince Edward Island	99	100	65
Nova Scotia	99	99	89
New Brunswick	99	100	65
Quebec	98	99	95
Ontario	100	100	110
Manitoba	101	100	84
Saskatchewan	101	101	77
Alberta	101	101	103
British Columbia	101	101	118
CANADA	100	100	100
Canadian Average[1]	70.3	77.8	83.62

1 Life expectancy in years, per-capita expenditure in dollars.

Source Based on B.L. Ouellet, Health Field Indicators, Canada and Provinces, Health and Welfare Canada, Ottawa, September 1979, Table 35, p. 89.

in each speciality is measured by applying standard rates to each of their activities. The details of data and estimation procedures are presented in the section below.

Data and Estimation Procedures

Physicians perform a great many services, ranging from thoracic surgery to research and administration. Expenditures on physicians' services vary across provinces, partly because of provincial variations in the number of physicians per 1,000 population, partly because of provincial variations in the degree of medical specialization, partly because of institutional differences and associated cost differences, e.g., clinic versus "solo" practice, partly because of provincial variations in fee schedules, and partly because of provincial variations in output per physician.

To separate the variations in output per physician from some of the other provincial variations, certain adjustments are made. First, the number of physicians is converted to "fee-practice" physicians and then to "physician equivalents". Fee-practice physicians include only those who practice their profession for a fee payment and exclude all those who work in government administration, medical research and other areas. The conversion to full-time physician equivalents allows for the fact that some of the fee-practice physicians work only part time. To arrive at full-time equivalents the Department of Health and Welfare has developed the "Median Equivalence Method". It is described in Appendix IV.

Provincial results of these adjustment procedures are summarized in Table 2. They show that the switch from "all physicians" to "fee-practice physicians" reduces the Canadian

Table 2

Various Measures of Physicians per 100,000 Population, Canada and Provinces, 1975-76

	All Physicians		Fee-Practice Physicians		Full-Time Equivalents	
	Rate	Per Cent	Rate	Per Cent	Rate	Per Cent
Nfld.	140	80	71	53	52	53[1]
P.E.I.	118	68	111	83	78	80
N.S.	169	97	129	96	94	96
N.B.	114	65	91	68	71	72
Que.	181	104	139	104	101	103
Ont.	184	106	139	104	103	105
Man.	173	99	138	103	98	100
Sask.	143	82	116	87	84	86
Alta.	158	91	125	93	91	93
B.C.	181	104	152	113	112	114
CANADA	174	100	134	100	98	100

1 Estimates of Newfoundland's fee-practice physicians and of full-time equivalents are not strictly comparable with other provinces when used as a measure of physician inputs per 100,000 population because they exclude the physicians employed by "cottage hospitals" who are classified as salaried and not as fee-practice physicians.

Source Based on B.L. Ouellet, Health Field Indicators, Canada and Provinces, Health and Welfare Canada, Ottawa, September 1979, Table 37, p. 91; and Data on Physician Equivalents provided by Mr. L.W. Rehmer of Health and Welfare Canada, 1980.

rate per 100,000 population from 174 to 134 physicians, and the conversion of "fee-practice physicians" to "full-time equivalents" from 134 to 98. These are sizeable reductions and they are roughly the same for all provinces.

As a further step of separating the provincial variations in output from some of the other variations, physicians' services are grouped according to specialties and activities. As shown in Table 3a gross payments (per physician equivalent) vary among specialties by as much as 70 per cent, with cardiac/thoracic surgeons ranking about 50 per cent above the Canadian average and psychiatrists about 20 per cent below this average.

Within each specialty gross payments per physician vary among the provinces partly because of provincial variations in the fees charged per activity and partly because of provincial variations in the real output per physician-equivalent in each specialty. To "standardize" for provincial variations in fee schedules the Canadian average fee is substituted for the provincial fee in each of 116 activities and in each of 18 specialties. Table 3b illustrates the provincial fees and the Canadian average fee for the adjustment of one year, but only for two of the 116 activities, i.e., complete examination (other than initial) and routine home visit, and only for three of the 18 specialties, i.e., general practice, internal medicine, and obstetrics.[12]

Table 3a

Variation in Relative Gross Payments of Physicians by Specialty, Canada, 1976

Specialty	Relative Gross Payments[1] Based on Fee-for-Service
	(per cent)
Cardiac/Thoracic Surgery	1.56
Otolaryngology	1.45
Ophthalmology	1.35
Obstetrics/Gynecology	1.34
Orthopedic Surgery	1.28
Dermatology	1.26
Urology	1.23
Physical Medicine	1.19
General Surgery	1.14
Plastic Surgery	1.12
Neurosurgery	1.07
Ophthalmology/Otolaryngology	1.04
Pediatrics	1.00
Internal Medicine	0.99
Neurology	0.98
Anaesthesia	0.92
General Practice	0.91
Psychiatry	0.82

1 These gross payments are estimated relative to the weighted average payment of all specialties. They cover only fee-for-service payments and no additional payments. For this reason and because gross payments differ from net returns to a varying extent among specialties, these estimates should not be taken for a ranking of physicians' incomes. Also, the gross payment of each specialty is estimated per full-time physician equivalent. As described in the text, this conversion from physician to physician equivalent allows for the fact that some physicians do not work full time.

Source Based on data provided by the Department of Health and Welfare and estimates by the Economic Council of Canada.

With the permission of the 10 provinces -- in most cases from the provincial health insurance commissions -- Health and Welfare Canada granted the Economic Council access to provincial data sets of each of the 16 medical specialties and 118 activities, individually for the years 1974, 1975 and 1976. Each data set consisted of two (16x118) matrices, one matrix for the number of services performed and the other for the average payment per service. In total there were 30 such data sets, one for each province and each year. Not all matrix elements were non-zero entries as not all of the activities were performed by physicians in each specialty. As well some of the smaller provinces did not have physicians in all specialties. Moreover in some cases adjustments were made to meet certain confidentiality requirements.

Productivity of Physicians

Given this data base, the principal objective of the analysis was to determine if and by how much the productivity of physicians varied among the provinces. After standardizing for fee schedules, the variations were attributed to two sources: the provincial degree of specialization and provincial output per physician in each specialty. As shown in (1) the provincial productivity of physicians is (identically) equal to the output per physician equivalent in the i-th specialty, weighted by its physician equivalent share, and summed over all 16 specialties. In turn the (provincial) output of physicians in the i-th specialty Q_i, is equal to the (provincial) number of services

Table 3b

Sample Payments Per Service, Three of Sixteen Selected Specialties and Two of One Hundred and Sixteen Activities,[1] Canada and Provinces, 1976

	General Practice		Internal Medicine		Obstetrics	
	Complete Examination	Routine Home Visit	Complete Examination	Routine Home Visit	Complete Examination	Routine Home Visit
	(in dollars)					
Newfoundland	7.92	9.30	19.22	9.16	9.36	7.76
Prince Edward Island	14.40	14.70	10.90	14.60	14.40	13.60
Nova Scotia	18.10	10.70	14.50	10.60	18.20	10.70
New Brunswick	14.20	10.90	9.50	10.90	14.20	11.00
Quebec	13.10	6.70	13.70	4.80	12.60	6.90
Ontario[3]	-	-	-	-	-	-
Manitoba	12.90	10.00	20.30	10.00	14.90	10.10
Saskatchewan	12.30	12.40	25.40	12.50	11.20	12.40
Alberta	12.10	11.50	12.00	9.20	12.20	11.40
British Columbia	19.40	17.70	19.40	17.00	19.30	17.90
Canadian Average Fee	12.59	9.87	14.29	6.92	12.12	9.97

1 Note: This example covers only three of eighteen specialties and only two of one hundred and sixteen activities used for estimating the provincial output of physicians. The 18 specialties are described in the text, the 116 activities are listed in Appendix V.

2 Other than initial examination.

3 At the request of Mr. H.I. MacKillop, Director of the Data Development and Evaluation Branch of the Ontario Ministry of Health, the sample payments per service in Ontario were deleted from this Table although they were used in the empirical analysis in the same manner as those of other provinces.

Source Based on data of the Health Economics and Statistics Division of the Department of Health and Welfare.

Qijp, categorized under the i-th activity, multiplied by the Canadian average payment for that service Pijc, and summed over 118 such activities.

$$(1) \quad \frac{Q.}{E.} \equiv \sum_{i}^{16} \frac{Ei}{E.} \frac{Qi}{Ei}$$

where $Qi \equiv \sum_{j}^{118} Qijp\ Pijc$

and where

$\frac{Q.}{E.}$ = average productivity of physician equivalents

$\frac{Ei}{E.}$ = degree of specialization as measured by the proportion of physician equivalents engaged in the i-th specialty

$\frac{Qi}{Ei}$ = output per physician equivalent in the i-th specialty

Qi = output per physician services in the i-th specialty

Qijp = provincial output of physician services in the i-th specialty and j-th activity

Pijc = Canadian average payment per physician service n the i-th specialty and j-th activity.

The difference in productivity performance between physicians of a particular province and the Canadian average performance, is estimated by comparing the degree of specialization as well as the output per physician in each province with the Canadian average. Computationally it amounts to comparing the provincial values in (1) with their Canadian counterpart and attributing the difference between the two, to the degree of specialization and the output per physician. It can be shown that this difference equals the two summations in (2).[13] In (2) a difference in productivity performance between a province and Canada is attributed to the degree of specialization whenever the physician-equivalent shares among the 16 specialities (Ei/E.) differ between the province and Canada, provided the output per physician equivalent in any particular specialty (Qi/Ei) differs from the national average (Q./E.). A difference in productivity performance is attributed to output per physician equivalent in individual specialties ($\overset{*}{Q}i/Ei$) whenever there is a difference between the province and Canada. It is weighted by the provincial employment share (Ei/E.)p and enlarged or diminished by the ratio (Qi/Q.)c ÷ (Ei/E.)c depending on whether the national output per physician equivalent in specialty i (Qi/Ei) is larger or smaller than the national average performance. Finally, the contributions imputed to specialization and output per physician are summed over all 16 specialties and thus account for the total difference between the provincial and Canadian productivity performance.

$$(2) \quad \frac{\overset{*}{Q.}}{E.} \equiv \sum_{i}^{16} \left(\frac{Ei}{E.}p - \frac{E}{E.}c\right) \left(\frac{Qi/Q.}{Ei/E.}c - 1.0\right)$$

$$+ \sum_{i}^{16} \frac{\overset{*}{Qi}}{Ei} \frac{Ei}{E.}p \frac{Qi/Q.}{Ei/E.}c$$

where the symbols are the same as in (1) and where

$$\frac{\overset{*}{Q.}}{E.} = \left(\frac{Q.}{E.}p - \frac{Q.}{E.}c\right) \div \frac{Q.}{E.}c$$

$$\frac{\overset{*}{Qi}}{Ei} = \left(\frac{Qi}{Ei}p \quad \frac{Qi}{Ei}c\right) \div \frac{Qi}{Ei}c$$

Qijp, categorized under the i-th activity, multiplied by the Canadian average payment for that service Pijc, and summed over 118 such activities.

$$(1) \quad \frac{Q.}{E.} \equiv \sum_{i}^{16} \frac{Ei}{E.} \frac{Qi}{Ei}$$

where $Qi \equiv \sum_{j}^{118} Qijp\ Pijc$

and where

$\frac{Q.}{E.}$ = average productivity of physician equivalents

$\frac{Ei}{E.}$ = degree of specialization as measured by the proportion of physician equivalents engaged in the i-th specialty

$\frac{Qi}{Ei}$ = output per physician equivalent in the i-th specialty

Qi = output per physician services in the i-th specialty

Qijp = provincial output of physician services in the i-th specialty and j-th activity

Pijc = Canadian average payment per physician service n the i-th specialty and j-th activity.

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$$(2) \quad \frac{\overset{*}{Q.}}{E.} \equiv \sum_{i}^{16} \left(\frac{Ei}{E.}p - \frac{E}{E.}c\right) \left(\frac{Qi/Q.}{Ei/E.}c - 1.0\right)$$

$$+ \sum_{i}^{16} \frac{\overset{*}{Q}i}{Ei} \frac{Ei}{E.}p \frac{Qi/Q.}{Ei/E.}c$$

where the symbols are the same as in (1) and where

$$\frac{\overset{*}{Q.}}{E.} = \left(\frac{Q.}{E.}p - \frac{Q.}{E.}c\right) \div \frac{Q.}{E.}c$$

$$\frac{\overset{*}{Q}i}{Ei} = \left(\frac{Qi}{Ei}p \quad \frac{Qi}{Ei}c\right) \div \frac{Qi}{Ei}c$$

Quality of Service

While this estimating procedure yields provincial comparisons of productivity performance, it reveals nothing about the quality of the services performed. Provincial variations in quality could, however, be important. It is quite conceivable that a higher output per physician is associated with a lower quality of service and, vice versa, a lower output per physician with a higher quality of service. Provincial comparisons of productivity performance would be misleading, therefore, if quality varied greatly from one province to the next. Unfortunately, no comprehensive measures of the quality of physicians' services exist. Some partial indicators, however, are available or can be derived. Among the latter are the post-operative mortality rates and the post-operative length of hospital stay.

The Morbidity Section of Statistics Canada has collected, with the cooperation of the provinces, data on length of post-operative hospital stay and post-operative mortality. Since these data are not available on a "standardized" basis and since post-operative mortality rates are generally very low -- on average less than one per cent -- estimates of provincial variations were not based on a small sample but derived from the population universe. It included all of the more common surgical procedures performed during the years 1974, 1975 and 1976 and in total encompassed over four million observations.

In standardizing post-operative rates of mortality and length of hospital stay essentially the same estimating technique was applied as in the earlier analysis of productivity performance. There, output per physician was standardized for degree of specialization, here the post-operative rates are standardized for the type of surgical procedure, the age of the patient, the sex of the patient, and some other factors. This could have been done by the usual standardization procedure of estimating how each province would have performed had its population characteristics been identical with the Canadian average. Instead, a procedure is applied which not only standardizes the provincial rates but also provides estimates of the impact of such population characteristics.

The performance of a province p, as measured by the provincial post-operative mortality rate Mp and covering all common surgical procedures performed in a particular year, is assumed to be a function of the type of operation T, the age of the patient A, the size of the hospital S, the degree of morbidity D, and the quality of surgery as well as all other residual factors Q. This reflects the fact that post-operative mortality rates do vary, in part, because of variations in the skill of the surgeon and attending medical staff and, in part, because some operations, e.g. brain surgery, are much riskier than others; and older patients are not as resilient as younger patients. They may also vary because the operations are performed in a smaller hospital where access to equipment and specialist is limited; and they may vary because the patient is in poor health or the disease has progressed to the stage where it makes the operation riskier. Denoting this functional relationship by (3), the objective of the analysis is to determine how much of the

$$(3) \quad M_p = f_p(T, A, S, D, Q)$$

where

M_p = average provincial mortality rate
T = type of operation
A = age of patient
S = size of hospital
D = degree of morbidity
Q = quality of surgery

difference between the Canadian mortality rate Mc and the provincial mortality rate Mp can be attributed to differences in the variables T, A, S, D, and the quality variable Q. It requires finding weights w_t, w_a, w_a, w_d and w_g which attribute the overall differences in mortality rates to individual sources as in (4).

$$(4) \quad \overset{*}{m} = f_d(W_t\overset{*}{T}, W_a\overset{*}{A}, W_s\overset{*}{S}, W_d\overset{*}{D}, W_q\overset{*}{Q})$$

where

$\overset{*}{m} = (M_p - M_c) \div M_c$
$\overset{*}{T} = (T_p - T_c) \div T_c$
$\overset{*}{A} = (A_p - A_c) \div A_c$
$\overset{*}{S} = (S_p - S_c) \div S_c$
$\overset{*}{D} = (D_p - D_c) \div D_c$
$\overset{*}{Q} = (Q_p - Q_c) \div Q_c$

The details of the weighting procedure are shown in (5) and (6). The two equations suggest that the difference $\overset{*}{m}$ between provincial and national mortality rates is attributed, at the most disaggregate level, to the difference in the post-operative mortality of the same type of operation t, of patients belonging to the same age group a, admitted to hospitals of the same size group s, being short or long term patients i. The weights w_{tasi} to w_t in (5) are more explicitly stated in (6) where the asterisks denote the differences in mortality rates m or in numbers n and where the hats denote certain ratios.

$$(5) \quad \overset{*}{m} = \sum_t \sum_a \sum_s \sum_i w_{tasi} \overset{*}{m}_{tasi}$$

$$+ \sum_t \sum_a \sum_s \sum_i w_{tasi} \overset{*}{n}_{tasi}$$

$$+ \sum_t \sum_a \sum_s w_{tas} \overset{*}{n}_{tas}$$

$$+ \sum_t \sum_a w_{ta} \overset{*}{n}_{ta}$$

$$+ \sum_t w_t \overset{*}{n}_t$$

(6) $$\overset{*}{m} = \sum_t \hat{m}_t \hat{n}_t \sum_a \hat{m}_{ta} \hat{n}_{ta} \sum_s \hat{m}_{tas} \hat{n}_{tas} \sum_i \hat{m}_{tasi} \hat{n}_{tasi} \overset{*}{m}_{tasi}$$

$$+ \sum_t \hat{m}_t \hat{n}_t \sum_a \hat{m}_{ta} \hat{n}_{ta} \sum_s \hat{m}_{tas} \hat{n}_{tas} \sum_i (\hat{m}_{tasi} - 1.0) \overset{*}{n}_{tasi}$$

$$+ \sum_t \hat{m}_t \hat{n}_t \sum_a \hat{m}_{ta} \hat{n}_{ta} \sum_s (\hat{m}_{tas} - 1.0) \overset{*}{n}_{tas}$$

$$+ \sum_t \hat{m}_t \hat{n}_t \sum_a (\hat{m}_{ta} - 1.0) \overset{*}{n}_{ta}$$

$$+ \sum_t (\hat{m}_t - 1.0) \overset{*}{n}_t$$

Essentially the same estimation technique applies to provincial variations in length of post-operative stay. It is only necessary to switch from differences and ratios of post-operative mortality to differences and ratios of post-operative stay. In either case, the derivation of the relevant equations is somewhat lengthy and, therefore, described elsewhere (see Appendix VII). Also during the course of the empirical analysis the estimating procedures were modified somewhat. This was done to facilitate computer programming and did not change the overall approach.

The underlying data base is large. As shown in Table 4, during the years 1974-76 about 3.7 million cases were admitted to hospitals annually. About half of them had surgery performed and of those the present study covers 1.4 million cases or roughly

70-75 per cent of all surgery. Cases were excluded for a variety of reasons: certain hospitals were excluded to abide by confidentiality requirements; all diagnostic and therapeutic treatments were excluded since they were not primarily surgical; and of the remaining cases all surgical procedures not performed at least 1,000 times per year in Canada (for one or both of the sexes), were excluded. As a result the data bank was limited to 163 surgical procedures of which 126 related to males and 155 to females.

Table 4

Data Base for the Analysis of Provincial Variations in Post-operative Mortality, Canada, 1974-76

	Number of Hospital Cases (Separations)		
	Hospital Morbidity	All Surgical, Diagnostic and Therapeutic Procedures	Surgical Procedures Included in Data Base
		(in 1,000's)	
1974	3,710	1,890	1,444
1975	3,680	1,900	1,431
1976	3,622	1,877	1,381
Three-year Total	11,012	5,667	4,256

Source Statistics Canada. Hospital Morbidity. STATCAN Catalogue No. 82-206; Statistics Canada. Surgical Procedures and Treatments. STATCAN Catalogue No. 82-208; and Data Base provided by the Morbidity Section of Statistics Canada.

To facilitate the analysis, the data on surgical procedures were grouped into 16 major "chapters" of surgical procedures and 5 "risk categories" within chapters; hospital patients were grouped into 11 age groups; hospitals into 5 size groups, and morbidity into 2 length-of-stay groups. They were grouped separately for males and females, and distributed annually over 10 provincial matrices with 17,600 elements each. Not all the matrix elements were non-zero since most of the surgical chapters did not contain all five risk categories and since some of the smaller, less populous provinces did not have hospitals in all five size groups.

The empirical analysis was subject to a variety of limitations. Confidentiality requirements imposed some restrictions. For example, in case of physicians' services all 10 provinces granted permission to access the data but some did not permit examination of the 116 different activities performed by any one of the 18 categories of specialists. Hence, it was not possible to determine how much the mix of activities, in one and the same specialty, varied across the country and, in particular, whether the mix of activities was conditioned by provincial variations in fee-payment schedules.

Also confidentiality requirements of post-operative mortality rates and length-of-stay rates imposed some restrictions. Data could only be accessed if at least two hospitals were in the same size group. In only three of the 10 provinces, i.e. Newfoundland, Ontario and Quebec, could data of all hospital size groups be accessed. Data restrictions of this type affected the empirical estimates but it was possible to test the robustness of the final results by pairing the "singles" in a particular hospital size group with one or two hospitals of adjacent size groups. As it turned out the omission of some of the hospitals did not alter the results significantly. Aside from hospital-size considerations it had no impact on the conclusions of the study.

Some of the data sets were adjusted for inconsistencies that emerged as the data were screened by sum and ratio tests. As a rule these adjustments were minor. Certain data gaps, however, could not be avoided and may have affected the results. Data on physicians' services were generally available for the years 1974, 1975, and 1976 but not all provinces reported each year. The data for Newfoundland were not available for the year 1974 and those of Prince Edward Island were only available for the year 1976 and, hence, the analysis of these two provinces did not cover all three years. Also, radiologists and pathologists were excluded from the analysis because of provincial incomparabilities. In some cases, one radiologist or pathologists was credited with the earnings of an entire clinic when much of it consisted of wages and salaries of other staff members and employees of the clinic. The impact of these data gaps and deletions remained unknown.

Empirical Analysis: Provincial Variations in Physicians' Productivity, 1974-76

According to our analysis productivity of physicians -- measured by the services delivered per physician equivalent -- varies among the provinces by 20 to 30 per cent (Table 5). Sizeable as these variations are, their range is not quite as large as that of some other sectors of the economy. In federal government administration the Income Maintenance Branch of the Department of Health and Welfare, for example, monitors its operations on a monthly basis and a three-year analysis shows that its productivity varies by as much as 50 per cent among the 10 provinces. In the major goods-producing industries the range of variation is even larger (Auer, 1979; pp. 39, 93). Compared with other sectors of the economy, therefore, the productivity of physicians is more uniform.

In Table 5 a distinction is drawn between the productivity performance of physicians (Col. 1) and output per physician (Col. 3). The first is a measure of the overall productivity performance, the second a measure of the productivity of physicians in individual specialties. To differentiate between the two, the first is defined, arbitrarily, as "productivity of physicians" and the second as "output per physician". Evidently, provincial variations in productivity of physicians come partly from the degree of specialization and partly from output per physicians in individual specialties. The effect of provincial specialization, however, is quite small and accounts for only

Table 5

Provincial Variations in the Productivity Performance of Physicians, Canada 1974-1976

	Difference Between Provincial and National Productivity of Physicians	Contribution	
		Specialization	Output per physician
	- percentage difference between province and Canada -		
All Physicians			
NFLD.	13	0	13
P.E.I.	-2	-2	0
N.S.	-6	-1	-5
N.B.	2	0	2
QUE.	6	1	5
ONT.	1	0	1
MAN.	-8	0	-8
SASK.	1	-2	3
ALTA.	-5	0	-5
B.C.	-10	0	-10
CANADA	0	0	0
General Practitioners and Medical Specialists			
NFLD.	19	-1	20
P.E.I.	0	-1	1
N.S.	-8	0	-8
N.B.	9	-1	10
QUE.	4	1	3
ONT.	1	0	1
MAN.	-8	0	-8
SASK.	5	-1	6
ALTA.	-4	-1	-3
B.C.	-10	0	-10
CANADA	0	0	0
Surgical Specialists (incl. Anesthetists)			
NFLD.	2	0	2
P.E.I.	-5	-1	-4
N.S.	-3	-2	-1
N.B.	-15	-1	-14
QUE.	8	0	8
ONT.	1	0	1
MAN.	-7	2	-9
SASK.	-6	0	-6
ALTA.	-7	0	-7
B.C.	-12	-1	-11
CANADA	0	0	0

Estimates of the output per physician are "standardized" for the effects of provincial variations in the distribution of specialists. Positive values indicate a better average performance, negative values a poorer performance.

Source Estimates are based on data of the Health Information Division of the Department of Health and Welfare.

about one-tenth of all the variation. Quebec is the only province where specialization has a positive effect, in the other provinces it has a slightly negative effect or none at all. Most of the provincial variations in productivity can be attributed, therefore, to higher or lower output of physicians in individual specialties.

Estimates of the contribution of specialization and output per physician equivalent in each speciality to the difference between provincial and national output per physician are based on three groupings listed separately in Table 5. The first grouping refers to "All Physicians" and includes all 18 specialities listed below. The second grouping refers to "General Practitioners and Medical Specialists" and consists of specialities

No.	Speciality
1	General Practice
2	Internal Medicine
3	Pediatrics
4	Psychiatry
5	Neurology
6	Dermatology
7	Physical Medicine
8	General Surgery
9	Orthopedic Surgery
10	Urology
11	Cardiac/Thoracic Surgery
12	Plastic Surgery
13	Neurosurgery
14	Ophthalmology
15	Otolaryngology
16	Ophthalmology/Otolaryngology
17	Obstetrics/Gynecology
18	Anaesthesia

1 to 7. The third grouping refers to "Surgical Specialists and Anesthetists" and comprises specialties 8 to 18. It is noteworthy that the General Practitioners and Medical Specialists of the second grouping account for nearly three quarters of all physicians while Surgical Specialists (including Anesthetists) of the third grouping, account for only a little over one quarter.

Estimates of the output per physician, therefore, depend to a greater extent on the performance of general practitioners and medical specialists than that of surgical specialists. The above-average performance of Newfoundland, for exampe, comes largely from the above average performance of general practitioners and medical specialists as does the below average performance of Nova Scotia. New Brunswick's close-to-average performance of all physicians comes from a strong performance of general practitioners and medical specialists and a weak performance of surgical specialists. The same goes for Saskatchewan. Elsewhere the performance is more evenly distributed. Quebec's output per physician is above average in all three groupings, Ontario's is close to average, and Manitoba's, Alberta's, and British Columbia's are below average.

These results are unexpected. They do not correspond to the earlier findings of provincial variations in the goods-producing industries (Auer, 1979). There, productivity performance was found to be consistently above the Canadian average in British Columbia, Alberta and Ontario but below average in Quebec and the Atlantic provinces. Here, output per physician is below the

Canadian average in British Columbia and Alberta but above average in Quebec and Newfoundland. It implies that physicians in some of the high-income provinces have a lower output than their counterparts in some of the low-income provinces.

Productivity and Income

This raises an interesting question. In the goods-producing industries wage rates of the "richer" provinces are higher than wage rates of the "poorer" provinces. Many factors give rise to these differences, for example, the provincial variations in machinery and equipment per worker, plant management, market demand, returns to scale, natural resources, and employment opportunities in different occupations. Overall, there is a fairly close relation between provincial wage rates and output per worker. The question here is whether provincial variations in payment per physician are primarily related to output per physician or more nearly associated with other variables.

If physicians were paid according to their output we would expect that payment for physicians' services in some provinces would be higher than in others, just as output per physician is higher in some than in others. Indeed if output per physician were the sole criterion of performance, we would expect a precise match between provincial variations in gross payment per physician and output per physician. In reality this is not so.

As shown in Table 6 the gaps between gross payment and output per physician are large in three of the ten provinces.

It would be premature at this point to conclude in which of the provinces the income of physicians is close to productivity and in which it is not. The correspondence of the two depends on which measures of income are used. Gross payment per physician in Table 6 is based on average provincial fee-for-service payments. This measure covers exactly the same services of physicians as those included in the productivity measure of Table 5. In concept gross payment comes fairly close to gross professional earnings but the latter covers a broader range of activities; it includes payments to physicians who "opted out" and includes wages and salaries incidental to practice. Net professional earnings exclude all expenses of practice and net income from all sources excludes all expenses of practice but includes income from all other sources.

A more comprehensive comparison of the productivity of physicians with their incomes is presented in Table 7. It shows how much the provincial incomes of physicians differ from productivity, for several measures of income. Negative values in this table imply that physicians of a particular province are paid less than their productivity and, conversely, positive values imply that they are paid more than their productivity.

Table 6

Comparison of Provincial With Canadian Gross Payments per Physician, 1974-1976

	Gross Payment[1] per Physician	Productivity of Physicians	Difference Between Gross Payment and productivity of physicians
	- percentage difference between province and Canada -		- percentage points -
All Physicians			
NFLD.	+ 1	13	-12
P.E.I.	+ 1	- 2	3
N.S.	- 1	- 6	5
N.B.	- 6	2	- 8
QUE.	- 3	6	- 9
ONT.	0	1	- 1
MAN.	- 6	- 8	2
SASK.	- 4	1	- 5
ALTA.	+ 7	- 5	12
B.C.	+10	-10	20
CANADA	0	0	0
General Practitioners and Medical Specialists			
NFLD.	0	19	-19
P.E.I.	- 2	0	- 2
N.S.	- 6	- 8	2
N.B.	- 1	9	-10
QUE.	- 5	4	- 9
ONT.	- 1	1	- 2
MAN.	- 6	- 8	2
SASK.	- 1	5	- 6
ALTA.	+10	- 4	14
B.C.	+13	-10	23
CANADA	0	0	0
Surgical Specialists incl. Anesthetists			
NFLD.	+ 3	2	1
P.E.I.	+ 8	-5	13
N.S.	+10	-3	13
N.B.	-14	-15	1
QUE.	- 1	8	- 9
ONT.	+ 1	1	0
MAN.	- 6	-7	1
SASK.	-11	-6	5
ALTA.	- 1	-7	6
B.C.	+ 3	-12	15
CANADA	0	0	0

1 Gross payment per physician is estimated as the percentage difference between the provincial fee-for-service payment per physician and the payment physicians would have received had they been paid the average Canadian fee-for-service payment in each of their specialities and activities.

2 Estimates of provincial variations in productivity of physicians are taken from column 1 of Table 5.

3 Negative values in this column imply that physicians are paid less than measured productivity and, conversely, positive values imply that they are paid more than their productivity.

Source Same as for Table 5.

For the Atlantic Region, for example, the estimates imply that physicians in Newfoundland and New Brunswick are underpaid while those of Nova Scotia are overpaid. In the central region Quebec's gross payments and earnings seem to be out of line but net earnings and net income are close to productivity. All of Ontario's income estimates are very close to the productivity estimates, closer than in any other province. By the same criterion Saskatchewan's physicians are underpaid while Alberta's are overpaid. Payments of physicians in British Columbia are well above productivity but their net income is nearly the same as their productivity.

Tentatively one might conclude, therefore, that physicians of Newfoundland, New Brunswick and Saskatchewan are paid below productivity while physicians of Nova Scotia and Alberta are paid above productivity. This is a tentative conclusion. Productivity of physicians - as measured in this context - is merely a quantitative measure and not designed to capture variations in the quality of service. Perhaps if quality were taken into account the apparent discrepancies between incomes and productivity of physicians would narrow or disappear entirely.

Quality of Services

Unfortunately, no comprehensive measures of the quality of physicians' services exist but certain indexes may serve as first indicators. Earlier it was shown that life expectancy and

Table 7

Comparison of Physicians' Productivity with Physicians' Incomes, by Province 1974-1976

	Difference Between Productivity and Income			
	Gross Payments	Gross Professional Earnings	Net Professional Earnings	Net Income from all Sources
	Difference in percentage points			
NFLD.	-12	-14	-7	- 6
P.E.I.	3	- 4	-9	-11
N.S.	5	3	9	11
N.B.	-8	-11	-5	- 6
QUE.	-9	-11	-1	2
ONT.	-1	0	-2	- 2
MAN.	2	16	1	4
SASK.	-5	- 4	-9	- 7
ALTA.	12	18	6	6
B.C.	20	10	5	1
CAN	0	0	0	0

1 The numbers in the first column of this Table from the third column of Table 6. The numbers of the other columns are estimated analogously. All of them represent the difference in percentage points between productivity and incomes of physicians. Negative values imply that physicians are paid less than measured productivity and, conversely, positive values imply that they are paid more than their productivity.

Source Same as for Table 5.

mortality rates are linked to the availability of physicians' services as indicated by population/physician ratios. It was also noted that this link was quite evident in international comparisons of low and high income countries but much less so, if at all, in comparisons of the highly industrialized countries where access to physicians has not been a major problem.

To measure the provincial variations in the quality of physicians' services, more refined measures are required. Ideally the quality of their services should be measured in each of the 18 specialities and for each of the 116 activities, for which the quantity of output was measured earlier. Data to cover all these elements, are not available. Certain aspects, however, can be quantified. Two measures will be used here: the postoperative mortality rate and the postoperative length of hospital stay. The underlying assumption is that superior quality of service lowers the postoperative mortality and shortens the length of hospital stay. Both measures are partial and somewhat diffused. They cover primarily the domain of surgical specialists and only marginally that of general practitioners and medical specialists. Neither of them is focussed exclusively on the quality of surgery but each encompasses a variety of other factors.

In analyzing variations in quality of surgery we start out with the provincial average rates of postoperative mortality and the provincial average length of hospital stay. Canada-wide the estimates reflect the outcome of over 4 million operations or 1.4 million per year. They include all those operations of which at least 1,000 were performed in Canada per year and comprise 126 different surgical procedures of males and 155 of females.[16] The latter include all the major gynocological procedures. For both sexes together, they span 75 to 80 per cent of all surgical procedures performed in Canada.

Postoperative mortality rates vary among the provinces, in the case of males from a low of 69 per cent of the Canadian average to a high of 121 per cent and in case of females from a low of 51 per cent to a high of 122 per cent, a range of 50 to 70 percentage points. The length of postoperative hospital stay varies less, with an approximate range of 20 to 40 per cent and with most provinces coming close to the Canadian average (Table 8).

Average rates of postoperative mortality and length of hospital stay differ among provinces not only because of variations in quality of surgery and postoperative care but because of other factors as well. They depend on the type of operations performed because some, e.g. cardiac or thoracic surgery, are far more risky than others, say tonsillectomy or appendectomy. They depend on the age of the patient since operations performed on infants below the age of one or on elderly patients above the age of 60, are more risky than for the age groups inbetween. And they may depend on the quality of surgical facilities which, in turn, may depend on hospital size.

Table 8

Average Annual Postoperative Mortality Rates and Length of Hospital Stay by Provinces: 1974-1976[1]

	Number of Operations per year	Average Postoperative Mortality		Average Length of Postoperative Hospital Stay	
	No.'s	Rate[2]	Per Cent	Days	Per Cent
Males					
NFLD.*	8 528	7.6	109	10.3	129
P.E.I.	2 222	6.5	94	6.8	85
N.S.*	12 376	8.2	119	9.2	115
N.B.*	10 816	4.8	69	8.0	100
QUE.	124 855	6.3	91	8.1	101
ONT.	208 875	6.9	100	7.7	96
MAN.	16 422	6.7	97	8.0	100
SASK.	18 214	5.0	72	8.2	103
ALTA.	55 796	8.3	121	8.1	101
B.C.	48 516	7.7	112	8.3	104
CANADA	507 000	6.9	100	8.0	100
Females					
NFLD.*	21 133	2.4	76	7.8	113
P.E.I.	3 201	3.0	94	6.3	92
N.S.*	22 655	3.9	122	7.9	114
N.B.*	24 002	1.6	51	6.9	100
QUE.	250 349	2.6	81	6.8	99
ONT.	353 502	3.6	112	6.8	99
MAN.	27 369	3.5	108	7.0	102
SASK.	29 147	3.0	93	7.0	101
ALTA.	96 163	3.5	109	6.7	98
B.C.	85 116	3.5	109	7.0	101
CANADA	912 000	3.2	100	6.9	100

1 These estimates are based on operations of which at least 1,000 were performed per year. They are not standardized for type of operation, age of patient, hospital size or co-morbidity. For standardized estimates see Tables 9 and 10.

2 Rate per 1000 cases.

* Based on two years of observations, estimates for other provinces are based on three years.

Source Estimates are based on data of the Health Division of Statistics Canada.

In estimating provincial variations of the quality of surgery the impact of all these and perhaps of some other factors ought to be taken into account. While a complete accounting is not possible it can be shown how important some of these factors are, how much they contribute to provincial variations in postoperative mortality rates, and whether quality of surgery is likely to vary among the provinces or not.

Results of this analysis are summarized in Table 9. They describe the provincial variations in postoperative mortality rates in terms of percentage differences from the Canadian average. The overall differences in rates are listed in the first column of the Table, those "standardized" for type of operation, age of patient, and size of hospital in the last column. The standardized rates show that under similar conditions the probability of survival after surgery varies considerably among the provinces. It is estimated to be at least 10 per cent higher in British Columbia and Prince Edward Island, and at least 15 per cent lower in Alberta and Nova Scotia, for both male and female patients. It suggests that quality of surgery and postoperative care may vary quite widely among the provinces.

Also the estimates show that some of the more difficult and riskier operations are performed in British Columbia and Newfoundland and that they have a negative effect on postoperative survival rates there. Similarly, less favourable

Table 9

Contribution of Selected Factors to Provincial Variations in Postoperative Mortality Rates, by Provinces, 1974-1976

	Difference Between Average Canadian and Provincial Mortality	Contribution of Selected Factors			
		Type of Operation	Age of Patient	Size of Hospital	Quality of Service
	- percentage point difference between Canada and province -				
Males					
NFLD.*	- 9	-34	14	6	5
P.E.I.	6	- 5	- 7	5	13
N.S.*	-19	13	-13	7	-26
N.B.*	31	20	- 1	7	5
QUE.	9	- 1	9	- 1	2
ONT.	0	0	0	0	0
MAN.	3	10	-16	4	5
SASK.	28	19	-13	7	15
ALTA.	-21	6	- 2	- 3	-22
B.C.	-12	-15	- 9	- 1	13
CANADA	0	0	0	0	0
Females					
NFLD.*	24	8	15	1	0
P.E.I.	6	-64	12	17	41
N.S.*	-22	17	-12	6	-33
N.B.*	49	16	9	6	18
QUE.	19	15	5	0	- 1
ONT.	-12	-10	- 4	- 1	3
MAN.	- 8	- 3	-15	3	7
SASK.	7	9	-12	7	3
ALTA.	- 9	1	11	- 3	-18
B.C.	- 9	-15	- 6	0	12
CANADA	0	0	0	0	0

1 Differences are derived from the "Average Mortality" rates of Table 8. The difference of -9 percentage points for Newfoundland, for example, implies that the mortality rate in Newfoundland was 9 percentage points less favourable, i.e., 9 per cent higher, than for Canada. It corresponds to the 109 per cent in column 3 of Table 8.

2 The variations in "Quality of Service" are standardized for type of operation, age of patient and size of hospital. They may relate not only to variations in quality of surgery and postoperative care but also to other factors not identified here. Positive values under "Quality of Service", so defined, denote a lower postoperative mortality and a potentially higher quality of service; negative values denote a higher postoperative mortality and a potentially lower quality of service. Estimates of the "Quality of Service" (Col. 5), together with the other factors (Cols. 2, 3, 4), are additive and account for the total difference between Canadian and provincial postoperative mortality rates (Col. 1).

* Based on two years of observations, others based on three years.

Source Estimates based on data of the Health Division of Statistics Canada.

age distributions with relatively more patients above the age of 50, lower the survival rates in British Columbia and even more so in Saskatchewan, Manitoba and Nova Scotia.[17]

Estimates of provincial variations in length of postoperative hospital stay are presented in Table 10. Again the provincial variations are measured in terms of percentage differences from the Canadian average. The differences between the average Canadian and the provincial postoperative hospital stays are listed in the first column and the contribution of five factors in the other columns. The more difficult and riskier operations which contributed to higher mortality rates in British Columbia and Newfoundland, also had a negative (lengthening) effect on hospital stay. Similarly the shift in age distribution towards the elderly has a negative effect in British Columbia, Saskatchewan and Manitoba. By contrast a more favourable age distribution, in Newfoundland and Quebec, with a shift towards younger age groups, has a positive effect and shortens hospital stay, at least for males. In British Columbia superior quality of surgery and postoperative care not only lowers postoperative mortality but also shortens stay. In Nova Scotia and Newfoundland, however, it lengthens it not only because of possible differences in quality of service but also because of a tendency for comorbidity or overstay. It means that in these two provinces some patients suffered from ailments, possibly not linked to the operation, or simply stayed in hospital for an abnormal length of time, sometimes for over a year or two.

Table 10

Contribution of Selected Factors to Provincial Variations in Postoperative Length of Stay, by Provinces, 1974-1976

	Difference Between Average Canadian and Provincial Stay	Contribution of Selected Factors				
		Type of Operation	Age of Patient	Size of Hospital	Comorbidity or Overstay	Quality of Service
	- percentage point difference between Canada and Province -					
Males						
NFLD.*	-29	- 8	5	1	- 7	-20
P.E.I.	15	7	- 1	6	0	3
N.S.*	-15	3	0	5	- 6	-17
N.B.*	0	7	1	6	- 3	-11
QUE.	- 1	- 1	2	- 1	0	- 1
ONT.	4	2	0	- 1	1	2
MAN.	0	1	- 3	3	- 2	1
SASK.	- 3	3	- 2	4	- 1	- 7
ALTA.	- 1	0	0	- 1	- 1	1
B.C.	- 4	- 9	- 2	0	1	6
CANADA	0	0	0	0	0	0
Females						
NFLD.*	-13	3	3	0	- 5	-14
P.E.I.	8	- 4	- 1	2	1	10
N.S.*	-14	2	0	2	- 4	-14
N.B.*	0	4	1	2	0	- 7
QUE.	1	3	0	- 1	0	- 1
ONT.	1	0	- 1	0	0	2
MAN.	- 2	- 1	- 3	2	0	0
SASK.	- 1	0	- 1	3	- 2	- 1
ALTA.	2	- 1	3	0	0	0
B.C.	- 1	- 5	- 1	0	- 2	3
CANADA	0	0	0	0	0	0

1 Differences are derived from the average-length-of-stay rates of Table 8. The difference of 29 percentage points for Newfoundland, for example, implies that the length of stay was 29 percentage points less favourable, i.e., 29 per cent longer than for Canada. It corresponds to the 129 per cent in column 5 of Table 8.

2 The variations in "Quality of Service" are standardized for type of operation, age of patient, size of hospital, and comorbidity or overstay. They may not only relate to variations in quality of surgery and postoperative care but also to other factors not identified here. Positive values under "Quality of Service", so defined, denote shorter postoperative stay and a potentially higher quality of service; negative values denote a longer postoperative stay and a potentially lower quality of service. Estimates of the "Quality of Service" (Col. 5), together with the other factors (Cols. 2, 3, 4) are additive and account for the total difference between Canadian and provincial postoperative mortality rates (Col. 1).

* Based on two years of observations; others based on three years.

Source Estimates based on data of the Health Division of Statistics Canada.

Earlier it was noted that physicians of Newfoundland, New Brunswick and Saskatchewan are paid below estimated productivity while physicians of Nova Scotia and Alberta are paid above estimated productivity. Taking postoperative mortality and hospital stay -- standardized for type of operation, age of patient, hospital size, and comorbidity -- as an indicator of quality of surgery and postoperative care, there is no clear evidence that quality is inferior in Newfoundland, New Brunswick or Saskatchewan. Although hospital stay in these provinces is longer, standardized postoperative mortality is below the national average and quality, so measured, is better than average in all three provinces. Nor is there evidence that the quality of services is superior in Nova Scotia and Alberta. In both provinces postoperative mortality (standardized) is well above the national average and hospital stay in Nova Scotia is longer than average. Among the other provinces Quebec and Ontario come closest to the national average, Manitoba is doing better than average, and British Columbia is doing consistently better (Table 11).

Other measures of the quality of physicians' services cannot be as readily standardized and give a more diffused impression. Sometimes they confirm the underlying provincial pattern traced by postoperative mortality and length of hospital stay, and sometimes they don't. A frequently used indicator of the quality of health care is infant mortality. It was shown earlier in this

Table 11

Provincial Variations in Postoperative Mortality and Length of Hospital Stay, Attributable to Quality of Service, by Provinces, 1974-1976[1]

	Index of Postoperative Mortality		Index of Postoperative Length of Stay	
	Males	Females	Males	Females
NFLD.	105	100	80	86
P.E.I.	113	141	103	110
N.S.	74	67	83	86
N.B.	105	118	89	93
QUE.	102	99	99	99
ONT.	100	103	102	102
MAN.	105	107	101	100
SASK.	115	103	93	99
ALTA.	78	82	101	100
B.C.	113	112	106	103
CANADA	100	100	100	100

1 The Index of Postoperative Mortality is based on Col. 5 of Table 9 and the Index of Postoperative Length of Stay on Col. 6 of Table 10. A better than average performance is rated above 100 and a poorer performance below 100 per cent.

paper that there was a link, albeit tenuous, between the number of physicians per capita and infant mortality. A more refined measure is neonatal mortality resulting from "injury at birth", which accounts for part of all neonatal deaths. This type of mortality was above the Canadian average in Newfoundland and in all three prairie provinces with Alberta ranking highest, at over twice the Canadian average (Table 12).

Postoperative mortality rates and infant mortality rates depend on the quality of physicians' services as well as on the quality of hospital care, that is the quality of nursing care, diagnostic and therapeutic services, and other supportive services. It might well be that turnover rates of hospital staff have an effect on hospital care. Turnover rates of hospital staff are below average in Prince Edward Island, in New Brunswick, Quebec, Ontario and British Columbia. They are above average in Newfoundland, Nova Scotia and the Prairie Provinces. In Alberta they are highest, nearly twice as high as the Canadian average (Table 13).

These additional indicators of quality are not closely correlated with those of postoperative mortality and hospital stay. Nor are they closely correlated with the provincial patterns of productivity and incomes of physicians. They do confirm, however, the earlier finding that Nova Scotia and Alberta -- the two provinces with above average income-to-productivity ratios of physicians -- do not perform consistently better than other provinces. The turnover rates of hospital staff are above average in both provinces and the neonatal mortality rate arising from injury at birth is highest in Alberta.

It seems, therefore, that the link between provincial productivity of physicians and provincial incomes of physicians is not very strong and that other factors must be involved. They

Table 12

Neonatal Mortality Rates, Canada and Provinces, 1974-76

	From all Causes[1]		From Injury at Birth[2]	
	Rate per 100,000	Per Cent	Rate per 100,000	Per Cent
NFLD.	1,040	111	66	129
P.E.I.	1,292	137	34	67
N.S.	910	97	28	55
N.B.	983	105	29	57
QUE.[3]	925	98	37	73
ONT.	899	96	50	98
MAN.	1,020	109	88	173
SASK.	1,070	114	69	135
ALTA.	928	99	111	218
B.C.	961	102	20	39
CANADA	940	100	51	100

1 They include, among others, infective and parasitic diseases, neoplasms, diseases of the respiratory system, congenital anomalies, accidents, poisonings and violence.

2 Refers primarily to instrumental injuries to the brain, spinal cord, bones and nervous system. It does not preclude non-instrumental injuries, however.

3 The neonatal rates of Quebec are not adjusted for under-reporting. Adjustment would have raised Quebec's rates by possibly 10 per cent.

Source Based on data of Statistics Canada and estimates by the Economic Council of Canada.

Table 13

Turnover Rates of Hospital Staff, Provinces Relative to Canada, 1973-75[1]

	Turnover Rates of Staff		
	Nursing Staff	Diagnostic and Therapeutic Staff	Administrative and Supportive Staff
	- per cent -		
NFLD.	135	115	106
P.E.I.	87	75	76
N.S.	119	105	110
N.B.	91	99	104
QUE.	85	94	87
ONT.	86	93	88
MAN.	123	118	144
SASK.	141	126	127
ALTA.	160	152	190
B.C.	104	90	72
CANADA	100	100	100

1 Turnover rates of staff refer to the numbers of separation per full-time staff members averaged over two years. The turnover rates in this table are averaged over the years 1973-75. The average values for 1975/76 have not yet been published.

Source Based on Hospital Statistics, Vol. I - Beds, Services Personnel, Statistics Canada, Catalogue No. 83-227; Hospital Statistics, Vol. II - Expenditures, Revenues, Balance Sheets, Statistics Canada, Catalogue No. 83-228; Hospital Statistics, Preliminary Annual Report, Statistics Canada, Catalogue No. 83-217.

will not be examined here. Instead the question of access to physicians' services will be raised. If the productivity of physicians in some of the poorer provinces is higher than in some of the richer provinces, as the results of this study imply, does it mean that these variations in productivity compensate for the smaller or larger numbers of physicians per capita so that people all across Canada have the same access to physicians' services?

Provincial Access to Physicians' Services

Federal provincial programs for financing health insurance programs have the central objective of providing "equal access" of health services to all Canadians irrespective of province of residence. When issues of equal access to service are raised, concern is expressed implicitly that demand and supply are not all that well matched in spite of public funding and ever rising costs. While it seems difficult to keep the costs of health services under control, it seems even more difficult to assure equal access across the provinces.

For a starter, equal access is not readily defined. It might be defined, for example, as the same expenditure of health services, irrespective of province. Or it might be defined as the same level of health services, irrespective of costs or prices. Then again it could be defined so as to take into account the provincial variations in age structure and possibly, too, the provincial incidence of morbidity.

A provincial ranking of physician equivalents per 100,000 population puts the level of services in the Atlantic Region and the Prairie Provinces 10 to 25 per cent below the national average and in Quebec, Ontario and in British Columbia about 5 to 10 per cent above the national average. This ranking approaches that of per capita incomes. There are exceptions, however. Quebec ranks substantially higher and Alberta considerably lower.

Table 14

Two Measures of Physician Inputs per 100,000 Population, Canada and Provinces, 1974-76

	Full-Time Equivalents			
	Fee-Practice		Productivity Adjusted	
	Rate	Per Cent	Rate	Per Cent
NFLD.	52	53	59	60
P.E.I.	78	80	78	80
N.S.	94	96	89	91
N.B.	71	72	73	74
QUE.	101	103	106	108
ONT.	103	105	104	106
MAN.	98	100	90	92
SASK.	84	86	87	98
ALTA.	91	93	86	88
B.C.	112	114	101	103
CANADA	98	100	98	100

1 Estimates of Newfoundland's full-time equivalents are not strictly comparable with other provinces when used as a measure of physician inputs per 100,000 population because they exclude the physicians employed by cottage hospitals who are classified as salaried and not as fee-practice physicians.

Source Based on B.L. Ouellet, Health Field Indicators, Canada and Provinces, Dept. of Health and Welfare, Sept. 1979, Table 37, page 91 and data of Physician Equivalents of the Health Information Division of the Department of Health and Welfare.

Combined with the earlier finding of provincial variations in productivity of physicians access to physicians' services can be measured on a per-capita basis. The results show that the provincial variations in physicians services narrow when productivity differences between provinces are incorporated. Nevertheless, there remains a twenty to thirty per cent range of disparities. The conclusion is that in spite of federal and provincial funding of health services some of the traditional disparities among the provinces have not been eliminated (Table 14).

As long as federal and provincial funding is based on per-capita requirements -- as it is today -- this is an important finding. If public funding were ever to take the age structure of the population into account -- as it should be -- these disparities might either narrow or widen. It would be of interest to explore this question in future research.

Notes

1 In the same publication other measures of a country's health status are listed as the crude rate of birth, the crude rate of death, and infant mortality (Annex 2, p. 73).

2 Access to physicians and nurses is measured here by the number of each per 100,000 people. A description of the regression analysis is presented in Appendix I.

3 The potential for prevention of infant mortality is assessed in Appendix II.

4 Results of the infant mortality analysis are described in Appendix III.

5 According to a recent study by Russell a substantial part of the unprecedented growth in recent years of medical care costs, and of hospital costs in particular, has come from the additional resources devoted to new technologies. Benefits attributed to them, appear to be of a much lower order than costs. The value of many forms of respiratory therapy, for example, has been seriously questioned. Nevertheless, it has spread with astonishing speed. The same pattern seems to hold for cobalt therapy, open-heart surgery and perhaps to a lesser extent, for diagnostic radio-isotopes (Russell, 1979, p. 157).

6 The acronym CAT refers to the "computerized axial tomographic" scanner, a sophisticated X-ray-like machine capable of vastly improving diagnostic techniques. According to one estimate a CAT scanner in Canada costs about $850,000 to buy and $400,000 annually to operate (Lilley, 1980).

7 According to a recent Canadian estimate, 12 per cent of (73,440) premature deaths in Canada in 1974 were found to be attributable to current smoking and 6 per cent to hazardous drinking. Whether premature mortality was expressed in terms of deaths or "premature years of life lost", about 18 per cent of Canadian premature mortality was found to be attributable to current smoking and/or drinking (Ouellet, 1979).

8 Several studies have indicated that the incidence of various kinds of diseases is generally much higher in urban areas than in rural areas, and many of the disparities in morbidity rates have been attributed to air pollution. Studies by Love and Seskin (1973), Smith (1976), Liu and Yu (1977) have shown that air pollution, morbidity, and mortality are correlated.

9 Numerous studies have shown that a significant relation exists between income level and use of health-care facilities.

- Enterline found that the introduction of the medical care insurance program in Quebec affected the profile of utilization. Those in the lower-income groups tended to consume more physician services after the program came into effect than those in the higher-income groups.

- Beck's results suggest that lower-income families in Saskatchewan had less contact with physicians and consumed fewer medical services than higher income families, that these disparities of consumption diminished over the years 1963 to 1968, and that a user charge or utilization fee discouraged the use of physician services more among the lower-income families than others.

- Rodrigue concludes that a small proportion of the Quebec population (about 7 per cent), largely comprised of the elderly, accounts for close to half of the physicians' services under the medical insurance program. Since a larger proportion of the elderly fall into the lower income groups it suggests an inverse relationship between income and use of medical care in Quebec.

- Manga, in a study for the Ontario Economic Council, finds a direct relationship between the value of health service consumed and family income although part of this relationship may have been attributable to other socio-economic and demographic characteristics.

- Statistics Canada published a study, covering family units in all 10 provinces, which concludes that, on average, there was a slightly higher rate of utilization of medical services among the lower income groups than among others.

- Boulet and Henderson examine the distribution of the benefits of the medical and hospital services and find that costs and benefits of these services are very "progressively" distributed and help pay the cost of those who need them most -- the poor and the elderly.

10 Ideally, work in this area should be carried forward to the point where potential improvements are directly linked to associated costs. It has been estimated, for example, that on average Americans would live one year longer if any one of the following causes were eliminated: degenerative diseases; certain infant diseases; motor accidents, other accidents and violence. Eliminate them all and American males would live five years longer. To give policy makers a handle on priorities, some attempts have been made to measure benefits and costs of a variety of programmes in terms of added life expectancy per dollar spent (The Economist, July 1980). It is not known how reliable such estimates are, but if realistic, they could be used to evaluate programme alternatives. Such cost estimates of extending the average life expectancy by alternative means, combined with population characteristics

and restrictions imposed by limited hospital space, physicians and other health service inputs, as well as by provincial and federal governments, would lend themselves to a linear-programming analysis of optimal allocation of scarce public funds.

11 There are quite likely some other sources of provincial variations. One is the quality of service, for example. One might argue that if the output of physicians is measured by the services performed ... "a physician who requires ten treatment services to deal with a flu stricken patient appears to be more productive than the physician who requires only a single service" (Thompson). This might be the case in comparisons of individual physicians, it is probably less significant in comparisons of provincial averages. Nevertheless, the question of provincial variations in quality of service will be examined later in this study.

12 A complete list of the 116 activities is provided in Appendix V.

13 This expression is based on a Taylor Expansion of (1) above. The details of the derivation are described in Appendix VI.

14 To distinguish between aggregate output per full-time physician equivalent (Q./E.) and the corresponding output in any particular specialty (Qi/Ei) the former is referred to as "productivity performance" and the latter as "output per physician equivalent".

15 Procedures of standardization will be described shortly.

16 For a listing of these operations see Appendix VIII.

17 The adjustments for hospital size are not considered here since they reflect, in part at least, the effect of excluding certain hospital sizes. They were excluded to meet confidentiality restrictions.

18 A hospital stay was considered to be of abnormal duration if a patient stayed beyond three standard deviations of the normal length of stay. The normal length of stay, in turn, was defined as the national average length of stay for a patient of the same age group, admitted to a hospital of the same size group, for the same type of operation.

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Appendix I

International Comparison of Life Expectancy

Estimates of the impact of physicians' services on life expectancy are derived from two sets of functions: a set of log-linear functions (Appendix Table I.1) and a set of non-log quadratic functions (Appendix Table I.2).

The first of the log-linear functions is based on a regression covering all 75 countries. The regression coefficients of this function imply that a 10 per cent improvement in access to health services will raise, on average, the life expectancy by 1.5 per cent.[I.1] They also imply that a proportionate increase in the number of physicians raises the life-expectancy five times as much as a corresponding increase in the number of nurses. These global regression coefficients are statistically significant at the 1 per cent level of significance.

The magnitude of the regression coefficients diminishes however, when the sampling range is narrowed. Excluding from the global sample of 75 countries, in stepwise fashion 15 countries at a time, starting with the countries of the lowest physician/population ratios and ending with those of the highest ratios, has the effect of lowering the productivity estimates of physicians. Their marginal productivity of raising life

Appendix Table I.1

Estimated Percentage Changes in Life Expectancy from a 10 Per Cent Improvement in Access to Health Service, 1970-75

	Response to a 10 Per Cent Increase		Variation of Life Expectancy Explained
	Number of Physicians	Number of Nurses	
	- per cent -		
All 75 Countries (57)	1.29**	0.24**	85
Grouped by number of physicians[1]			
Excl. 15 lowest (71)	1.40**	0.30**	81
" 15 next lowest (91)	1.26**	0.27*	68
" 15 next lowest (120)	0.52**	0.49**	73
" 15 next lowest (157)	-0.71**	0.23**	88
Grouped by G.N.P. per capita[2]			
Excl. 15 lowest (1911)	1.51**	0.14	83
" 15 next lowest (2454)	1.11**	0.33**	83
" 15 next lowest (3396)	1.19**	0.37**	83
" 15 next lowest (5110)	1.65**	0.65**	86

**, * Regression Coefficients tested statistically significant at the 1 or 5 per cent levels respectively.

1 Figures in brackets below represent the number of physicians per 100,000 people for the countries included in the analysis.

2 Figures in brackets below represent the G.N.P. per capita in U.S. dollars for the countries included in the analysis.

Source: Based on Data of World Bank. World Tables, 1976. Health Section Policy Paper, 1975.
and
United Nations. Demographic Year Book, 1977 (ECC Library HC59.W92 and Ser.HAP858) Computer Printout 54892A, Sept. 18, 1980.

expectancy declines as the regression coefficients of physicians' services decrease from +1.40 to -.76.[I.2] In fact, the latter estimates would imply that in the 15 countries with the highest physician/population ratios further increases in the number of physicians would not raise life expectancy but lower it.

If the sampling procedure is changed and the countries are grouped according to their Gross National Product (GNP) per capita instead of the number of physicians per capita, the estimated response to a 10 per cent increase in the number of physicians and nurses does not diminish. For the 15 countries with the highest GNP per capita ($5,110), the response in years of life expectancy is estimated at +1.65 per cent. This is greater than the average response of the global sample and greater than that of any of the other subsamples. It implies that in the highest-income countries some factors other than easier access to physicians, shorten life expectancy.

Modifying the functional form of the regression equation to allow for this possibility, leads to somewhat inconclusive results. A quadratic function permits a changing response to per-capita GNP values. Regression coefficients, so estimated, suggest that a higher GNP per capita, or factors closely associated with it, could indeed shorten life expectancy. Unfortunately, the results are not very robust and some of the variables, including GNP per capita, do not test statistically significant at acceptable levels (Appendix Table I.2).

Appendix Table I.2

Regression Estimates of Life Expectancy as a Function of Physicians, Nurses and GNP, per Capita, Based on Cross-Sectional Data of 75 Countries, 1970-75

	Including GNP per Capita	Excluding GNP per Capita	Excluding GNP per Capita
Equation No.	I	II	III
Intercept	39.41**	39.42**	39.60**
Sex Dummy	4.03**	4.03**	4.03**
Physicians/Capita	0.401**	0.391**	0.389**
Nurses/Capita	(10^{-1}) 0.324**	(10^{-1}) 0.304*	0.265
GNP/Capita	(10^{-3}) 0.680	Var. deleted	
$(\text{Physicians/Capita})^2$	(10^{-2})-0.131**	(10^{-2})-0.129**	-0.128**
$(\text{Nurses/Capita})^2$	(10^{-4})-0.411*	(10^{-4})-0.401*	-0.366*
$(\text{GNP/Capita})^2$	(10^{-3})-0.680	(10^{-7})-0.400	Var. deleted
R^2	.86	.86	.86

**, * Tested statistically significant (at least) at the one or the five per cent levels respectively.

Source: Based on the same sources as Table I.1 above.

Although the regression estimates of the impact of higher GNP levels on life expectancy are inconclusive, those of the impact of numbers of physicians and nurses per capita are statistically significant and very stable. The combination of positive linear terms (rows 3 and 4 of Appendix Table I.2) and negative quadratic terms (rows 6 and 7) implies a further increase in the number of physicians and nurses per capita will lengthen life expectancy at a diminishing rate until eventually a point is reached where further increases yield zero gains. Differentiating Equation III in Appendix Table I.2, setting the differential quotient of life expectancy with respect to physicians equal to zero as in I.1,

$$(I.1)\ \frac{\partial LEXP}{\partial PHYS} = 0.389 + 2(-0.00128)\ PHYS = 0$$

$$(I.2)\quad PHYS = \frac{0.389}{0.00256} = 152$$

where

LEXP = average life expectancy in years

PHYS = number of physicians per 100,000 people

and solving for the number of physicians, yields an estimate of 152 physicians per 100,000 persons. At this level the productivity would be zero, at higher levels it would become negative.

Based on this estimate, Canada's number of physicians exceeds the "critical" point of (estimated) zero marginal productivity.

Appendix I Notes

I.1 This percentage increase in life expectancy is estimated as the sum of the coefficients of physicians and nurses in the first row of Appendix Table I.1.

I.2 More precisely the marginal productivities of physicians' services at these points are (1.40) (LEXP/PHYS) and (-0.71) (LEXP/PHYS), respectively. Over this range the marginal productivities decline, reach zero and become negative as the regression coefficients decline from +1.40 to -0.71. In this context LEXP denotes years of life expectancy and PHYS is the number of physicians per 100,000 persons.

Appendix II

Potential for Prevention of Infant Mortality

Below is a list of the major causes of infant mortality and an indication of the potential for prevention as provided by Dr. D.T. Wigle, Chief of the Non-Communicable Disease Division of the Bureau of Epidemiology. According to him prevention is possible through optimization of the health care delivery system. Appendix Table II gives the 1978 incidence and preventability by cause of death.

Appendix Table II.1

Incidence and Preventability of Infant Deaths, Canada, 1978

Cause of Death [1]	Number and Per Cent of Total	Preventable through Optimal Health Care
All Causes (000-999)	4289 (100.0)	-
Infective and Parasitic Diseases (000-136)	141 (3.3)	Yes
Cancer (140-239)	18 (0.4)	Partially
Endocrine, Nutritional and Metabolic Disease (240-279)	35 (0.8)	Partially
Diseases of the Blood and Blood-Forming Organs (280-289)	12 (0.3)	Partially
Diseases of the Nervous System (320-389)	77 (1.8)	Partially
Inflammatory Diseases [2] (320-324)	34 (0.8)	Yes
Diseases of the Circulatory System (390-458)	24 (0.6)	Partially
Diseases of the Respiratory System (460-519)	236 (5.5)	Yes
Diseases of the Digestive System (520-577)	77 (2.3)	Yes
Diseases of the Genitournary System (580-629)	7 (0.2)	Yes
Congenital Anomalies (740-759)	1172 (27.3)	Limited Potential
Anencepahlus (740) [2]	106 (2.5)	No
Perinatal Causes (760-779)	1810 (42.2)	Partially
"Sudden Death" (795)	504 (11.8)	? (limited potential at present)
Accidents, Poisonings and Violence (E800-E999)	145 (3.4)	Limited Potential
Other Causes	31 (0.7)	-

(1) The numbers in parentheses under "Cause of Death" are the rubrics from the 8th Revision of the International Classification of Diseases

(2) Note that "Inflammatory Diseases" and "Anencephalus" are subdivisions of the preceeding cause of death categories.

Source: Dr. D.T. Wigle, Bureau of Epideminology, memo of Sept. 15, 1980.

Appendix III

Provincial Variations in Infant Mortality and Health Services

Regression estimates of provincial variations in infant mortality were based on provincial data of infant mortality and health services. The estimating equation was specified as a transcendental log-function as in III.1, where the variables for infant mortality (INFM), physicians (PHYS), nurses (NURS) and hospital beds (HOSP) are expressed in numbers per 1,000 population and as the (base-10) logarithms of the province-to-Canada ratios. If there are differences between the provinces and Canada, the logarithms of the ratios will assume non-zero values and the coefficients can be tested for statistical significance. If there are no differences both sides of the function will assume zero-values and not test statistically significant.

$$\text{(III.1)} \quad INFM = CONST + aPHYS + bNURS + cHOSP + d(PHYS)^2 + e(NURS)^2 + f(HOSP)^2 + \sum_{p-1} g(PROV)_p$$

where

$$INFM = LOG(INFM_p \quad INFM_c)$$
$$PHYS = LOG(PHYS_p \quad PHYS_c)$$
$$NURS = LOG(NURS_p \quad NURS_c)$$
$$HOSP = LOG(HOSP_p \quad HOSP_c)$$
$$PROV = 1 \text{ or } 0$$

The results of this analysis are summarized in Appendix Table III.1. They vary depending on how the function is specified. The estimates in Columns I and II include provincial dummy variables, as suggested by the variable PROV of function (III.1), those in Columns III and IV exclude them. Coefficients of the latter suggest that infant mortality could be reduced if the number of physicians in a province were increased relative to the Canadian average. With increasing numbers of physicians, however, the rate of improvement would gradually diminish since the squared term of the physician variable is positive. Similar estimates are obtained for additional nursing staff. If provincial dummy variables are included (as in Columns I and II) the overall fit of the regressions becomes more acceptable but the regression coefficients for physicians and nurses lose their statistical significance. It appears that other provincial characteristics, not identified here, assume greater importance and that, ceteris paribus, infant mortality in Newfoundland and Saskatchewan is somewhat higher than in other provinces.

Appendix Table III.1

Regression Estimates of Infant Mortality as a Function of Physicians, Nurses, Hospitals and Provinces, Canada, 1966-75

Variables in Logarithm (Base 10)	Equations Including Provincial Variables I	II	Equations Excluding Provincial Variables III	IV
Intercept	-.117*	.002*	.022*	.002**
Physicians[1]	.357	.033	-.137†	-.021**
Nurses[2]	.052		-.194*	
Hospitals[3]	.415**		.214	
$(Physicians)^2$	-.048	-.039	.904**	.078**
$(Nurses)^2$	.038		.194	
$(Hospitals)^2$	1.623		.293	
Trend	.001		.000	
Newfoundland	.124**	.007**		
P.E.I.	.006	-.003		
N.S.	.077†	-.004†		
N.B.	.068**	-.002†		
Quebec	.047	-.006†		
Manitoba	.079**	-.000		
Saskatchewan	.104**	.003*		
Alberta	.030	-.003*		
B.C.	.049	-.002		
Multiple correlation	.77	.48	.27	.19
Degrees of freedom	83	88	92	97

1 Fee-practice physicians.

2 Employed nurses only.

3 Rated hospital-bed capacity.

*, **, † Regression coefficients tested statistically significant at least at the 1, 5 or 10 per cent levels.

Source: Based on Statistics Canada. Vital Statistics, Volume III, Deaths. STATCAN Cat. No. 84-206 and population statistics from CANSIM.

Computer printouts: J5909A Nov. 3, 1980 and J9140A Jan 28, 1981.

Appendix IV

Estimation of Full-Time Physician Equivalents by the "Median Equivalence Method"[1]

Summary steps of the estimation procedure are listed in sequence below:

(A) For a given specialty, identify all fee-for-service physicians to whom the medicare plan made at least a single payment over the course of the year. A physician who had more than one specialty during a year is assigned the one in which he received most of his payments.

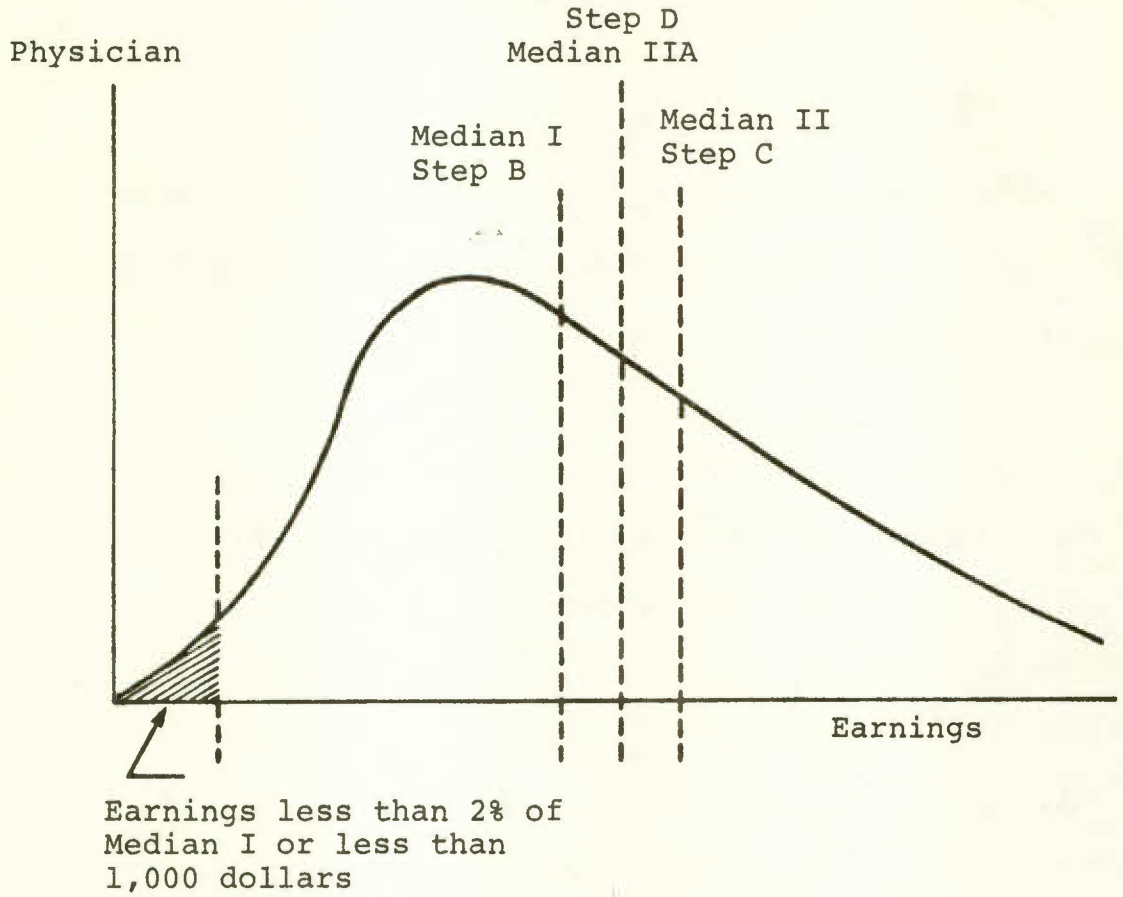
(B) Arrange in rank-order of their earnings the physicians as identified in (A) and determine the median earnings of the specialty, i.e., Median I (see Appendix Chart IV).

(C) From the physicians in (A), remove those physicians whose earnings are less than 2 per cent of Median I or less than $1,000, whichever is higher, and then determine the new median earnings for the remaining physicians, i.e., Median II.

(D) Obtain Median IIA which is equal to 90 per cent of Median II.

Appendix Chart IV

Median Earnings of Physicians, Hypothetical[1]



1 Definitions:

Median I - median earnings of all physicians

Median II - median earnings after excluding those physicians whose earnings were less than 2 per cent of Median I or less than $1,000.

Median IIA - 90 per cent Median II.

(E) Assign the weight unity to each of those physicians whose earnings are larger than or equal to Median IIA, and obtain the subtotal of all unity.

(F) Assign the weight 0.875 to each of those physicians whose earnings are less than Median IIA but larger than or equal to 75 per cent of Median IIA, and obtain the subtotal of all 0.875s.

(G) Assign the weight 0.625 to each of those physicians whose earnings are less than 75 per cent of Median IIA, but larger than or equal to 50 per cent of Median IIA, and obtain the subtotal of all 0.625s.

(H) Assign the weight 0.375 to each of those physicians whose earnings are less than 50 per cent of Median IIA but larger than or equal to 25 per cent of Median IIA, and obtain the subtotal of all 0.375s.

(I) Assign the weight 0.125 to each of those physicians whose earnings are less than 25 per cent of Median IIA, and obtain the subtotal of all 0.125s.

(J) For the total number of full-time physician equivalents of the specialty, add together the subtotals (E) through (I).

(K) For each of the remaining specialties, repeat the step (A) through (J).

(L) Add together the results from (J) and (K) to get the total number of full-time physician equivalents for all specialties. The estimating procedure is summarized in Appendix Table IV.1 below.

Appendix Table IV.1

Format for Calculation of Median Equivalents

Step	Full-Time Physician Weights (1)		Earnings Classes (2)	Fee-for-Service Physicians (3)	Full-Time Physicians Equivalents (4) = (1)x(3)
E	1,000		X Median IIA 75 % of		
F	0.875	Median IIA X	Median IIA		
G	0.625	75 % of Median IIA X	50 % of Median IIA		
H	0.375	50 % of Median IIA X	25 % of Median IIA		
I	0.125	25 % of Median IIA X	25 % of		
J	Total				

Source Based on the Median Equivalents Method developed by Mr. W. L. Rehmer of the Department of Health and Welfare.

For certain specialties, the medians are rather sensitive to the sample size so that their stability from year to year is less than acceptable. Also, the specialty Psychiatry in certain provinces tends to have a larger number of physicians whose earnings are low compared to other specialties, and that brings down their median earnings to a level which by all probability cannot be regarded as commensurate with the level of an average full-time psychiatrist's earnings. These difficulties are overcome, when calculating full-time physician equivalents, by using the median earnings of Internal Medicine for Psychiatry, Neurology, Dermatology, Physical Medicine and Public Health; by using the median earnings of General Surgery for Thoracic Cardiovascular Surgery and Plastic Surgery; and by using the median earnings of Ophthalmology for Otolaryngology/ Ophthalmology.

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1 This summary is based on material provided by Mr. W.L. Rehmer of the Health Information Division of the Department of Health and Welfare.

Appendix V

List of 116 Physician Activities

As indicated in the text, the provincial fee schedules were replaced by the Canadian fee schedule so that all of the 116 physician activities were assessed at the same rate. Provincial variations in physicians' output, based on the frequencies of service in each of 116 activities were thus standardized for provincial variations in fee schedules. The 116 activities are listed below.

Major Category	
No.	Individual Activity
Consultations	
1.	Major/Initial
2.	Other Consultations
Complete Examinations	
3.	Complete Examination in Office - Initial
4.	Complete Examination in Office - Other
5.	Complete Examination in Hospital
Other Office Visits	
6.	Partial/Minor/Subsequent Examination
7.	Psychoterapy
8.	Special Eye Examination
9.	Well-Baby Care
10.	Other Office Visits

Other Hospital Visists

11. Regular - Up to 28/30/31 Days
12. Regular - Over 28/30/31 Days
13. Regular - Up to 35/42 Days
14. Regular - Over 35/42 Days
15. Newborn/Premature Care
16. Other Visits - Per Diem or Per Visit
17. Other Hospital Visits

Home Visits

18. Routine
19 Out-of-Hours/Emergency
20.
21. Other Home Visits

Major Surgery

22. Integumentary: Mastectomy
23. Integumentary: Other
24. Musculo-Skeletal: Fractures
25. Musculo-Skeletal: Other
26. Respiratory: Sub-Mucous Resection, etc.
27. Respiratory: Other
28. Cardiovascular: Heart and Pericardium
29. Cardiovascular: Varicose Veins
30. Cardiovascular: Other
31. Digestive System: Appendectomy
32. Digestive System: Laparotomy
33. Digestive System: Cholecystectomy
34. Digestive System: Tonsillectomy - Child
35. Digestive System: Tonsillectomy - Adult
36. Digestive System: Inguinal/Femoral Hernia
37. Digestive System: Haemorrhoidectomy
38. Digestive System: Other
39. Urinary/Male Genital: Prostatectomy
40. Urinary/Male Genital: Vasectomy
41. Urinary/Male Genital: Other
42. Female Genital: Prolapse
43. Female Genital: Hysterectomy
44. Female Genital: Sterilization
45. Female Genital: Other
46. Eye/Ear: Cataract
47. Eye/Ear: Other
48. Other Major Surgery

Minor Surgery

49. Incision - Abscess, etc.
50. Removal of Foreign Body
51. Excision - Benign Tumour/Cyst/Wart, etc.
52. Suture Wounds
53. Excision of Nail

Minor Surgery (cont.)

54 Chalazion
55. Circumcision - Newborn
56. Myringotomy
57. Fractures
58. Other Minor Surgery

Surgical Assistance

59. Appendectomy
60. Cholecystectomy
61. Inguinal/Femoral Hernia
62. Prostatectomy
63. Hysterectomy
64. Caesarian Section
65. Other Surgical Assisatnce

Obstetric Services

66. Confinement - Total Care
67. Confinement - Other
68. Caesarian Section
69. Therapeutic Abortion
70. Other Obstetric Services

Anaesthesia

71. Appendectomy
72. Cholecystectomy
73. Haemorrhoidectomy
74. Prostatectomy
75. Hysterectomy
76. Tonsillectomy - Child
77. Tonsillectomy - Adult
78. Confinement and Caesarian Section
79. Cystoscopy
80. D & C
81. Nerve Blocks

Diagnostic/Therapeutic Radiology and Radioisotopes

83. Head and Neck
84. Spine and Pelvis
85. Extremities
86. Chest
87. G. I. Tract
88. G. U. Tract
89. Therapeutic Radiology and Radioisotopes
90. Other Diagnostic Radiology

Laboratory Services (Tests)

91. Haematology - Automated
92. Haemotology - Manual
93. Haemotology - Unspecified
94. Biochemistry - Automated
95. Biochemistry - Manual
96. Biochemistry - Unspecified
97. Radioisotopes (Diagnostic)
98. ECG, EEG, & BMR - Technical Component Only
99. Other Laboratory Services

Other Diagnostic/Therapeutic Services

100. Allergy Tests/Hyposensitization
101. Injection/Aspiration of Joint
102. ECG - Prof. Component Incl.
103. Cystoscopy - Diagnostic
104. Sigmoidoscopy
105. Other Endoscopy
107. Procedures Associated with Diag. Rad. (includes lumbar myelogram)
108. D & C
110. EEG - Prof. Component Incl.
111. Biopsies
112. Other Diag./Therap. Services

Special Diagnostic/Therapeutic Services

106. Injections, Subcutaneous, Intramuscular for Varicose Veins, Immunications
109. Papanicolau Smear
113. Insertion of IUD

Miscellaneous Services

114. Detention Fees
115. Other Identified
116. Unidentified

Appendix VI

Estimating the Contribution of Specialization and Output per Physician to Differences Between the Provincial and Canadian Productivity Performance of Physicians

After standardization of pay schedules, provincial variations in the productivity performance are attributed to two sources: the degree of specialization and output per full-time physician equivalent in individual specialties. In the text the estimating procedure is described by equations (1) and (2). This Appendix shows how to get from (1) to (2). As illustrated elsewhere (Auer, 1979, pp. 109ff) differences in a dependent variable Y can be imputed to differences in a vector of independent variables X by application of a Taylor expansion provided the function which describes the relation between Y and X has finite and continuous derivatives. Noting first that the difference of a sum equals the sum of the differences as in (VI.1), a Taylor expansion applied to equation (1) in the text, is defined by (VI.2), solved in (VI.3), and rearranged in (VI.4). This rearrangement of terms involves dividing both summations in (VI.3) by Q./E., changing actual differences to relative differences, subtracting unity from the first summation, and collecting the remainder terms in the second summation.

(VI.1) $$\Delta\frac{Q.}{E.} \equiv \sum_{i}^{16} \Delta\frac{Ei}{E.}\,\frac{Qi}{Qi}$$

(VI.2) $$\Delta\frac{Q.}{E.} \equiv \sum_{i}^{16} \frac{\partial(Q./E.)}{\partial(Ei/E.)}\,\Delta\frac{Ei}{E.} + \frac{1}{2}\,\Delta\frac{Ei}{E.}\Delta\frac{Qi}{Ei}\,\frac{\partial^2(Q./E.)}{\partial(Ei/E)\ (Qi/Ei)}$$

$$+ \sum_{i}^{16} \frac{\partial(Q./E.)}{\partial(Qi/Ei}\,\Delta\frac{Qi}{Ei} + \frac{1}{2}\,\Delta\frac{Ei}{E.}\Delta\frac{Qi}{Ei}\,\frac{\partial^2(Q./E.)}{\partial(Ei/E)\ (Qi/Ei)}$$

(VI.3) $$\frac{Q.}{E.} \equiv \sum_{i}^{16} \frac{Qi}{Ei}\Delta\frac{Ei}{E.} + \frac{1}{2}\,\Delta\frac{Ei}{E.}\Delta\frac{Qi}{Ei}$$

$$+ \sum_{i}^{16} \frac{Ei}{Ei}\Delta\frac{Qi}{Ei} + \frac{1}{2}\,\Delta\frac{Ei}{E.}\Delta\frac{Qi}{Ei}$$

where

$$\Delta\frac{Q.}{E.} = (\frac{Q.}{E.}p - \frac{Q}{E}c)$$

$$\Delta\frac{Ei}{E.} = (\frac{Ei}{E.}p - \frac{Ei}{E.}c)$$

$$\Delta\frac{Qi}{Ei} = (\frac{Qi}{Ei}p - \frac{Qi}{Ei}c)$$

(VI.4) $$\overset{*}{\frac{Q.}{E.}} \equiv \sum_{1}^{16} (\frac{Ei}{E.}p - \frac{Ei}{E.}c)(\frac{Qi/Q.}{Ei/E.}c - 1.0)$$

$$+ \sum_{1}^{16} \frac{\overset{*}{Qi}}{Ei}\,\frac{Ei}{E.}p\,\frac{Qi/Q.}{Ei/E.}$$

where

$$\overset{*}{\frac{Q.}{E.}} = (\frac{Q.}{E.}p - \frac{Q.}{E.}c) \div \frac{Q.}{E.}c$$

$$\overset{*}{Qi} = (\frac{Qi}{Ei}p - \frac{Qi}{Ei}c) \div \frac{Qi}{Ei}c$$

Appendix VII

Estimating the Contribution of Several Factors to Provincial Variations in Post-operative Mortality and Length of Hospital Stay

To facilitate the description of the estimation procedure the notation is summarized in Appendix Table VII.1. This table consists of four parts. The uppermost part lists the relevant numbers and mortality rates of patients who undergo an operation of type t, at age a, in a hospital of size s, and are of either type 1 or 2. A patient of type 1 is a low-morbidity, short-stay patient, a patient of type 2 is the opposite.[1] The second part of the table lists the same kind of information but each row represents the sum of the part above. Correspondingly the third and fourth parts of the table list the sums of the preceding parts. Throughout, the letter n refers to the number of patients and the letter p to the proportion of patients dead at the time of hospital discharge. The subscripts t, a, s refer to type of operation, age of patient and size of hospital, respectively.

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1 A long-stay patient of type 2 is defined as a patient who stays in hospital for an abnormal length of time which exceeds the national average length (for a particular operation, age group and hospital size) by at least three standard deviations.

Using this notation, the degree of success in surgical performance can be measured by the post-operative mortality rate as follows. A patient undergoing operation t, at age a, in a hospital of size s, is classified first as a low or high morbidity case. Since no direct measure of the degree of

Appendix Table VII.1

Summary of Notations, Post-operative Mortality Rates Grouped According to Degree of Morbidity, Hospital Size, Age of Patient and Type of Operation

Degree of Morbidity i Hospital Size s Age of Patient a Type of Operation t	Province		Canada	
	Number of all patients(n)	Proportion which died(p)	Number of all patients(n)	Proportion which died(p)
Degree of Morbidity				
Low Morbidity (short stay)	n_{tas1}	p_{tas1}	n_{tas1c}	p_{tas1c}
High Morbidity (long stay)	n_{tas2}	p_{tcs2}	n_{tas2c}	p_{tas2c}
Both	$n_{tas.}$	$p_{tas.}$	$n_{tas.c}$	$p_{tas.c}$
Hospital Size				
Size 1	$n_{tal.}$	$p_{tal.}$	$n_{tal.c}$	$p_{tal.c}$
Size s	$n_{tas.}$	$p_{tas.}$	$n_{tas.c}$	$p_{tas.c}$
All Sizes	$n_{ta..}$	$p_{ta..}$	$n_{ta..c}$	$p_{ta..c}$
Age of Patient				
Age 1	$n_{t1..}$	$p_{t1..}$	$n_{t1..c}$	$p_{t1..c}$
Age a	$n_{ta..}$	$p_{ta..}$	$n_{ta..c}$	$p_{ta..c}$
All Ages	$n_{t...}$	$p_{t...}$	$n_{t...c}$	$p_{t...c}$
Type of Operation				
Type 1	$n_{1...}$	$p_{1...}$	$n_{1...c}$	$p_{1...c}$
Type t	$n_{t...}$	$p_{t...}$	$n_{t...c}$	$p_{t...c}$
All types	$n_{....}$	$p_{....}$	$n_{....c}$	$p_{....c}$

morbidity is available we rely solely on his/her post-operative length of stay as the relevant indicator. As shown in Appendix Table VII.1, the mortality rate of the short-stay patient is p_{tas1} and that of the long-stay patient p_{tas2}. The corresponding proportions of patients falling into category 1 or 2 are ($n_{tas1}/n_{tas.}$) and ($n_{tas2}/n_{tas.}$). The degree of success of the operation, averaged over the two states of morbidity, can then be defined as the weighted average of both, as in (VII.1).

$$\text{(VII.1)} \qquad p_{tas.} = \sum_{1}^{2} \frac{n_{tasi}}{n_{tas.}} p_{tasi}$$

where $p_{tas.}$ = mortality rate of patients who underwent operation t, at age a, in a hospital of size s

n_{tasi} = number of patients of short stay (i=1) or of long stay (i=2)

p_{tasi} = mortality rate of short (i=1) or long stay patients (i=2)

To estimate how much the degree of morbidity, as indicated by the ratio ($n_{tasi}/n_{tas.}$), and quality of surgery, as indicated by the mortality rate p_{tasi}, contribute to provincial variations of mortality rates $p_{tas.}$, e.g. in appendectomy, we compare the provincial proportions of patients undergoing this type of surgery ($n_{tasi}/n_{tas.}$) with the corresponding national proportion ($n_{tasic}/n_{tas.c}$) and we compare the provincial success rates in surgery p_{tasi} with the corresponding national success rate p_{tasic}. This can be done as in (VII.2) where the left-hand side (LHS) measures the

(VII.2) $$\text{LHS } \overset{*}{m}_{tas} = \frac{P_{tas.} - P_{tas.c}}{P_{tas.c}}$$

$$\text{RHS } \overset{*}{m}_{tas} = \sum_i \left\{\frac{P_{tasi} - P_{tasic}}{P_{tasic}}\right\} \left\{\frac{P_{tasic}}{P_{tas.c}} \frac{n_{tasi}}{n_{tas.}}\right\}$$

$$+ \sum_i \left\{\frac{n_{tasi}}{n_{tas.}} - \frac{n_{tasic}}{n_{tas.c}}\right\} \left\{\frac{P_{tasic}}{P_{tas.c}} - 1.0\right\}$$

relative difference in mortality rates between the province and Canada. The right-hand side (RHS) attributes this difference to two factors: one, the percentage difference between provincial and national quality of surgery and, two, the difference between the provincial and national proportions of patients (entering hospitals of the same size groups, for the same type of operation, being of the same age group) having arrived at the hospital in similar condition.

Wheter or not quality of surgery makes a contribution to differences in post-operative mortality rates $\overset{*}{m}$ depends on two factors. First, it depends on the measured difference between the two, the first term of VII.2 will automatically go to zero. If there is a difference, it will be weighted by two ratios which vary with the relative mortality rates and numbers of cases in each category. Second, it depends on the measured difference between the provincial proportion $n_{tasi}/n_{tas.}$ and the national proportion $n_{tasic}/n_{tas.c}$. If there is no difference because the provincial and national proportions are identical, the seecond term becomes zero. Also, it becomes zero if there is no difference between the mortality of the one category, e.g., short stay, and the other. The logic of this procedure, therefore, conforms to what is perhaps intuitively self-evident.

Next we examine the effect of hospital size. Ignoring for the moment the degree of morbidity, the quality of surgery is now measured by the mortality rates of patients undergoing a specific operation in hospitals of hospital of different size. The degree of success, averaged over the hospitals of all size groups can be defined as the weighted average of the surgical performance in each size group. This relationship is defined in (VII.3). It

(VII.3) $$p_{ta..} = \sum_{s} \frac{n_{tas.}}{n_{ta..}} p_{tas.}$$

where $p_{ta..}$ = mortality rate of patients who underwent operation t, at age a

$n_{ta..}$ = number of patients who underwent operation t, at age a

$n_{tas.}$ = number of patients who underwent operation t, at age a, in hospitals of size groups s

$p_{tas.}$ = mortality rate of patients who underwent operation t, at age a, in

states that the mortality rate of a patient who underwent operation t at age a is the weighted average of mortality rates of the different hospital size groups.

To estimate how much hospital size and quality of surgery contribute to the provincial variations of mortality rates of patients undergoing surgery for, say, appendectomy, we compare the provincial proportions of patients undergoing surgery and the provincial success rate of the operation, of each of the hospital

(VII.4) LHS $\overset{*}{m}_{tas..} = \dfrac{P_{ta..} - P_{ta..c}}{P_{ta..c}}$

$$\text{RHS } \overset{*}{m}_{ta..} = \sum_s \left\{ \frac{P_{tas.} - P_{tas.c}}{P_{tas.}} \frac{P_{tas.c}}{P_{ta..c}} \right\} \frac{n_{tas.}}{n_{ta..}}$$

$$\sum_s \left\{ \frac{n_{tas.}}{n_{ta..}} - \frac{n_{tas.c}}{n_{ta..c}} \right\} \left\{ \frac{P_{tas.c}}{P_{ta..c}} - 1.0 \right\}$$

size groups, with the Canadian average. This is done in (VII.4) where the asterisk above the mortality rate $m_{ta..}$ denotes the relative difference between the provincial and national mortality rates. The RHS of (VII.4) attributes this difference to two factors: one, the relative difference $(p_{tas.} - p_{tas.c})/p_{tas.c}$ between the provincial and national quality of surgery performed in hospitals of the same size and two, the difference between the provincial and national proportions of patients entering hospitals of size group s.

Whether or not quality of surgery makes a contribution to differences in post-operative mortality rates depends on the first term of the RHS summation in (VII.4). A negative value of this difference, for example, would mean that higher-quality surgery in hospitals of size group s lowered the post-operative mortality in the province relative to Canada. This quality comparison is made in two steps: first, the provincial quality is compared to the national quality in $(p_{tas.} - p_{tas.c})/p_{tas.c}$ and second, the national average quality of hospitals of size s is compared to hospitals of all sizes in $p_{tas.c}/p_{ta..c}$, and then weighted by the provincial proportion $n_{tas.}/n_{ta..}$ of the different hospital size groups.

According to the second summation of the RHS of (VII.4), the contribution of hospital size also depends on the difference between the provincial and national distributions of hospital sizes, i.e., $(n_{ta.}/n_{ta..}) - (n_{tas.c}/n_{ta..c})$, as well as on variations in the quality of surgery among hospital size groups at the national level. Should there be no variations in post-operative mortality rates among hospital size groups nationally, the ratio $p_{tas.c}/p_{ta..c}$ becomes 1.0 and the second term of the second summation becomes zero. Should there be, however, variations in the quality of surgery around the national average of all size groups so that the ratio $p_{tas.c}/p_{ta..c}$ differs from 1.0, then this narrows (or widens) the difference $\overset{*}{m}_{ta...}$ between provincial and national mortality rates.

For extension of the analysis to different age groups and different types of operations assume, for the moment, that hospital size has no effect on quality of surgery. Under this assumption the RHS of (VII.4) reduces to (VII.5) since the second summation in (VII.4) vanishes and the ratio $p_{tas.c}/p_{ta..c}$) of the first summation becomes unity. It implies that the relative difference in mortality rates $\overset{*}{m}_{ta..}$ between a province and Canada is simply the summation of quality differences in surgery weighted by the proportion of patients in different hospital size groups.

$$\text{(VII.5)} \qquad \overset{*}{m}_{ta..} = \sum_{s} \left\{ \frac{p_{tas.} - p_{tas.c}}{p_{tas.c}} \right\} \frac{n_{tas.}}{n_{ta..}}$$

There is ample statistical evidence which suggests, however, that post-operative mortality rates vary greatly among different age groups. To measure the importance of the age factor we ignore, for the moment, the state of morbidity as well as the size of hospital and assume that operations are performed with varying degrees of success on patients of different age groups. Averaged over all age groups, the success rate can then be defined as a weighted average of the performance in surgery on patients of all ages as in (VII.6).

$$P_{t...} = \sum_{a} \frac{n_{ta..}}{n_{t...}} p_{ta..} \qquad \text{(VII.6)}$$

where

$P_{t...}$ = mortality rate of all patients who underwent operation t

$n_{ta..}$ = number of patients of age group a who underwent operation t

$n_{t...}$ = number of all patients who underwent operation of type t

$P_{ta..}$ = proportion of patients who underwent operation t and died post-operatively.

The contribution of the provincial performance in surgery and the type of operation to differences in mortality rates between a province and Canada can be evaluated as in (VII.7). Both formulations correspond to the earlier ones in (VII.1 and VII.2) or (VII.3 and VII.4), except for the subscripts which are changed according to the underlying assumptions. If nationally the post-operative mortality is identical for all age groups, the ratio $(p_{ta..c}/P_{t...c})$ in the first summation of (VII.7) equals 1.0 and the second summation vanishes as all of the difference between the provincial and national mortality rate is attributed to quality of surgery.

$$\text{(VII.7)} \qquad \text{LHS } \overset{*}{m}_t = \frac{p_{t...} - p_{t...c}}{p_{ta..c}}$$

$$\text{RHS } \overset{*}{m} = \sum_a \left\{\frac{p_{ta..} - p_{ta...c}}{p_{ta..c}}\right\} \frac{p_{ta..c}}{p_{t...c}} \frac{n_{ta..}}{n_{t...}}$$

$$+ \sum_a \left\{\frac{n_{ta..}}{n_{t...}} - \frac{n_{ta..c}}{n_{t...c}}\right\} \left\{\frac{p_{ta..c}}{p_{t...c}} - 1.0\right\}$$

Of course, if there are age-specific mortality rates (i.e., $p_{ta...c}/p_{t...c}$) and if there are differences between the provincial and national age distributions of patients, the second part of the summation will be non-zero and thus contribute to the difference in mortality rates between the province and Canada.

Again assuming for the moment that the second summation in RHS of (VII.7) is zero and that age does not matter, the difference in mortality rates between a province and Canada simply becomes the weighted average of the quality of surgery of all age groups.

If neither age, nor hospital size, nor degree of morbidity mattered, the analysis of mortality rates would be reduced to quality of surgery and mix of operations. Following the same procedures as before, appropriate equations for this situation would be (VII.8) and (VII.9). Equation (VII.9) attributes the difference between the provincial and national post-operative mortality rate solely to differences in the quality of surgery and differences in the proportionate distribution of t types of operations. Individual terms of the two summations in (VII.9) can be interpreted in the same manner as before.

(VII.8) $$p.... = \sum_t \frac{n_{t...}}{n_{....}} P_{t...}$$

where $p....$ = average mortality rate of all patients who underwent operation

$n_{t...}$ = number of patients who underwent operation t

$n_{....}$ = number of all patients who underwent an operation

$P_{t...}$ = proportion of patients who underwent operation t and died

(VII.9) $$\text{LHS} \;\hat{=}\; \frac{p.... - p....c}{p....c}$$

$$\text{RHS} \;\hat{=}\; \sum_t \left\{\frac{P_{t...} - P_{t...c}}{P_{t...c}}\right\} \frac{P_{t...c}}{p....c} \frac{n_{t...}}{n_{....}}$$

$$+ \sum_t \left\{\frac{n_{t...}}{n_{...}} - \frac{n_{t...c}}{n_{....c}}\right\} \left\{\frac{P_{t...c}}{p....c} - 1.0\right\}$$

By now four formulas are available, the first for morbidity, the second for hospital size, the third for age, and the fourth, for type of operation. All four equations are reproduced in (VII.10a) to (VII.10d), respectively.

Morbidity
(VII.10a)

$$\overset{*}{m}_{tas} = \sum_i \left\{\frac{P_{tasi}-P_{tasic}}{P_{tasic}}\right\} \frac{P_{tasic}}{P_{tas.c}} \frac{n_{tasi}}{n_{tas.}}$$

$$+ \sum_i \left\{\frac{n_{tasi}}{n_{tas.}} - \frac{n_{tasic}}{n_{tas.c}}\right\} \left\{\frac{P_{tasic}}{P_{tas.c}} -1.0\right\}$$

Hospital Size
(VII.10b)

$$\overset{*}{m}_{ta} = \sum_s \left\{\frac{P_{tas.} - P_{tas.c}}{P_{tas.c}}\right\} \frac{P_{tas.c}}{P_{tas.c}} \frac{n_{tas.}}{n_{ta..}}$$

$$+ \sum_s \left\{\frac{n_{tas.}}{n_{ta..}} - \frac{n_{tas.c}}{n_{ta..c}}\right\} \left\{\frac{P_{tas.c}}{P_{ta..c}} -1.0\right\}$$

Age of Patient
(VII.10b)

$$\overset{*}{m}_{t} = \sum_a \left\{\frac{P_{ta..} - P_{ta..c}}{P_{ta..c}}\right\} \frac{P_{ta..c}}{P_{t...c}} \frac{n_{ta..}}{n_{t...}}$$

$$+ \sum_s \left\{\frac{n_{ta..}}{n_{t...}} - \frac{n_{ta..c}}{n_{t...c}}\right\} \left\{\frac{P_{ta..c}}{P_{t...c}} -1.0\right\}$$

Type of Operation
(VII.10d)

$$\overset{*}{m} = \sum_t \left\{\frac{P_{t...} - P_{t...c}}{P_{t...c}}\right\} \frac{P_{t...c}}{P_{....c}} \frac{n_{t...}}{n_{...}}$$

$$+ \sum_t \left\{\frac{n_{t...}}{n_{....}} - \frac{n_{t...c}}{n_{....c}}\right\} \left\{\frac{P_{t...c}}{P_{....c}} - 1.0\right\}$$

These are the RHS the equations. Their LHS counterparts are reproduced in (VII.11a) to (VII.11d), respectively.

(VII.11a) $$\overset{*}{m}_{tas} = \frac{p_{tas.} - p_{tas.c}}{p_{tas.c}}$$

(VII.11b) $$\overset{*}{m}_{ta} = \frac{p_{ta..} - p_{ta..c}}{p_{ta..c}}$$

(VII.11c) $$\overset{*}{m}_{t} = \frac{p_{t...} - p_{t...c}}{p_{t...c}}$$

(VII.11d) $$\overset{*}{m} = \frac{p_{....} - p_{....c}}{p_{....c}}$$

It is apparent now that the LHS definitions of (VII.11) are identically equal to the first terms of the RHS summations in (VII.10). We can substitute therefore (VII.10a) into (VII.10b), VII.10b) into (VII.10c), and (VII.10c) into (VII.10d).

After simplifying the notation for (VII.10) and (VII.11) as in (VII.12), this relationship between successive differences becomes more evident. In (VII.12) the symbol m refers to mortality rates and n refers to number of patients. The asterisk * denotes a relative difference and the hat ^ a simple ratio. The subscripts refer to the level or the node at which the difference analysis is performed.

(VII.12a) $$\overset{*}{m}_{tas} = \sum_i \overset{*}{m}_{tasi} \; \hat{m}_{tasi} \; \hat{n}_{tasi} \; \hat{n}_{tasi} + \sum_i \overset{*}{n}_{tasi} \; (\overset{*}{m}_{tasi} - 1.0)$$

(VII.12b) $$\overset{*}{m}_{ta} = \sum_s \overset{*}{m}_{tas} \; \hat{m}_{tas} \; \hat{n}_{tas} + \sum_s \overset{*}{n}_{tas} \; (\overset{*}{m}_{tas} - 1.0)$$

(VII.12c) $$\overset{*}{m}_{t} = \sum_a \overset{*}{m}_{ta} \; \hat{m}_{ta} \; \hat{n}_{ta} + \sum_a \overset{*}{n}_{ta} \; (\overset{*}{m}_{ta} - 1.0)$$

(VII.12d) $$\overset{*}{m} = \sum_t \overset{*}{m}_{t} \; \hat{m}_{t} \; \hat{n}_{t} + \sum_t \overset{*}{n}_{t} \; (\overset{*}{m}_{t} - 1.0)$$

The objective of the analysis is to link the overall difference between provincial and national post-operative mortality rates to the weighted differences of morbidity, hospital size, age of patient, and type of operation. This is achieved by the substitution of (VII.12a) into (VII.12b), (VII.12b) into (VII.12c), etc.

The details of the weighting procedure are specified in (VII.13). In this equation the overall difference in post-operative mortality rates is ultimately traced to differences in the quality of hospital surgery (and other closely related factors) at the most disaggregate level $\overset{*}{m}_{tasi}$ where the from other principal factors, i.e., morbidity (short or long term), hospital size, age of patient, and type of surgical procedure, are held constant. The remainder of the difference is attributed to differences in the mix of short and long-term patients $\overset{*}{n}_{tasi}$, the mix of hospital sizes $\overset{*}{n}_{tas}$, the mix of patients among age groups $\overset{*}{n}_{ta}$, and the mix of operations $\overset{*}{n}_{t}$.

(VII.13)
$$\overset{*}{m} = \sum_t \hat{m}_t \hat{n}_t \sum_a \hat{m}_{ta} \hat{n}_{ta} \sum_s \hat{m}_{tas} \hat{n}_{tas} \sum_i \hat{m}_{tasi} \hat{n}_{tasi} \overset{*}{m}_{tasi}$$

$$+ \sum_t \hat{m}_t \hat{n}_t \sum_a \hat{m}_{ta} \hat{n}_{ta} \sum_s \hat{m}_{tas} \hat{n}_{tas} \sum_i (\hat{m}_{tasi} - 1.0) \overset{*}{n}_{tasi}$$

$$+ \sum_t \hat{m}_t \hat{n}_t \sum_a \hat{m}_{ta} \hat{n}_{ta} \sum_s (\hat{m}_{tas} - 1.0) \overset{*}{n}_{tas}$$

$$+ \sum_t \hat{m}_t \hat{n}_t \sum_a (\hat{m}_{ta} - 1.0) \overset{*}{n}_{ta}$$

$$+ \sum_t (\hat{m}_t - 1.0) \overset{*}{n}_{t}$$

This completes the derivation of the weighting procedure as equation (VII.13) is the same as equation (6) in the text. During the empirical analysis, however, some modifications were introduced to facilitate programming. To reduce the large data base of individual observations to more acceptable dimensions the data were grouped into a five-branch structure:

1. 16 chapters of surgical procedures
2. 5 risk groups
3. 11 age groups
4. 5 hospital size groups
5. 2 length-of-stay groups.

This was done separately for male and female hospital patients. The first two branches of the five distributed the 163 surgical procedures over 16 chapters and 5 risk groups where the risk groups were defined as:

Risk Group	Risk of Postoperative Mortality	Post-operative Mortality Rate Range	Post-operative Mortality Rate Approximate Rate
1	low	0.00 - .49	less than 1/200
2	average	0.50 - 1.49	1/100
3	above average	1.50 - 2.49	1/50
4	high	2.50 - 7.49	1/20
5	very high	7.50 and over	more than 1/10

This reduced the original 163 categories to 37. As shown in Table VII.2 the number of surgical procedures included in the 16 chapters ranged from one to many and the risk of post-operative death from low to high, sometimes covering a substantial range within the chapter. The 11 age groups related to the ages: up to 1, 1-4, 5-9, 10-14, 15-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75 years and older; the five hospital size groups to 0-99, 100-299, 300-499, 500-699 and 700 and more beds. Finally the two length-of-stay categories, designed to separate the long-term stay (and comorbidity cases) from the regular cases, consisted of those patients who stayed three standard deviations beyond the

Table VII.2: Distribution of Surgical Procedures and Risk Categories Among Major Chapters[1]

Chapter	No. of Surgical Procedures Included	Risk Categories: No. in Chapter	Risk Categories: Range of Risk
1. Neurosurgery	5	3	1-5
2. Ophthalmology	7	1	1
3. Otorhinolaryngology	13	2	1-2
4. Thyroidectomy	1	2	1-2[1]
5. Vascular and Cardiac Surgery	9	5	1-5
6. Thoracic Surgery	1	1	4
7. Abdominal Surgery	17	5	1-5
8. Proctological Surgery	6	3	1-4
9. Urological Surgery	14	3	1-4
10. Mastectomy	4	2	1-2
11. Gynecological Surgery	19	1	1
12. Obstetrical Surgery	17	1	1
13. Orthopedic Surgery	37	4	1-5
14. Plastic Surgery	10	2	1-2
15. Oral and Maxillo Facial Surgery	1	1	1
16. Dental Surgery	2	1	1
Total	163	37	

1 Surgical procedures of individual Chapters are listed in in Appendix VIII

average patient of the same sex, age group, and surgical procedure, and those who left earlier.

The modified formula, which allows for the redistribution of the 163 post-operative procedures into 16 chapters and 5 risk groups can be readily derived from equation (VII.13). For the full "five-branch" difference analysis -- with chapters c, risk r, age a, hospital size s and length of stay i -- equation (VII.13) becomes (VII.14). The notation is essentially the same

(VII.14)

$$\overset{*}{m} = \sum_c \hat{m}_c \hat{n}_c \sum_r \hat{m}_{cr} \hat{n}_{cr} \sum_a \hat{m}_{cra} \hat{n}_{cra} \sum_s \hat{m}_{cras} \hat{n}_{cras} \sum_i \hat{m}_{crasi} \hat{n}_{crasi} \overset{*}{m}_{crasi}$$

$$+ \sum_c \hat{m}_c \hat{n}_c \sum_r \hat{m}_{cr} \hat{n}_{cr} \sum_a \hat{m}_{cra} \hat{n}_{cra} \sum_s \hat{m}_{cras} \hat{n}_{cras} \sum_i (\hat{m}_{crasi} - 1.0) \overset{*}{n}_{crasi}$$

$$+ \sum_c \hat{m}_c \hat{n}_c \sum_r \hat{m}_{cr} \hat{n}_{cr} \sum_a \hat{m}_{cra} \hat{n}_{cra} \sum_s (\hat{m}_{cras} - 1.0) \overset{*}{n}_{cras}$$

$$+ \sum_c \hat{m}_c \hat{n}_c \sum_r \hat{m}_{cr} \hat{n}_{cr} \sum_a (\hat{m}_{cra} - 1.0) \overset{*}{n}_{cra}$$

$$+ \sum_c \hat{m}_c \hat{n}_c \sum_r (\hat{m}_{cr} - 1.0) \overset{*}{n}_{cr}$$

$$+ \sum_c (\hat{m}_c - 1.0) \overset{*}{n}_c$$

as before except for the subscripts c and r which denote the chapters and risk categories.

Estimates derived by these procedures give an indication of the sources of provincial variations in post-operative mortality rates. To arrive at a corresponding set of estimates of provincial variations in length of post-operative hospital stay it is only necessary to replace the mortality data -- grouped by chapters, age, risk categories, hospital size and sex -- by length-of-stay data and to apply the same estimation procedure as before.

Appendix VIII

Surgical Procedures and Risk Categories Included in the Analysis of Postoperative Mortality and Hospital Stay

The summary below lists the surgical procedures, included in the analysis of postoperative mortality and length of hospital stay, under 16 Chapter headings. Individual surgical procedures are preceded by a five-digit code. The first three digits represent the ICDA-8 code[1] of surgical procedures. The next two digits represent the mortality-risk code for male and female patients respectively.

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1 Surgical procedures and treatments organized according to the "Eighth Revision of the International Classification of Diseases" as described in Statistics Canada. Surgical Procedures and Treatments. STATCAN Cat. No. 82-208 Annual.

SUMMARY OF SURGICAL PROCEDURES AND RISK

Categories Included in the Analysis of
Postoperative Mortality and Hospital Stay

Chapter I: NEUROSURGERY

010 5 5 CRANIOTOMY - (SKULL OPERATION)
030 3 3 LAMINECTOMY - (OPERATIONS ON SPINAL CORD STRUCTURES)
040 1 1 EXPLORATION OF PERIPHERAL NERVE
042 1 1 EXCISION AND DESTRUCTION OF LESION OF PERIPHERAL NERVE
051 3 3 SYMPATHECTOMY OR GANGLIONECTOMY

Chapter II: OPTHALMOLOGY

074 1 1 BLEPHAROPLASTY
105 1 1 MYECTOMY AND TENECTOMY, OCULAR - (OPERATION ON EYE)
106 1 1 ADVANCEMENT OR RESECTION OF EYE MUSCLE
121 1 1 IRIDECTOMY AND DESTRUCTION OF LESION OF IRIS OR CILARY BODY
135 1 1 OTHER REATTACHMENT OF RETINA
144 1 1 EXTRACTION OF LENS, EXTRASCAPULAR
145 1 1 EXTRACTION OF LENS, INTRASCAPULAR

Chapter III: OTORHINOLARYNGOLOGY

170 1 1 MYRINGOTOMY - (OPERATION ON THE MIDDLE EAR)
172 1 1 MASTOIDECTOMY, COMPLETE OR RADICAL - (OPERATION ON THE MIDDLE EAR)
174 1 1 STAPEDECTOMY WITH OSSICULAR RECONSTRUCTION - (OPERATION ON THE MIDDLE EAR
176 1 1 TYMPANOPLASTY, TYPE ONE - (OPERATION ON THE MIDDLE EAR)
190 1 1 EXCISION OF LESION OF NOSE
191 1 1 SECTION OF NASAL SEPTUM
193 1 1 RHINOPLASTY AND REPAIR OF NOSE
194 1 1 REDUCTION OF FRACTURE OF NASAL BONES
195 2 2 OTHER OPERATIONS OF NOSE
201 1 1 LOCAL EXCISION AND DESTRUCTION OF LESION OF LARYNK, VOCAL CORDS AND TRACHEA
211 1 1 TONSILLECTOMY WITHOUT ADENOIDECTOMY
212 1 1 TONSILLECTOMY WITH ADENOIDECTOMY
213 1 1 ADENOIDECTOMY WITHOUT TONSILLECTOMY

Chapter IV: THYROID, PRATHYROID AND ADRENAL OPERATIONS

221 2 1 THYROIDECTOMY, PARTIAL OR SUBTOTAL

Chapter V: VASCULAR AND CARDIAC SURGERY

224 1 1 EXCISION AND LIGATION OF VARICOSE VEINS
245 2 1 EXCISION OF ANEURYSM OF PERIPHERAL VESSELS
247 4 4 RECONSTRUCTION OF PERIPHERAL ARTERY BY BLOOD VESSEL GRAFT
251 4 3 SIMPLE EXCISION OF LYMPH NODES AND LYMPHCYSTS
275 4 4 RECONSTRUCTION OF INTRA-ABDOMINAL ARTERIES BY BLOOD VESSEL GRAFT
298 4 4 CARDIAC REVASCULARIZATION
302 3 3 CARDIAC CHATERTERIZATION RIGHT HEART
304 5 5 INSERTION OF ELECTRONIC DEVICE, HEART
305 3 2 REPLACEMENT OF ELECTRONIC HEART DEVICE

Chapter VI: THORACIC SURGERY

302 4 4 THORACOTOMY AND PLEUROTOMY

Chapter VII: ABDOMINAL SURGERY

380 2 2 REPAIR OF DIAPHRAGM AND DIAPHRAGMATIC HERNIA, ABDOMINAL APPROACH
382 1 1 REPAIR OF INGUINAL HERNIA EXCEPT RECURRENT
383 1 1 REPAIR OF RECURRENT INGUINAL HERNIA
384 2 2 REPAIR OF FEMORAL HERNIA EXCEPT RECURRENT
386 1 1 REPAIR OF VENTRAL OR INCISIONAL HERNIA
388 1 1 REPAIR OF UMBILICAL HERNIA
391 5 5 EXPLORATORY LAPAROTOMY OF CELIOTOMY (OPERATION ON THE ABDOMEN)
403 4 3 DIVISION OF PERITONEAL ADHESIONS
411 1 1 APPENDECTOMY
435 2 1 CHOLECYSTECTOMY - (GALL BLADER REMOVAL)
451 4 4 SPLENECTOMY - (OPERATION ON THE SPLEEN)
461 3 3 PYLO ROPLASTY AND OTHER DRAINAGE PROCEDURES (OPERATION ON THE STOMACH)
462 4 4 GASTRIC RESECTION, PARTIAL OR SUBTOTAL
468 2 2 VAGOTOMY - (OPERATION ON THE STOMACH)
474 5 5 RESECTION OF SMALL INTESTINE
475 4 4 RESECTION OF COLON, PARTIAL OR SUBTOTAL
478 5 5 COLOSTOMY

Chapter VIII: PROCTOLOGICAL SURGERY

502 2 2 LOCAL EXCISION AND DESTRUCTION OF LESION OF RECTUM
503 4 4 PROCTECTOMY - (OPERATION ON THE RECTUM)
511 1 1 INCISION OR EXCISION OF PERIANAL TISSUE
512 1 1 LOCAL EXCISION AND DESTRUCTION OF LESION OF ANUS
513 1 1 HEMORRHOIDECTOMY
521 1 1 EXCISION OF PILONIDAL SINUS OR CYST

Chapter IX: UROLOGICAL SURGERY

550 1 1 URETEROTOMY
557 1 1 PASSAGE OF CATHETER TO KIDNEY
561 2 2 LOCAL EXCISION AND DESTRUCTION OF LESION OF BLADDER, TRANSURETHRAL
571 1 1 HEATOTOMY - (OPERATION ON URETHRA)
574 1 1 REPAIR AND PLASTIC OPERATIONS ON URETHRA
575 4 4 DILATION OF URETHRA (deleted from statistical analysis)
581 3 0 PROSTATECTOMY, SUPRAPUBIC
582 2 0 PROSTATECTOMY, TRANSURETHRAL
583 2 0 PROSTATECTOMY, OTHER
591 1 0 EXCISION OF HYDROCELE AND HEMATOCELE - (OPERATION ON THE SCROTUM)
594 2 0 ORCHIECTOMY, UNILATERAL - (OPERATION ON SCROTUM)
597 1 0 ORCHIOPEXY - (OPERATION ON SCROTUM)
601 1 0 VASECTOMY
612 1 0 CIRCUMCISION

Chapter X: BREAST SURGERY

652 1 1 MASECTOMY, PARTIAL
653 1 2 MASTECTOMY, COMPLETE
654 1 1 MASTECTOMY, EXTENDED SIMPLE
655 1 1 MASTECTOMY, RADICAL

Chapter XI: GYNECOLOGICAL SURGERY

671 0 1 LOCAL EXCISION OR DESTRUCTION OF LESION OF OVARY
672 0 1 COPHORECTOMY, UNILATERAL - (OPERATION ON OVARY)
673 0 1 SALPINGO-OOPHORECTOMY, UNILATERAL - (OPERATION ON OVARY)
681 0 1 SALPINGECTOMY, UNILATERAL - (OPERATION ON FALLOPIAN TUBES)
682 0 1 SALPINGECTOMY, BILATERAL - (OPERATION ON FALLOPIAN TUBES)
685 0 1 LIGATION AND DIVISION OF FALLOPIAN TUBES, BILATERAL
691 0 1 ABDOMINAL HYSTERECTOMY, PARTIAL OR SUBTOTAL
692 0 1 ABDOMINAL HYSTERECTOMY, COMPLETE OR TOTAL
694 0 1 VAGINAL HYSTERECTOMY, TOTAL AND SUBTOTAL
702 0 1 LOCAL EXCISION DESTRUCTION OF OTHER LESIONS UTERUS, CERVIX, SUPPORTING STRUCT
703 0 1 DILATION AND CURETTAGE OR UTERUS
704 0 1 TRACHELECTOMY - (OPERATION ON UTERUS OR SUPPORTING STRUCTURE)
707 0 1 UTERINE SUSPENSION
709 0 1 OTHER OPERATIONS ON THE UTERUS, CERVIX AND SUPPORTING STRUCTURES
713 0 1 COLPORRHAPY - (OPERATION ON VAGINA)
714 0 1 PLASTIC REPAIR OF CYSTOCELE AND/OR RECTOCELE - (OPERATION ON VAGINA)
716 0 1 DILATION OF VAGINA
720 0 1 INCISION OF VULVA AND PERINEUM - NON-OBSTETRICAL
721 0 1 EXCISION OF LESION OF VULVA AND PERINEUM

Chapter XII: OBSTETRICAL PROCEDURES

747 0 1 DILATION AND CURETTAGE TO TERMINATE PREGNANCY
748 0 1 INTRA-AMNIOTIC INJECTION TO TERMINATE PREGNANCY
749 0 1 OTHER ANTEPARTUM PROCEDURES TO TERMINATE PREGNANCY
750 0 1 ARTIFICAL RUPTURE OF MEMBRANES - (OPERATION INDUCING OR ASSISTING DELIVERY)
753 0 1 OUTLET FORCEPS DELIVERY WITHOUT EPISIOTOMY
754 0 1 OUTLET FORCEPS DELIVERY WITH EPISIOTOMY
755 0 1 LOW FORCEPS DELIVERY WITHOUT EPISIOTOMY
756 0 1 LOW FORCEPS DELIVERY WITH EPISIOTOMY
757 0 1 MID FORCEPS DELIVERY
750 0 1 EPISIOTOMY
760 0 1 BREECH EXTRACTION, PARTIAL - (OPERATION INDUCING OR ASSISTING DELIVERY)
762 0 1 FORCEPS ROTATION OF FETAL HEAD
771 0 1 CESAREAN SECTION, LOW CERVICAL
779 0 1 CESAREAN SECTION, TYPE UNSPECIFIED
780 0 1 REMOVAL OF RETAINED PLACENTA
781 0 1 DILATION AND CURETTAGE AFTER DELIVERY OR ABORTION
783 0 1 REPAIR OF OTHER OBSTETRICAL LACERATIONS

Chapter XIII: ORTHOPEDIC SURGERY

802 1 1 DIVISION OF BONES OF FOOT AND TOES
803 1 1 DIVISION OF OTHER BONES
804 1 1 EXCISION OF BONE, PARTIAL
806 1 1 OSTECTOMY, COMPLETE
808 1 1 REMOVAL OF FIXATION DEVICE - INTERNAL
810 1 1 BONE GRAFT WITHOUT METALLIC INTERNAL FIXATION
814 2 2 REVISION OF AMPUTATION STUMP
815 4 4 INTERNAL FIXATION DEVICE WITHOUT FRACTURE REDUCTION
816 2 2 TRACTION AND EXTERNAL FIXATION DEVICE, NO MANIPULATION FOR REDUCTION
825 5 4 OPEN REDUCTION INTERTROCHANTERIC FRACTURE WITH INTERNAL FIXATION
829 5 5 OPEN REDUCTION OF OTHER HIP FRACTURE WITH INTERNAL FIXATION DEVICE
830 1 1 CLOSED REDUCTION OF ANKLE FRACTURE
832 1 1 OPEN REDUCTION OF ANKLE FRACTURE WITH INTERNAL FIXATION
833 1 1 CLOSED REDUCTION OF WRIST FRACTURE
840 1 1 CLOSED REDUCTION OF ELBOW, KNEE OR SHOULDER REGION FRACTURE
843 1 1 OPEN REDUCTION ELBOW, KNEE, SHOULDER REGION FRACTURE WITH INTERNAL FIXATION
844 1 1 CLOSED REDUCTION OF OTHER BONE SITE FRACTURE
846 1 2 OPEN REDUCTION OF OTHER BONE SITE FRACTURE WITHOUT INTERNAL FIXATION
847 2 4 OPEN REDUCTION OF OTHER BONE SITE FRACTURE WITH INTERNAL FIXATION DEVICE
850 1 1 AMPUTATION AND DISARTICULATION OF FINGERS EXCLUDING THUMB
860 1 1 ARTHROTOMY - (INCISION AND EXCISION OF JOINT STRUCTURES)
864 1 1 EXCISION OF INTERVERTEBRAL CARTILAGE - PROLAPSE DISK
865 1 1 EXCISION OF SEMILUNAR CARTILAGE OF KNEE JOINT
871 4 4 ARTHROPLASTY OF HIP WITH MECHANICAL DEVICE
872 1 1 REPAIR AND PLASTIC OPERATIONS ON JOINTS OF FOOT AND TOES
873 1 1 REPAIR AND PLASTIC OPERATIONS ON OTHER JOINTS
874 1 1 SPINAL FUSION
875 1 1 ARTHRODESIS AND STABILIZATION OF FOOT AND ANKLE
877 1 1 CLOSED REDUCTION OF DISLOCATION OF JOINT
881 1 1 DIVISON OF MUSCLE, TENDON AND FASCIA

Chapter XII: OBSTETRICAL PROCEDURES (cont.)

882 1 1 EXCISION OF LESION OF MUSCLE, TENDON AND FASCIA
883 1 1 RESECTION OF MUSCLE, TENDON, FASCIA AND BURSA
884 1 1 SUTURE OF MUSCLE, TENDON AND FASCIA
885 1 1 TRANSPLANTATION OF MUSCLE AND TENDON
887 1 1 OTHER PLASTIC OPERATIONS ON TENDON AND FASCIA
892 1 1 RESECTION OF MUSCLE, TENDON AND FASICIA OF HAND
893 1 1 SUTURE OF MUSCLE, TENDON AND FASCIA OF HAND
882 1 1 EXCISION OF LESION OF MUSCLE, TENDON AND FASCIA
883 1 1 RESECTION OF MUSCLE, TENDON, FASCIA AND BURSA
884 1 1 SUTURE OF MUSCLE, TENDON AND FASCIA
885 1 1 TRANSPLANTATION OF MUSCLE AND TENDON
887 1 1 OTHER PLASTIC OPERATIONS ON TENDON AND FASCIA
892 1 1 RESECTION OF MUSCLE, TENDON AND FASICIA OF HAND
893 1 1 SUTURE OF MUSCLE, TENDON AND FASCIA OF HAND

Chapter XIV: PLASTIC SURGERY

920 2 2 INCISION OF SKIN AND SUBCUTANEOUS TISSUE
921 2 1 LOCAL EXCISION OF LESION OF SKIN AND SUBCUTANEOUS TISSUE
922 2 2 WIDE OR RADICAL EXICISION OF LESION OF SKIN
924 1 1 REMOVAL OF NAIL, NAILBED OR NAILFOLD
925 1 2 SUTURE OF SKIN OR MUCOUS MEMBRANE
930 1 1 Z-PLASTY FOR RELAXATION OF SCAR OR WEB CONTRACTURE (RECONSTRUCTIVE SURGERY)
933 2 2 FREE SKIN GRAFT TO OTHER SITES
940 1 1 SURGICAL CORRECTION OF PROMINENT EAR
944 1 1 AUGMENTATION MAMMOPLASTY - (REPARATIVE AND RECONSTRUCTIVE SURGERY)
045 1 1 SIZE-REDUCTION PLASTIC OPERATION

Chapter XV: ORAL AND MAXILLOFACIAL SURGERY

951 1 1 EXCISION OF SALIVARY GLANDS, LOCAL OR TOTAL

Chapter XVI: DENTAL SURGERY

993 1 1 EXTRACTION OF TOOTH, FORCEPS EXTRACTION
994 1 1 SURGICAL REMOVAL OF TOOTH