ORIGINAL ARTICLE

Disproportion of economic impact, research achievements and research support in digestive diseases in Canada

Ivan T. Beck, MD, PhD

Dr. Beck is with the Gastrointestinal Diseases Research Unit, Division of Gastroenterology, Department of Medicine and Department of Physiology, Queen’s University, Hotel Dieu Hospital, Kingston, Ont.

Medical subject headings: academies and institutes; awards and prizes; biological sciences; colonic diseases, functional; digestive system diseases; dyspepsia; fellowships and scholarships; financing, organized; gastrointestinal diseases; health care economics and organizations; research; research support; societies

(Original manuscript submitted Aug. 25, 2000; received in revised form Dec. 4, 2000; accepted Dec. 4, 2000)

© 2001 Canadian Medical Association

Abstract

Objectives: To assess the economic impact, research output and research support of digestive diseases, and to compare them to those of other common disease entities, specifically mental, cardiovascular, respiratory, and central nervous system diseases.

Methods: Economic burden was assessed with the use of (a) published Canadian government data of direct cost from 1963 to 1993, (b) data from the Canadian Institute of Health Information and (c) recent Canadian economic studies. Research achievements were assessed on the basis of (a) research training in Canadian units, (b) individual achievements by Canadian investigators and (c) contribution to meetings and reception of awards. Research support was assessed by reviewing (a) Canadian government publications, (b) the Association of Canadian Medical Colleges, (c) the Medical Research Council (MRC) of Canada, (d) charitable organizations and (e) the Canadian Association of Gastroenterology (CAG).

Results: Digestive diseases are responsible for 15% of the total direct economic burden of Canadian health costs, and this figure exceeds those for mental, cardiovascular, respiratory and central nervous system diseases. Hospital discharges for digestive diseases contribute 12% of all hospitalizations and 20% of all neoplasias. Digestive diseases cause short-term loss of productivity, costing $1.14 billion/yr and exceeding the costs of mental, cardiovascular, respiratory and central nervous system diseases. Eighty-one percent of Research Fellows trained in Canadian units entered academic positions, and 63% obtained operating grants. Canadian investigators made important contributions in all areas of digestive science and received major international awards. Government support for digestive diseases was less than that for cardiovascular and neurologic research. In contrast to the highest economic burden, university staffing and residents were fewer for digestive than for mental, cardiovascular, respiratory and neurologic diseases. The number of MRC grants decreased, mainly because of organizational problems. Most charitable organizations support research specifically oriented to the disease of their interest. The CAG was the major supporter of non-specified research.

Conclusions: Digestive diseases are responsible for a major economic burden. Scientists in this field have established international recognition, but research support lags behind the need to correct the economic burden and to provide future generations of scientists in the digestive sciences. There is need for government to readdress this shortcoming and to review its method of support.
Résumé

Objectifs : Évaluer l’impact économique des maladies digestives, les résultats de recherche et l’appui à la recherche dans ce domaine, et les comparer à ceux d’autres entités morbides courantes, et plus particulièrement les maladies mentales, cardio-vasculaires, respiratoires et du système nerveux central.

 Méthodes : On a évalué le fardeau économique en utilisant a) des données publiées par le gouvernement du Canada sur le coût direct de 1963 à 1993, b) des données de l’Institut canadien d’information sur la santé et c) des études récentes sur l’économie canadienne. On a évalué les résultats de recherche en fonction a) de la formation en recherche dans des services canadiens, b) de réalisations individuelles de chercheurs canadiens et c) de la contribution à des réunions et des distinctions reçues. On a évalué l’appui à la recherche en étudiant des publications a) du gouvernement du Canada, b) de l’Association des facultés de médecine du Canada, c) du Conseil de recherches médicales (CRM) du Canada, d) d’organismes de bienfaisance et e) de l’Association canadienne de gastro-entérologie (ACG).

Résultats : Les maladies digestives causent 15% du fardeau économique direct total que représentent les coûts de santé au Canada et ce chiffre dépasse ceux des maladies mentales, cardio-vasculaires, respiratoires et du système nerveux central. Les congés d’hôpital à la suite de maladies digestives représentent 12% du total des hospitalisations et 20% des néoplasies. Les maladies digestives entraînent une perte de productivité à court terme de 1,14 milliard de dollars par année, ce qui dépasse les coûts des maladies mentales, cardio-vasculaires, respiratoires et du système nerveux central. Parmi les boursiers en recherche qui ont reçu leur formation dans des services canadiens, 81 % ont accepté des postes universitaires et 63% ont obtenu des subventions de fonctionnement. Les chercheurs du Canada apportent des contributions importantes à tous les domaines de la science de la digestion et ont reçu d’importantes distinctions internationales. Le gouvernement a accordé moins d’appui aux maladies digestives qu’à la recherche sur les maladies cardio-vasculaires et neurologiques. Même si le fardeau économique y est le plus lourd, il y avait moins de résidents et d’effectifs universitaires dans le domaine des maladies digestives que dans ceux des maladies mentales, cardio-vasculaires, respiratoires et neurologiques. Le nombre de subventions du CRM a diminué, surtout à cause de problèmes organisationnels. La plupart des organismes de bienfaisance appuient les recherches axées spécifiquement sur la maladie qui les intéresse. L’ACG a été le principal organisme à appuyer des recherches non spécifiées.

Conclusions : Les maladies digestives engendrent un fardeau économique important. Les scientifiques de cette discipline sont reconnus sur la scène internationale, mais l’appui à la recherche a du retard sur le besoin d’alléger le fardeau économique et de produire de futures générations de scientifiques spécialisés dans la digestion. Le gouvernement doit se pencher de nouveau sur cette lacune et revoir sa méthode d’appui.

Introduction

The excellence of Canadian research is internationally recognized, but the infrastructure of financial support appears to be inadequate. Friesen, in his Presidential report to the Medical Research Council (MRC) of Canada indicated that Canadian researchers per 100 000 population published more papers than investigators of other first world western nations, including the United Kingdom (UK), United States (US), France, Germany, Japan and Italy. Canadian investigators are first among these nations in publications and citations per dollar spent on research and development. In contrast, Canadian research expenditures as a percentage of the Gross Domestic Product, is among the lowest. Research support in Canada is only somewhat better than that in Mexico and Italy but is less than that in the UK, France, Germany, US, Switzerland, Japan and Sweden. The present review tries to establish how research in digestive diseases fares in this environment.

The overall cost of diseases of different organ systems varies substantially in Canada. If we assume that the research results diminish human suffering, improve the delivery of health care and thus decrease the economic cost of the different diseases, the proportion of research support should parallel the relative cost of each specific disease category. The following review of economic burden compared to research support suggests that in Canada this is not the case for many conditions, including those of the digestive system. With the use of Canadian data, I shall review the relation of the direct economic burden of digestive diseases to the level of their research support and discuss this in relation to the overall research output of Canadian investigators working in this area of medicine.
Methods

Assessment of economic burden

Calculation of economic cost

Economic studies may express the burden of disease in both direct and indirect costs and calculate a total cost from these data. Direct cost reflects the services and value of goods for which payment was made and resources were used. This includes the cost of care by physicians and health professionals, the cost of hospitals or other health care institutions, the expenses of drugs and appliances and the moneys committed to health science research. Although costing of any of these items may depend on the approach taken to calculate it, if an identical method is used for each category, direct cost is reasonably straightforward and can be estimated more easily than the more complex indirect cost. The assessment of long-term indirect costs to a disease category represents the value society places on health. This calculation considers the value of long-term loss of productivity as a result of prolonged disability or premature death. It calculates monetary loss due to loss of earnings and then calculates the impact that premature death and disability have on individuals and society. These costs are extremely difficult to calculate and require individual judgement. Because of these uncertainties, the present review considers only costs that are less difficult to assess. These consist of the direct cost and the immediate short-term loss of productivity. Furthermore, only Canadian data are presented in detail, because the economic burden and research support in other countries differs from those in Canada.

Methods of assessment of the burden

The cost of diseases in Canada can be gathered from 3 main sources: published literature, hospital discharges and outpatient utilization. The published literature provides a general trend throughout the years. It can be expressed as total dollar value or as a percentage of its cost in relation to the combined expenses of all diseases. The latter provides better comparison among disease categories and will be used in this review.

More recent data were obtained from hospital discharges and from outpatient utilization. In every Canadian hospital, discharge summaries containing primary and secondary diagnosis are collected using either the International Classification of Diseases, 9th revision (ICD-9) or its clinical modification (ICD-9-CM) or the Canadian Classification of Diagnostic, Therapeutic and Surgical Procedures. Each hospital submits its discharge data to the Canadian Institute of Health Information (CIHI). The accuracy of primary discharge diagnosis lies between 74% and 94% depending on the province and the disease entity studied. Because of its relative accuracy, it was reasonable to obtain hospital discharge diagnoses to provide the most recent comparative statistics. The raw data for the fiscal year 1996/97, which were available in 1999, were kindly provided by K. Handa. These were analyzed in the present study to provide the comparative data described below.

It was more difficult to obtain reliable outpatient data. Most provinces do not require an accurate diagnosis for payment of physician fees, therefore review of provincial diagnostic data would be of little help. Provincial drug care programs are of partial help because they deal mainly with the elderly. Furthermore, most patients suffering from mild, but often debilitating digestive disease, use over-the-counter (OTC) medication, and OTC drugs and nutrients, except under specific conditions, are not covered by provincial drug care programs. Despite these limitations, a general impression of the relative economic burden of gastrointestinal drugs could be obtained from provincial drug care programs. The data for 1998 of the Ontario Drug Benefit Program was kindly provided by DeFelice and Fraser and are being used in the present study. There were 3 recent prospective articles on the economic burden of “nonorganic” gastrointestinal diseases, irritable bowel syndrome and dyspepsia. Analysis of the data provided reasonable evidence for outpatient utilization of digestive diseases.

Disease categories compared to digestive diseases

Review of the literature indicates that the highest
direct economic burdens are digestive, mental, cardiovascular and central nervous system (CNS) diseases. Other conditions with high economic costs are neoplastic diseases and accidents. In this review, wherever possible, neoplastic diseases are broken down to organ-specific neoplasms and are covered within these specific conditions. With respect to accidents, no data are presented to define which organ system is involved in the “accident” (CNS, musculoskeletal, cardiovascular or gastrointestinal, shock), so this category cannot be classified and therefore will not be dealt with in this review.

Definition of disease categories

The ICD-9 includes, in the section on digestive diseases, afflictions of the oral cavity, tongue, teeth, pharynx, esophagus, stomach, small and large bowel, as well as diseases of the liver and pancreas. Under mental disease, all outpatient, institutional and care in special institutions are included. The category of cardiovascular diseases encompasses affection of the heart and vascular system, including strokes. Diseases of the respiratory system involve all acute and chronic diseases of the upper and lower respiratory tract, and CNS diseases encompass affections of the CNS plus those of the sense organs, eye care and hearing aids. Different reviewers deal with the above-described categories in a dissimilar fashion, making time-specific comparison difficult. In contrast to the data of Kohn, and Fraser and associates, Moore and colleagues in Table 2 of their manuscript (summarizing the direct economic burden of diseases), do not always include all expenses related to that category and provide some of these as “aggregate costs.” They indicate that these “aggregate levels” could be allocated to the specific diagnostic categories. To provide comparison to the percentage calculated by those authors who already included these aggregates to the basic calculations, in the present study the “aggregate levels” (6,631,000). (It should be noted, however, that calculations of this sort are never accurate enough, since 7.6 billion in Table 2 of Moore and colleagues could not be allocated to any disease category. This could provide a disadvantage to those diseases for which aggregate data were not available [Rachael Moore: personal communication, 2000].)

<table>
<thead>
<tr>
<th>Diagnostic category</th>
<th>Canada 1961</th>
<th>Ontario 1971</th>
<th>Canada 1993</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infectious diseases</td>
<td>5.4</td>
<td>1.9</td>
<td>1.5</td>
</tr>
<tr>
<td>Neoplasms</td>
<td>4.5</td>
<td>6.3</td>
<td>6.3</td>
</tr>
<tr>
<td>Endocrine diseases</td>
<td>1.7</td>
<td>2.5</td>
<td>2.6</td>
</tr>
<tr>
<td>Blood diseases</td>
<td>0.4</td>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Mental disorders</td>
<td>25.6</td>
<td>15.1</td>
<td>11.4</td>
</tr>
<tr>
<td>Central nervous system and sense organ diseases</td>
<td>4.3</td>
<td>5.1</td>
<td>7.2</td>
</tr>
<tr>
<td>Cardiovascular diseases</td>
<td>6.5</td>
<td>12.6</td>
<td>14.4</td>
</tr>
<tr>
<td>Respiratory diseases</td>
<td>7.2</td>
<td>7.1</td>
<td>7.4</td>
</tr>
<tr>
<td>Digestive diseases</td>
<td>14.6</td>
<td>15.3</td>
<td>15.7</td>
</tr>
<tr>
<td>Genitourinary diseases</td>
<td>4.6</td>
<td>5.8</td>
<td>4.4</td>
</tr>
<tr>
<td>Obstetrical disorders</td>
<td>6.7</td>
<td>4.9</td>
<td>4.0</td>
</tr>
<tr>
<td>Skin diseases</td>
<td>2.8</td>
<td>1.8</td>
<td>1.7</td>
</tr>
<tr>
<td>Musculoskeletal diseases</td>
<td>3.8</td>
<td>4.5</td>
<td>4.8</td>
</tr>
<tr>
<td>Congenital diseases</td>
<td>0.5</td>
<td>1.1</td>
<td>0.6</td>
</tr>
<tr>
<td>Perinatal conditions</td>
<td>0.6</td>
<td>0.5</td>
<td>1.1</td>
</tr>
<tr>
<td>Ill-defined conditions</td>
<td>2.4</td>
<td>2.8</td>
<td>3.7</td>
</tr>
<tr>
<td>Accidents</td>
<td>4.9</td>
<td>7.1</td>
<td>6.2</td>
</tr>
<tr>
<td>Well-patient care/other</td>
<td>3.5</td>
<td>5.0</td>
<td>6.5</td>
</tr>
</tbody>
</table>

Data are expressed as a percentage of the total money for all diseases spent on these specific disease categories. Percentages were obtained from Fraser and associates and Moore and colleagues. The 1961 Canadian date of Kohn were quoted in Fraser and associates. Moore and colleagues. To provide comparative percentages, the values for 1993 were recalculated with use of the basal and “aggregated” data of Moore and colleagues (their Table 2) (see Methods section. Definition of disease categories). These data are used with permission of the Government of Ontario, Queen’s Printer for Ontario, and the Government of Canada, Minister of Public Works and Government Services.
Assessment of research achievements

Results of research training in Canadian gastroenterology units between 1987 and 1997 are based on recently reviewed data by Beck and Depew.\textsuperscript{13,14} Research contributions by Canadian investigators were assessed by a literature search of major contributions by Canadian investigators to digestive sciences. This could not provide a comprehensive review of all the achievements of Canadian researchers in the field. The ones selected are recent reviews or important late publications of some of the well-known Canadian investigators.\textsuperscript{*} A more specific comparison with scientists of other countries can be assessed by Canadian contributions to North American meetings, such as the American Gastroenterological Association and the number of individual awards at international competitions, such as the Janssen Award in Digestive Sciences.

Assessment of research support

Data on general research support were obtained from official Canadian government publications.\textsuperscript{2–4} More recent data on personnel and trainees was obtained for the year 1996/97 from the Association of Canadian Medical Colleges (ACMC).\textsuperscript{15} Data from the MRC were obtained from the yearly President’s report.\textsuperscript{1,16–27} Data on the contribution of charitable organizations were based on correspondence with their executive directors or their delegates (Donna Richards-Mason, Canadian Celiac Association: personal communication, 1999).\textsuperscript{28–30} The research support by the Canadian Association of Gastroenterology (CAG) was derived from the President’s page of the CAG.\textsuperscript{31,32}

Results

Economic impact on digestive diseases

Published Canadian data

Digestive diseases have been in the past and continue to be the highest or close to highest direct economic burden of all health related expenses in Canada (Table 1). In 1961, Kohn\textsuperscript{2} found that 14.6% of the national direct health expenses was devoted to digestive diseases, and only mental diseases at 25.6% exceeded this. With the rapid advances in pharmacologic therapy of mental diseases, by 1971 an Ontario based statistic reported by Fraser and associates\textsuperscript{3} indicated that digestive diseases were highest in their economic impact. They cost 15.3% of the total Ontario health care system, with mental diseases running a close second at 15.0%. The direct expense for digestive diseases exceeded those of cardiovascular and respiratory diseases.\textsuperscript{5} In 1993, digestive diseases constituted 15.7% of the total Canadian health expenses, followed by cardiovascular diseases with 14.4% of total costs. These were followed in descending order by mental (11.4%), respiratory (7.4%) and CNS diseases (7.2%).\textsuperscript{4} These 5 constituted over 60% of the total direct disease-related national expenses, and digestive diseases (except for 1961) exceeded in their direct expenses, mental disease, cardiovascular, respiratory and all other disease categories. None of these statistics included the organ-specific direct cost of neoplastic diseases (see below).

Inpatient discharges for the fiscal year 1996/97

Hospital discharge statistics provided more recently recorded data for the relative frequency of digestive diseases in comparison with the other conditions.\textsuperscript{10} As shown in Fig. 1, of a total of 3 156 728 hospital discharges, 11.3% had a primary diagnosis of gastrointestinal diseases (excluding neoplasms) (Fig. 1A). This was second only to circulatory diseases, which constituted 14.6% of all discharges. Hospital separations for digestive conditions were greater than for diseases of the respiratory, mental and central nervous systems. In most statistics, neoplasms are dealt separately from non-neoplastic diseases. To assess the economic burden of organ-specific disorders, neoplasms should be included in the statistics (Fig. 1B). Inpatient discharges for all benign and malignant neoplasms were 217 926. The number of discharges for gastrointestinal neoplasms was 44 014, which was highest amongst the above-men-

\textsuperscript{*}The author apologizes to those whose contributions are not quoted in this article. Their absence from this text is the fault of the author alone and should not detract from their achievements.

Clin Invest Med • Vol 24, n° 1, février 2001
tioned conditions. Adding the number of neoplastic diseases to the organ-specific hospitalizations is shown in Fig. 1C. Thus, based on hospital separations for 1996/97, the frequency of discharges for gastrointestinal disease was second only to cardiovascular disease and discharges for neoplasm were highest for digestive diseases.

**Outpatient activity and short-term disability**

For reasons described in the Methods section, only data for drug benefit programs and prospective studies were used to assess the economic burden of outpatient utilization for digestive diseases. The Ontario Drug Benefit Program data indicate that in 1998 total drug expenses for all conditions were $1,643,720,968. The expenses for nutrients were $17,031,109 and drug utilization for digestive diseases $212,170,495, a combined 14% of total expenditures. However, because the provincial drug benefits are provided to a demographically unrepresentative group of patients (age over 65 years and welfare recipients) and do not cover OTC medications, such as antacids, antispasmodics, anti diarrheal agents, the true outpatient utilization for gastrointestinal diseases may be higher and therefore cannot be fully evaluated by these data.

Dyspepsia and irritable bowel syndrome are amongst the most common reasons why Canadians visit their family physicians. Three recent prospective Canadian investigations deal with the economic impact of irritable bowel syndrome and dyspeptic symptoms of the upper gastrointestinal tract. The study of Bentkover and associates is based on the experience of 2 clinics (1 academic, 1 private) in Quebec and of 2 similar clinics in Ontario. They examined the direct cost of adult patients (older than 20 years) seen in these clinics by adding the costs of physician fees, investigation, drug expenses, referrals to specialists and emergency visits (Table 2). They found that in Ontario the annual cost of a patient with irritable bowel syndrome is $255.48, in Quebec $265.73 and in Canada $258.82. The prevalence of irritable bowel syndrome in the general population is approximately 15%, and it is estimated that 42% of these patients consult physicians. Accordingly, Canadian physicians would see yearly 1,361,277 adult patients suffering from irritable bowel syndrome. The total direct cost of this is $32.1 million. The immediate indirect cost

---

**Fig. 1:** Hospital discharges for the fiscal year 1996/97, calculated from data provided by K. Handa. Digestive disease was second highest in hospital discharges and had the highest neoplastic component. Digestive = digestive diseases, CVS = cardiovascular diseases, Mental = mental diseases, Resp = diseases of the respiratory system; CNS = diseases of the central nervous system. A: without neoplastic diseases × 10,000. The figures at the end of the columns indicate the percent of the total 3,156,728 discharges (e.g., discharges for digestive diseases numbered 358,446 or 11.3%). B: neoplastic diseases × 1,000. The figures at the end of the columns indicate the percent of malignant disease calculated from the total number neoplastic discharges of 217,926. Discharge numbers for neoplastic conditions for digestive diseases were 44,014 (20%), for respiratory diseases 27,412 (12.5%), for central nervous system diseases 9,929 (4.5%). C: combined general and neoplastic diseases × 10,000. The figures at the end of the column indicate the percent of the sum of the non-neoplastic and neoplastic discharges. Shaded bars = non-neoplastic disease, white bars = neoplastic disease.

---

**Table 2:** Average annual direct cost in dollars per patient suffering from irritable bowel syndrome for patients over 20 years of age

<table>
<thead>
<tr>
<th>Region</th>
<th>Social perspective</th>
<th>Provincial health plan perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ontario</td>
<td>255.48</td>
<td>247.10</td>
</tr>
<tr>
<td>Quebec</td>
<td>265.73</td>
<td>220.78</td>
</tr>
<tr>
<td>Canada</td>
<td>258.82</td>
<td>235.86</td>
</tr>
</tbody>
</table>

*Sum total of costs irrespective of payer.
Reorganized with permission from Table 11 of Bentkover JD, Field C, Green EM, Plourde V, Cascarina J. The economic burden of irritable bowel syndrome in Canada. Can J Gastroenterol 1999;13(Suppl A):89A-96A.
in this population is high: the average lost work days per year is 13.4,\(^{36}\) amounting to 18.2 million days per year in Canada.

The prevalence and psychological impact of lower gastrointestinal symptoms was recently confirmed by Chen and associates\(^{12}\) in a prospective study on the general Canadian population. Substantial chronic symptoms of irritable bowel occurred in 11.5% of a randomly selected test population. Based on an accepted measure of well-being,\(^{37}\) subjects with lower gastrointestinal symptoms had a significant decrease in their psychological well-being index (\(p < 0.001\)).

Nonspecific upper gastrointestinal symptoms, generally referred to as “dyspepsia” have been reported to make up 7.3% of the practice of Canadian family physicians.\(^{33}\) The prevalence of dyspepsia and its effect on psychological well-being and economic impact of the Canadian population was recently studied.\(^{8}\) Assessing randomly selected, apparently healthy subjects\(^{12}\) Tougas and colleagues\(^{8}\) found that 28.6% experienced substantial upper gastrointestinal complaints during the 3 months preceding the questionnaire. The majority of these had had symptoms for over 1 year. According to an accepted method of psychological well-being,\(^{37}\) dyspeptic subjects experienced increased anxiety, depressed mood and well-being, less self-control and a decreased feeling of general health and vitality (Fig 2). The magnitude of this interference with psychological well-being was similar to that reported for moderate congestive heart failure.\(^{38}\) Symptoms of dyspepsia interfered with social activities (\(p < 0.002\)) and caused sleep disturbance (\(p < 0.001\)). The immediate short-term indirect economic burden was substantial. Subjects who suffered from gastrointestinal symptoms missed 9 times as many days of work than subjects without these complaints, and on the days they worked, their efficiency was affected by disagreeable gastrointestinal symptoms.\(^{4}\) These findings on irritable bowel syndrome by Bentkover and associates\(^{7}\) and Tougas and colleagues\(^{8}\) correspond to the data on short-term disability by Moore and colleagues,\(^{4}\) where loss of work for digestive diseases costs Canadians $1.147 billion (Table 4). This was superseded only by respiratory diseases, injuries and musculoskeletal diseases.\(^{4}\)

In summary, 3 published government publications, recent discharge data, Ontario Drug Benefit Program expenses and 3 prospective outpatient studies indicate that digestive diseases constitute one of the major economic burdens in Canada and cause considerable absenteeism and interference with work performance.

**Canadian research achievements in digestive sciences**

Research fellowship training

During the last 15 years CAG-sponsored fellowship support steadily increased.\(^{31,32}\) Simultaneously the

### Table 3: Basis for calculating overall cost in Canada for irritable bowel syndrome

<table>
<thead>
<tr>
<th>Study</th>
<th>Prevalence, %</th>
<th>Consults physician, %</th>
<th>Consulting estimate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandler et al, 1984(^{14})</td>
<td>15.0</td>
<td>48.0</td>
<td>7.2</td>
</tr>
<tr>
<td>Jones and Lydeard, 1992(^{15})</td>
<td>21.6</td>
<td>33.4</td>
<td>7.2</td>
</tr>
<tr>
<td>Drossman et al, 1993(^{16})</td>
<td>9.4</td>
<td>45.8</td>
<td>4.3</td>
</tr>
<tr>
<td>Mean</td>
<td>15.3</td>
<td>42.4</td>
<td>6.2</td>
</tr>
</tbody>
</table>

\(^{14}\)Estimate of the percentage of patients with irritable bowel syndrome who visit physicians. Reorganized with permission from Table 1 of Bentkover JD, Field C, Green EM, Plourde V, Casciano JP. The economic burden of irritable bowel syndrome in Canada. Can J Gastroenterol 1999;13(Suppl A):89A-96A.

**Fig. 2: General well-being of randomly selected, apparently healthy Canadian subjects with (C) or without (H) dyspeptic symptoms. Note the significantly decreased values for those with dyspepsia.**

The calculated psychological general well-being (PGWB) index is also significantly well below normal. Reproduced with permission from Tougas and colleagues. Prevalence and impact of upper gastrointestinal symptoms in the Canadian population: findings from the DIGEST study. Domestic/International Gastroenterology Surveillance Study. Am J Gastroenterol 1999;94:2845-54.
available operating grants for digestive sciences from the MRC steadily decreased.\textsuperscript{1,16–27} To assess how research trainees fared in an environment of decreasing research funds, a recent study investigated the academic success rate of research fellows trained in Canadian gastroenterology units.\textsuperscript{13,14} This study dealt only with the outcome of “research fellows” (i.e., those who spent 1 year or more in research training). It did not include research by clinical trainees carried out during their elective research time. Between 1986 and 1997 86 research fellows were trained. Eighty-one percent received academic appointments, and of these 63% were successful in obtaining operating grants. Twenty-seven percent were of foreign origin, who came to Canada for training. Canadian fellows in Canada and foreign fellows returning home had a similar academic success rate. The number of non-Canadians coming to train in Canada and who subsequently obtained academic appointments in their country indicates the high reputation and success of research training in Canadian centres.

Individual achievements

Canadian investigators in the basic sciences and in clinical settings have achieved international recognition. Canadians were the first to clone the cystic fibrosis gene.\textsuperscript{39,40} Major contributions in the study of gastrointestinal motility were made by Canadians, and this country is now considered one of the leading centres in motility research.\textsuperscript{41–58} Investigations in Canada clarified some of the complex interactions of the enteric nervous\textsuperscript{79–83} and endocrine systems.\textsuperscript{74–78} Canadian scientists have made major contributions to the understanding of gastric pathophysiology\textsuperscript{96,79–87} and the biochemistry of gastric mucus.\textsuperscript{88,89} The basic principles and clinical approach to small intestinal transport were investigated and established,\textsuperscript{53,73,90–100} and advances in inflammatory bowel disease were made in the laboratories and at the clinical level\textsuperscript{93,95,96,99,101–110} by Canadian investigators, while other Canadians achieved international reputation in functional bowel disease.\textsuperscript{58,119–124} Outstanding work was carried out on the pathophysiology of splanchnic circulation,\textsuperscript{125–133} gallbladder physiology,\textsuperscript{55,134} bile secretion,\textsuperscript{135} pediatric,\textsuperscript{136,137} and adult nutrition\textsuperscript{115,116,138} by investigators in this country. Canadians have made contributions to the understanding of acute pancreatitis, pancreatic function and pancreatic physiology\textsuperscript{139–150} and contributed advances to the understanding of liver physiology and disease.\textsuperscript{51} Their investigation advanced our understanding\textsuperscript{135,152–156} and therapy of primary biliary cirrhosis,\textsuperscript{157–159} iron metabolism and hemochromatosis,\textsuperscript{160,161} viral hepatitis,\textsuperscript{162–164} the treatment of hepatitis B,\textsuperscript{165–167} the pathophysiology of ascites\textsuperscript{168,169} and liver transplantation.\textsuperscript{170–176} On the technical aspect of gastroenterology Canadians have established a major presence in endoscopic investigation.\textsuperscript{177–179} Cost-effective studies published in other countries cannot be applied to Canadian circumstances. Investigators in digestive diseases established cost-effective analysis of specific treatment methods based on Canadian circumstances and values.\textsuperscript{90,180–184}

Contributions to scientific meetings and awards

The yearly Digestive Disease Week held by several American societies interested in digestive sciences, including the American Gastroenterological Association (AGA), has become the site of an international gathering of clinicians and scientists in the field of digestive sciences. Contribution to this meeting is

---

**Table 4: Annual value, by diagnostic category, of lost productivity due to short-term disability, Canada 1993**

<table>
<thead>
<tr>
<th>Diagnostic category</th>
<th>1993 cost/$1000</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory diseases</td>
<td>4 357 224</td>
<td>24.8</td>
</tr>
<tr>
<td>Injuries</td>
<td>3 242 540</td>
<td>18.5</td>
</tr>
<tr>
<td>Musculoskeletal diseases</td>
<td>1 753 851</td>
<td>10.0</td>
</tr>
<tr>
<td>Digestive diseases</td>
<td>1 147 567</td>
<td>6.5</td>
</tr>
<tr>
<td>Central nervous system and sense organ diseases</td>
<td>896 058</td>
<td>5.1</td>
</tr>
<tr>
<td>Mental disorders</td>
<td>811 508</td>
<td>4.6</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>681 726</td>
<td>3.9</td>
</tr>
<tr>
<td>Genitourinary diseases</td>
<td>521 505</td>
<td>3.0</td>
</tr>
<tr>
<td>Cardiovascular diseases</td>
<td>425 348</td>
<td>2.4</td>
</tr>
<tr>
<td>Infectious and parasitic diseases</td>
<td>381 704</td>
<td>2.2</td>
</tr>
<tr>
<td>Neoplasms</td>
<td>251 205</td>
<td>1.4</td>
</tr>
<tr>
<td>Skin and related diseases</td>
<td>108 808</td>
<td>0.6</td>
</tr>
<tr>
<td>Blood and related diseases</td>
<td>86 926</td>
<td>0.5</td>
</tr>
<tr>
<td>Perinatal conditions</td>
<td>66 696</td>
<td>0.4</td>
</tr>
<tr>
<td>Ill-defined conditions</td>
<td>1 819 170</td>
<td>10.5</td>
</tr>
<tr>
<td>Other diagnostic categories</td>
<td>996 937</td>
<td>5.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>17 548 772</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

selective, and over 30% of submissions are rejected. The membership of the AGA in 2000 was 11,230, with 339 (3.0%) Canadian members. At the May 2000 meeting, the AGA accepted 3,634 presentations of which 152 (4.2%) originated in Canada — a 25% higher acceptance than expected from the membership numbers (Matthew Glaser, Senior Manager of Section Programs, American Gastroenterological Association: personal communication, 2000).

The presentation of the Janssen Award is one of the major events at the yearly Digestive Disease Week. This award was initiated 6 years ago, and at first was given mainly to US scientists and only for motility work. More recently it has become an international award for which competitions are received from all over the world. Of the total of 60 awards, 8 (13%) were won by Canadians (Bryan deCastro, Project Manager, SCP Communications, New York: personal communication, 2000).†

Research support

Overall research support

This section considers overall provincial or national support. There are 2 factors that promote research in a specific discipline: the availability of research funds and the presence of well-trained research personnel. Research support in digestive diseases in relation to direct cost has been disproportionately low in the past. In the Ontario report of 1976‡ (Table 5) digestive diseases had the highest percentage of direct economic burden, but the infrastructure on which research is based was very low. Research funding for the digestive sciences constituted only 5.4% of all moneys available for research, and only 5.3% of all researchers worked in this field. In contrast, CNS and cardiovascular diseases had twice as much of their direct economic burden spent on research funds and one-third more of all investigators in Ontario carried out research in either one of these fields. However, mental and respiratory diseases received even lower research support than did diseases of the digestive system (Table 5).

The situation did not improve during the last 20 years. Moore and colleagues³ found that digestive diseases received research support of only 0.5% of their direct economic cost (Figs. 3 and 4). Fig. 3A demonstrates that in 1993 digestive diseases had the highest direct economic burden among the disease categories reviewed; Fig. 3B indicates that research funds as a percentage of the cost were low for digestive diseases (0.5% of the direct economic burden for gastrointestinal disease is spent on research), but were somewhat higher than for mental (0.3%) and respiratory (0.4%) diseases. Although still very low, funds for research on CNS diseases were considerably higher, 2.8% (see also Fig. 4). Data for research personnel for the period of 1993 were not available.

<table>
<thead>
<tr>
<th>Diagnostic category</th>
<th>Direct economic burden, %</th>
<th>Research funds, %</th>
<th>Research personnel, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infectious diseases</td>
<td>2.0</td>
<td>4.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Neoplasms</td>
<td>5.7</td>
<td>16.0</td>
<td>10.9</td>
</tr>
<tr>
<td>Endocrine diseases</td>
<td>3.5</td>
<td>7.0</td>
<td>7.4</td>
</tr>
<tr>
<td>Blood diseases</td>
<td>0.7</td>
<td>2.9</td>
<td>3.2</td>
</tr>
<tr>
<td>Mental disorders</td>
<td>13.6</td>
<td>4.4</td>
<td>5.3</td>
</tr>
<tr>
<td>Central nervous system and sense organ diseases</td>
<td>5.3</td>
<td>7.9</td>
<td>8.9</td>
</tr>
<tr>
<td>Cardiovascular diseases</td>
<td>12.9</td>
<td>11.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Respiratory diseases</td>
<td>8.5</td>
<td>3.9</td>
<td>3.6</td>
</tr>
<tr>
<td>Digestive diseases</td>
<td>13.9</td>
<td>5.4</td>
<td>5.3</td>
</tr>
<tr>
<td>Genitourinary diseases</td>
<td>5.9</td>
<td>1.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Obstetrical disorders</td>
<td>4.4</td>
<td>1.5</td>
<td>1.8</td>
</tr>
<tr>
<td>Skin diseases</td>
<td>2.1</td>
<td>0.1</td>
<td>0.4</td>
</tr>
<tr>
<td>Musculoskeletal diseases</td>
<td>4.6</td>
<td>3.5</td>
<td>4.8</td>
</tr>
<tr>
<td>Congenital diseases</td>
<td>1.0</td>
<td>1.4</td>
<td>2.2</td>
</tr>
<tr>
<td>Perinatal conditions</td>
<td>0.4</td>
<td>1.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Ill-defined conditions</td>
<td>3.0</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Accidents</td>
<td>6.7</td>
<td>1.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Special (other)</td>
<td>5.8</td>
<td>26.0</td>
<td>26.6</td>
</tr>
</tbody>
</table>

The direct economic burden is expressed as the percentage of the costs in the disease category in relation to the direct costs of all diseases. Research funds are expressed as the percentage of all research funds available in 1971 in Ontario. Research personnel is expressed as the percentage of all investigators working in the field of the specific disease category.

Reorganized with permission from Table 4 of Fraser RD, Spasoff RA, Prime MG. Towards the establishment of health research priorities: an estimate of the economic burden of ill health. Toronto: The Ontario Council of Health; 1976.

†Canadians received awards in several categories: in “Basic and clinical research” — Drs. Victor Plourde, Stephen Collins, Gervais Tougas and William Paterson; in “Outstanding clinical achievements” — Dr. Grant Thomson; in “Lifetime achievements in motility and digestive sciences” — Drs. Edwin Daniel, Nicholas Diamant and Ivan Beck.

‡The direct economic burden in this figure was obtained by re-calculation of data in Table 2 of Moore and colleagues³ and by adding the aggregate levels to the direct cost of digestive, mental and central nervous system diseases (see Methods section).
Assuming that the number of clinical investigators depends on the number of full-time academic staff at Canadian universities, data from the ACMC for 1996/97 were obtained. Fig. 3C indicates that compared to 758 full-time staff in mental diseases, 211 in cardiovascular diseases, 153 in respiratory diseases and 236 in CNS diseases, there were only 86 full-time academics in gastroenterology and hepatology. These 86 full-time academic staff had to deal with the clinical problems of the highest number of patients (Fig. 3A) and, thus, would have less time to devote to research. Another even more worrisome situation for future clinical investigators in digestive diseases is the low number of clinical trainees in this field. Fig. 1D demonstrates ACMC data on clinical residents in training. In 1996/97 there were 48 clinical residents in gastroenterology in a 2-year program (24 per year). In contrast there were 650 residents in psychiatry (130 per year), 148 in cardiovascular (50 per year), 70 in respirology (35 per year) and 153 in neurology (51 per year). The very low number in digestive diseases may barely be sufficient for clinical practice and will leave very few to engage in clinical investigation.

The overall Canadian research support in 1993 for all disease categories as a proportion of direct expenses is represented in Fig. 4 (reproduced from Moore and colleagues). It indicates a major disproportion between the different disease categories. Digestive disease research is supported at a level of 0.5% of its direct economic cost, whereas research areas with strong advocacy have higher support. This holds for infectious diseases (probably mainly because of support for AIDS), blood diseases, CNS
diseases, diabetes and cancer, all of which have 2.5% or more research shares of their direct cost (Fig. 4). (It was difficult to classify some basic research to specific disease categories [B. Moore : personal communication, 2000].) The data provided by Health Canada in Fig. 4 do not indicate what percentage of cancer research is used to support investigations of neoplasias in digestive diseases.

Research support of digestive diseases by the Medical Research Council of Canada

The major source of support for digestive diseases research in the past should have come from the MRC (presently the Canadian Institutes of Health Research). Digestive science-related grants at the MRC are judged by the Experimental Medicine panel. Between 1988 and 1998 successful gastroenterology grants decreased from 76 in 1988 to 53 in 1998 (Fig. 5).1,18–27 The total dollar value for digestive diseases in 1988 was $6 million and in 1998 $4.4 million. This decrease occurred in spite of an increase in total MRC operating grants from 1,892 successful grants ($129 million) in 1988 to 2018 grants ($171 million) in 1998. There was an understandably large increase in the research share for newer disciplines, such as molecular biology. There was, however, also a mild increase in a similarly stable disease condition, the cardiovascular system, where 158 successful grants in 1988 rose to 173 in 1998 (Fig. 5). In parallel to gastrointestinal grants, there was a steady decrease of the success rate of grants in nephrology (from 40 in 1988 to 25 in 1999) and hematology (from 63 to 36), the other 2 research areas assessed by the Experimental Medicine panel.

![Fig. 5: Medical Research Council (MRC) of Canada grant profiles between 1988 and 1998, indicating a steady decrease of funded grants by the Experimental Medicine Panel. Total MRC grants are shown × 10 to accommodate the findings to the scale of the other data. Total number of grants (diamonds) increased from 1892 in 1988 to 2018 in 1998; cardiovascular research grants (squares) increased from 158 to 173 during the same period. Successful grants for digestive diseases (circles) decreased from 76 to 53, for hematologic diseases (triangles) from 63 to 36 and for nephrology (asterisks) from 40 to 25. The data were obtained from the MRC presidents’ reports.1,18-27](image)

![Fig. 6: Comparative success rates of peer review panels in 7 competitions between September 1995 and September 1998. Note that em, the Experimental Medicine panel, deviates negatively from the norm. The names or the different panels are as follows: bma = biochemistry/molecular biology A, bmb = biochemistry/molecular biology B, bme = biomedical engineering, bsa = behavioural sciences A, bsb = behavioural sciences B, ca = cancer A, cb = cancer B, ci = clinical investigations, cp = cell physiology, cas = cardiovascular systems A, cab = cardiovascular systems B, ct = clinical trials, ds = dental sciences, e = endocrinology, em = experimental medicine, g = genetics, hsr = health services research, it = immunology and transplantation, mi = microbiology and infectious diseases, mn = metabolism and nutrition, nsa = neurosciences A, nsb = neurosciences B, pm = pathology and morphology, pop = population health, ps = pharmaceutical sciences, pt = pharmacology and toxicology, rs = respiratory system. Figure supplied by the MRC, Program Branch, courtesy of Fay Kert, Director of Communications.](image)
There are 3 possible explanations for a steady decrease of the success rate of these 3 specialties: a decrease in the quality of submission in all 3 disciplines; the Experimental Medicine panel is more “demanding” than others; and organizational problems. The international recognition of workers in these specialties speaks against a steady decline in the quality of submissions. MRC recently reviewed the success rate of different committees in 7 competitions between September 1995 and September 1998 (Fig. 6). Certain panels deviate positively and others negatively from the norm. The Experimental Medicine panel is among those that provide lower ratings. This may result from the method utilized by MRC panels and Council to decide which applications are funded. Each panel submits its best 20 grants to MRC Council and these 20 are granted without further review. Thus, if a specialty has 2 panels (e.g., cardiovascular disease) a priori 40 grants are approved, whereas if a panel like Experimental Medicine deals with 3 disease categories for each specialty, on average only one-third of the grants will be put forward to Council. The membership of the Experimental Medicine panel is made up of representatives of 3 specialties. Two-thirds of the members of the panel lack the detailed expertise for most applications (e.g., an expert in digestive sciences is unable critically to judge applications in nephrology or hematolgy, and vice-versa). This could lead to lower ratings for the grants of the other 2 specialties, resulting in generally lower average ratings by the panel (Fig. 6). Thus, the decreased success rate of grants in digestive diseases, nephrology and hematolgy may be the result of an organizational problem related to assigning 3 unrelated areas to the same panel.

Research support by other organizations

Research in digestive diseases has been supported by charitable and professional organizations. Some of these, the Canadian Celiac Association, Canadian Cystic Fibrosis Foundation, Canadian Liver Foundation and the Canadian Digestive Disease Foundation (CDDF) are minor donors whereas the Crohn’s and Colitis Foundation of Canada (CCFFC) (previously the Canadian Foundation for Ileitis and Colitis) and the CAG have contributed enormously to digestive disease research. Except for the CAG and CDDF most charitable organization support is for research in a single disease area. The Canadian Cystic Fibrosis Foundation supports research for all organ systems affected by this disease, including grants on lung disease. The total grant support related to digestive diseases for 1999/2000 was $230 152. The Canadian Celiac Association provides small grants of $5000 to young investigators for research on celiac disease and dermatitis herpetiformis (Donna Richards-Mason, Canadian Celiac Association: personal communication, 1999). The Canadian Liver Foundation has for the last 2 years stopped providing funds for research.

The Crohn’s and Colitis Foundation of Canada provides mainly operating grants and grants to summer students related to inflammatory bowel disease. Based on funds provided by the Kahanoff Founda-

![Fig. 7: Crohn's and Colitis Foundation of Canada operating grants (A) 1976 to 1985 versus (B) 1986 to 2000. The data in B indicate strong support of the intestinal disease research units at McMaster University and the University of Calgary. UB = University of British Columbia, AL = University of Alberta (Edmonton), CA = University of Calgary, SA = University of Saskatchewan, MA = University of Manitoba, WO = University of Western Ontario, Mc = McMaster University, TO = University of Toronto, QU = Queen’s University, OT = University of Ottawa, MT = Université de Montréal, MG = McGill University, SH = Université de Sherbrooke, LA = Université Laval, DA = Dalhousie University, ME = Memorial University. Data supplied by courtesy of M. Howarth.](image-url)
tion of Calgary, in 1982 the CCFC called a competition for 2 intestinal disease research units. The University of Calgary and McMaster University in Hamilton, Ont., were successful in this competition, and each of the units received approximately $2.8 million for their establishment. This created powerful research bases at these universities. The Foundation tends to support established researchers working in the field of inflammatory bowel disease. The dollar value of operating grants provided by the CCFC between 1976 and 2000 reached $13,734,876. Although up to 1984 operating grants were equally distributed among the universities, as of 1986 (Fig. 7A), soon after the establishment of the intestinal disease research units and because of the general philosophy of the Foundation, there appears to have been favouring of these 2 units. Of 94 operating grants between 1986 and 2000, 46 (51%) were awarded to members of the units at McMaster and Calgary, leaving a total of 46 operating grants for researchers in the other 8 medical schools (Fig. 7B). In 1997, the Foundation introduced a yearly competition for small grants on “innovation in inflammatory bowel disease,” but some of these also went to senior investigators. The Research Fellowship and the Summer Student Scholarships programs were designed to stimulate the development of new scientists. Between 1986 and 1999, of the 129 studentships, 63 (48%) were funded to work under the direction of scientists at the intestinal disease research units.30

The Canadian Association of Gastroenterology provides funds for fellowship support, summer student awards, new investigator establishment operating grants and general operating grants. Research support by the CAG initially was mainly for fellowships and studentships. The first negotiated research fellowship was a 3-year grant initiated in 1986 by Glaxo Canada to Queen’s University. Based on this experience, in 1989 Glaxo Canada provided 3-year support for clinical research fellows to 5 adult and 2 pediatric university-based gastroenterology units. However, with changes in the primary interest of the supporting industry, Glaxo’s support had decreased to 1 fellow per year by 1994. Because of the success of these fellowships, and realizing the potential vulnerability of relying on a single donor, the CAG approached several other pharmaceutical companies for research fellowship support.** The number of these fellowships increased to 4 in 1994 and then progressively to 17 by 1998 (Fig. 8).31,32 The CAG fellowship program, jointly supported by industry and some in combination with the MRC, further increased its funding, and in 2000 the CAG funded 31 fellowships, of which 13 were new grants.187 The “new investigator establishment grant” was introduced in 1997 to provide initial operating funds for young faculty members. These grants facilitated new investigators to establish sufficient data to allow for a successful application to other peer-reviewed agencies, such as the MRC or CCFC. Because of the paucity of operating grants by the MRC and the disease-specific support by the charitable organizations, the CAG recently initiated operating grants that were not organ- or disease-oriented. With all these undertakings, the funds raised for research by the CAG in 1999 reached $1,600,000 (Fig. 9), and with this the CAG has become one of the major granting agencies in gastroenterology.31,32,187

The Canadian Digestive Disease Foundation received its charitable status in 1995. Since that time it has provided 1-year support for novel ideas to investigators who had no other major funds. This initial 1-

**The industrial donors were: Glaxo Wellcome; AstraZeneca; Janssen–Ortho; Hoechst Marion Roussel Canada; Axcan Pharma; Merck–Frosst Canada; Searle Canada; Schering Canada; Solvay Pharma; Carsen Group.

![Fig. 8: Research fellowship support by the Canadian Association of Gastroenterology. Note the consistent increase in support over the years. Reproduced with permission from Fedorak RN. Growth of the Canadian Association of Gastroenterology: controlled, effective and impressive. Can J Gastroenterol 1999;13:191-3.](image-url)
year support should allow the investigator to accumulate sufficient data to compete successfully at other organizations. Since 1998, the CDDF and the MRC partnered fellowship support in gastroenterology. The most recent development is that the CDDF and the CAG will attempt to correlate their forces. Hopefully, the combination of a professional (CAG) and this new charitable organization will become the major supporting agency for non-disease-specific digestive science research.20

Discussion

This study was undertaken to compare the economic burden with research achievements and research support of digestive diseases. To achieve this, decisions had to be made about the approach for assessing the economic costs, research achievements and research support in this field. The purpose of cost of illness assessment is to provide data to policymakers, researchers, and charitable and professional organizations to prioritize the allocation of funds appropriately. A MEDLINE search indicates that since 1966 there were 3239 studies dealing with cost of illness. Studies have been used to assess loss to business due to staff illness188 or to determine the cost of specific diseases.189 General population cost-of-illness surveys are used to provide data on the economic impact of different illness categories.3,4,189–195 The economic burden can be expressed in 2 ways: core costs resulting directly from the illness (direct cost) and those that include additional non-illness related expenses (indirect cost). Direct costs include the value of goods and services and resources used for care of an individual patient (hospitalization, outpatient clinical care, care in nursing homes, home health care, services of primary physicians, dentists, specialists, other allied professionals, costs for drugs, prostheses, appliances, and disbursements invested in research). These data appear clear cut, but for each study standardization is needed to avoid inaccuracies. The cost for the same event may vary depending on the country, currency and the method employed for pricing.5,6 There may be differences in the spectrum of diseases that various authors include into the specific disease categories.3,4 However, if Canadian data and the same approach to pricing are used, and if inclusion of diseases is defined by the ICD-9, the direct cost assessment is accurate and can provide an accurate basis for calculations 3,4,189–195

Assessments of indirect costs are more complex. These costs include the value of health and life to society or the individual. There are 2 methods to study indirect cost: the “human capital” and the “willingness to pay” approaches.196 In the first, consideration is given to the value of lost productivity due to disability or early death. This approach considers lost earnings as a surrogate for the impact that disability and death have on individuals and society.3,4,191,193,195,197 The main criticism of this approach is that it does not recognize pain and suffering and the psychological consequences of illness. Furthermore, earnings do not always accurately reflect one’s ability to produce, and some groups may be over- or undervalued. The cost of other non-market values, such as housekeeping services, the difference of income of males and females are difficult to assess, and additional costs that family members spend looking after and visiting patients cannot be estimated. Furthermore, it does not account for consumer behaviour in purchasing goods and services.195 The second approach, the willingness to pay, is favoured by other economists since a decision whether or not a health program should proceed is ultimately driven by the willingness of the beneficiaries to incur costs for health
care. This is further broken down to what society and what the individual is prepared to pay. For instance, preserving the life of an elderly person with no future economic productivity may be a decision for which a family but not society is willing to pay. Thus, indirect costs can be calculated by 2 methods, each requiring different interpretations. Whether the author calculates the human capital or one of the willingness to pay methods, the inclusion criteria of expenses require individual judgement. Rice195 concluded that national surveys provide reasonably good information on the use of services for estimation of direct costs, but charge and cost data are less readily available and probably less reliable. Fraser and colleagues stated, regarding indirect costs, that they “result in some unknown degree of inaccuracy,”31 and Moore and colleagues indicated that “indirect costs are less reliable indicators than estimates of direct cost.”34 In a recent review, Hodgson194 indicated that in a cost-effective analysis indirect costs should be excluded on ethical grounds to prevent inclusion of not fully substantiated elements, and that these should be included only when appropriate, depending on the perspective of the analysis. On the basis of this evidence, the present economic assessment deals only with Canadian data of direct costs. Only those indirect costs that are easily measurable are included: the immediate changes of emotional effects and productivity related to irritable bowel syndrome and dyspepsia.

Canadian government data of 1961,2 19733 and 19934 indicate that digestive diseases constitute the highest direct burden in Canadian health care and throughout the years constituted about 15% of all direct health care costs (Table 1, Fig. 3). Data calculated from discharge summaries for 1996/9710 indicate that hospital separation for diseases of the gastrointestinal system was second after cardiovascular diseases (Fig. 1). Digestive diseases had the highest neoplastic component, 20% of all discharges for neoplasm was due to gastrointestinal disease.10†† Outpatient data indicate that a large component of the total drug expenses, 14%, is devoted to medications used for digestive problems and superseded all other categories.11 Three prospective studies indicate that common “nonorganic gastrointestinal diseases,” irritable bowel syndrome and dyspepsia, create major psychological disturbance and loss of productivity (Tables 2 and 3; Fig. 2)3,12 and cause psychological impact similar to that of mild congestive heart failure.36 Short-term disability and absenteeism for digestive problems are high and follow immediately after respiratory diseases, injuries and musculoskeletal problems (Table 4).4

In the future digestive diseases will have an even greater impact. With the aging population, chronic problems will create an as-yet-undetectable burden. Canadian hospital discharges for Crohn’s disease have been steadily rising and for both Crohn’s disease and ulcerative colitis, the elderly population (patients over 55 years) requires longer hospitalization.194 The number of patients with hepatitis will become a major problem owing to the recent arrival of immigrants from the East and the sequelae of transfusion-induced hepatitis C. While there is no direct and representative measurement of the prevalence of hepatitis C in Canada, a plausible estimate is 210 000 to 275 000 (the MRC/Health Canada Research Initiative on hepatitis C). As a result, the

![Fig. 10: United States data on the direct cost of digestive, mental, cardiovascular, respiratory and central nervous diseases for 1963 by Rice190 and for 1976, by Brown and Everhart.201 Note the similarity to Canadian data. Di = digestive diseases, Me = mental diseases, Cv = cardiovascular diseases, Re = respiratory diseases; Cn = diseases of the central nervous system and sense organs.](#)

††It is of interest that at the same time (1996/97) discharges for neoplasm of the breast made up 8.5% of all neoplastic conditions.10
economic burden due to hepatocellular carcinoma will also increase. Recent advances in liver transplantation, possibly using split livers or genetically altered animal tissues, may create a health problem owing to the increased availability of livers for transplantation and the resulting prolonged survival and ongoing care of liver-transplant patients.

This paper deals only with Canadian economic data because the actual Canadian dollar values are not comparable to those of the US. It is, however, of interest that in the US in 1963 the direct cost of digestive diseases was ranked first among all conditions and that it constituted 19.1% of all direct expenses. In 1975, the direct economic burden of digestive diseases was $22,341,000. This figure exceeded that of cardiovascular diseases ($16,017,000), mental diseases ($9,411,000) and diseases of the respiratory system ($7,571,000). Fig. 10 depicts these data as a percentage of total costs compared with Canadian costs. Thus, digestive diseases in the US, as in Canada, caused the greatest direct economic burden to that country’s health care system, and the 19% in the US is even higher than that in Canada (15%) (see Table 1).

A general review of the literature indicates that Canadian workers publish in the best scientific journals and have established an international reputation in the digestive sciences. A review of the accomplishments of individual investigators reveals many world-renowned names. As to the usefulness of this research to Canada, results of Canadian investigations have been directly applied to the Canadian economic environment and been used to educate practising physicians by establishing clinical practice guidelines provided by the CAG. Canadian scientists in digestive sciences established an outstanding research-training program. The majority of recent fellows trained between 1988 and 1997 (81%) received academic appointments and 63% of these have been successful in obtaining research grants. The international reputation of Canadian research training programs is demonstrated by the fact that 27% of research fellows have come from abroad to train in Canada and returned to successful academic careers in their countries.

To compare the output of all Canadian investigators, irrespective of field, to that of other countries, in a recent study the MRC extracted from literature the output of scientific papers originating from Canada and related this to the record of other countries. The data indicated that Canadian productivity was superior to that of other first-world countries. A similar breakdown or a citation index cannot be established for any of the subspecialties without knowledge of the names of all Canadian investigators in this field. However, acceptance rate of Canadian submissions to North American meetings can be considered a somewhat similar type of assessment. Canadian participation at the May 2000 Digestive Disease Week in the US exceeded the expected participation based on Canadian membership (Matthew Glaser, personal communication, 2000), and there is ongoing recognition of outstanding scientists with international awards in this field (Bryan deCastro: personal communication, 2000).

The immediate aim of economic estimates is to produce information to be used in the allocation of resources within, specifically, the health research sector. However, support of research in individual health sectors seems to depend less on the economic need than on several other factors. Governments seem to favour the entrepreneurial approach to research and are entering in partnership with industry or are influenced by lobby groups of patients and other advocates of special interest. To solve the problem of AIDS, the amount of funds provided for research in infectious diseases increased disproportionately to 4.2% of the direct economic impact of all infections (Fig. 4). Similarly, the emotional embrace by Canadians of seeing children suffering from leukemia and other blood-related cancers, and observing the devastating effect of CNS abnormalities increased research support for these diseases to 3.2% and 2.8% of their direct economic costs respectively. In contrast, research support for digestive sciences is supported only at 0.5% of its direct economic impact. Recent stakeholder representation has increased support for breast cancer even though, in contrast to gastrointestinal tumours (20%), breast neoplasia constitutes only 8.2% of hospitalizations.

The underfunding of research for certain diseases and support of investigation in politically “correct” areas holds not only for Canada but also for other countries. In the US the influence of lobbyists on the
National Institutes of Health has been questioned and proven. In comparison to the economic burden, research support was generally appropriate. However, AIDS, breast cancer, diabetes and dementia received relatively generous funding, whereas investigation for chronic obstructive pulmonary disease and perinatal conditions was less well supported. Research for peptic ulcer was the most underfunded area.

Recently, because of the Krever report, research for hepatitis C has become an issue. The MRC has, in combination with Health Canada, suddenly launched a 5-year $18 375 000 grant for hepatitis C (the MRC/Health Canada Research Initiative on hepatitis C). As stated in the description of the grant “The research initiative represents a response to Minister Allan Rock’s comprehensive September 18, 1998 proposal, aimed at building knowledge about and helping Canadians living with hepatitis C.” The description of the problem by the MRC states “It is clear that Canada’s research capacity to deal with this important health issue needs to be increased.” Unfortunately, focused opportunistic research in a single subject may create problems. Researchers dealing in areas not fully related to this subject may change their focus to apply for the sudden windfall of funds. It may convert a few investigators into this field, but, because of the generally undersupplied research infrastructure (Table 5, Fig. 3), other areas in digestive sciences could be neglected. It may take a long time before a set of new workers has been trained to replace those who entered the hepatitis field. Had there been ongoing support throughout the years for digestive diseases, earlier discovery of diagnostic methods for hepatitis C might have averted the present problem. To establish a wider base of scientists, it is important for Canada to appreciate the value of serendipitous discoveries. It must support not only "goal oriented" research but also research carried out by individual investigators.

There appears to be a problem in the distribution of funds to digestive sciences. The success rate of grant applications by the MRC for digestive diseases decreased in the last 10 years (Fig. 5). This occurred despite a general increase in total funding by the MRC and an increase in many other disciplines. The international recognition of Canadian investigators in this field speaks against the fact that this was due to a decrease in the quality of submissions. The observation that the 2 other specialties, hematology and nephrology, reviewed by the same panel have done similarly poorly, tends to indicate that there may be an organizational problem with the method of joint assessment of 3 different specialties by the same panel (Fig. 6). This issue was raised several times to the MRC, the first time in 1968. The argument has become a circular one. Investigators in digestive sciences continue to request a separate panel, because under the present conditions grant applications in this area are disadvantaged. In contrast the MRC believes that there are not sufficient grants in the field to justify a separate committee. This philosophy was reconfirmed by the fact that the joint application by digestive sciences, nutrition and dentistry failed to receive institute status at the recently established Canadian Institutes of Health Research.

Research support by the CCFC is disease-specific. The majority of this Foundation’s grants support established investigators who are mainly concentrated in their established intestinal disease research unit at McMaster University and the University of Calgary (Fig. 7). The objective of the Foundation is to find a “cure” for inflammatory bowel disease, and its Board believes that established investigators will provide an answer much faster than would new investigators. One could, however, argue that developing wider research contingency throughout the country might improve the chance.

The major source for broad-based research support in digestive sciences is the CAG. Much of the funding distributed by this Association came from the pharmaceutical industry. This support is fickle, as demonstrated by the sudden diminution of the original Glaxo fellowships at a time when the H2 receptor inhibitor became generic and when the interest and management of the company changed. Therefore, it has become necessary to approach a wider range of donors in the pharmaceutical industry. Finally, it will become essential to approach the general public, industrial and business donors outside the pharmaceutical companies. This was the reason for the establishment of a wide-based charitable organization, the CDDF. This organization is in its early stages. It is hoped that in time it should ob-
tain as widespread support as the Heart and Stroke Foundation or any of the other population-based charitable organizations. The CAG and the CDDF together may become the major donors for research in digestive sciences.

One of the major objectives of cost-of-illness studies is to provide information on which to base the planning of health improvement and to determine the areas where research is needed.\textsuperscript{3,4} Research improves the understanding of the mechanisms of disease and as a result improves therapy and thus decreases the cost of illness. To decrease the national economic burden, research support should be directed to those areas where the burden is high. Comparing the considerable economic burden with the relatively low financial investment for research in digestive diseases, the present study indicates an urgent national need to increase research support in this field. By contrasting the internationally recognized research achievements of Canadians with the relatively low financial support provided for this effort, this study demonstrates outstanding cost-efficiency of work carried out by investigators in this field. It is unlikely that this efficiency can be maintained for any length of time without a considerable increase and reorganization of research support in the field of digestive sciences.

**Summary and conclusions**

Digestive diseases have the highest direct economic burden in Canada and lead to considerable loss of productivity and absenteeism. In contrast, support in research funding, personnel and trainees is disproportionately low. In spite of this underfunding, investigators in digestive sciences have established an outstanding research training program and have gained international recognition in all fields of digestive sciences. To further improve this, it is necessary to provide a steady flow of research funds and personnel. The MRC’s present grant organizational system is disadvantageous for digestive scientists and the reluctance to establish a Canadian institute of health research in digestive, nutrition and dental sciences will probably make this situation worse. Charitable organizations up to now have supported only specific disease-oriented investigation. General non-goal-oriented research throughout the country was mainly supported by the CAG. It is hoped that in the future a joint effort of this Association with the CDDF will result in a wide population-based support for research in digestive diseases.

**Acknowledgements:** I thank Dr. R. Fedorak (University of Alberta, Edmonton), President of the Canadian Association of Gastroenterology (CAG) for initiating this research by asking me to prepare background material for the submission to Medical Research Council (MRC) of Canada for a Canadian Institute of Health Research in Digestive, Nutrition and Dental Sciences. I am also grateful for a grant from the CAG for updating the history of the Association, as this review represents a portion of that work. Thanks are also due for helpful suggestions from Drs. M.G. Blennerhassett (Queen’s University, Kingston, Ont.), W.T. Depew (Queen’s University), J. Duffin (Queen’s University), C.E. Hill (Queen’s University), R. Moore (Laboratory Centre for Disease Control, Ottawa), W.G. Paterson (Queen’s University) and E. Shaffer (University of Calgary). Special thanks are due to Dr. F. Kert (Deputy Director of Communications, MRC, Ottawa) for providing many of the MRC data.

**References**

10. Handa K. *Special study on acute care hospital separa-*


47. Beck IT, Barreiro MA. First description of the “migrating motor complex” and its physiological function.


103. Yacyshyn BR, Bowen-Yacyshyn MB, Jewell LD, Tami MT, Thomson AB. Lactobacillus species prevents colitis in in-


exogenous nitric oxide decreases TNF-alpha-induced leukocyte rolling. 


Economic burden and research support of digestive disease


Reprint requests to: Dr. Ivan T. Beck, Hotel Dieu Hospital, 166 Brock St., Kingston ON K7L 5G2; fax 613 544-3114

Correction: Pagination of the December 2000 issue

There was a major error in the pagination of articles in the December 2000 issue of the Journal (vol. 23, no. 6). The pagination of the October issue was repeated. An amended list of contents appears in this issue on page 4, and an amended index, which notes the error for each entry in the December issue and directs readers to the corrected contents, appears at the end of this issue. The new pagination will appear in MEDLINE and in the online version at the CMA Web site. The Journal apologizes to its readers for this error and for any inconvenience it has caused.