Exploring Technological Innovation in Health Systems

Centre for Health Care and Innovation
Preface

This report explores technological innovation in Canada’s health system. Using The Conference Board of Canada’s innovation framework to analyze the innovation environment and the creation, diffusion, transformation and use of knowledge, it provides a snapshot of where Canada stands when compared with Organisation for Economic Co-operation and Development countries with high-performing health systems. This report also provides suggestions for improving Canada’s capacity for technological innovation.

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This report would not have been possible without the input, support, and guidance from the members of the Centre for Health Care and Innovation.
EXECUTIVE SUMMARY

Exploring Technological Innovation in Health Systems

At a Glance

- In order to know how to boost technological innovation in health, we need to know our strengths and weaknesses. This was achieved using The Conference Board of Canada’s innovation framework to compare Canada with Organisation for Economic Co-operation and Development countries with high-performing health systems, and with the United States and Great Britain.

- We compare unfavourably in terms of the number of university graduates with advanced research qualifications in the health and life sciences sectors; our venture capital investment in health as a percentage of GDP is lower; and we offer relatively weak protection of patents. Our universities—where the majority of our health-related R&D is conducted—have markedly lower invention disclosures, patent applications, patents granted, and licences executed than their counterparts in the U.S. and Europe.

- Targeted efforts are needed to address the identified areas for improvement in the innovation environment, and in the creation, diffusion, transformation, and use of knowledge. This report contains many suggestions to start focusing on these efforts.

Analyzing the environment and conditions that facilitate technological innovation in health systems is a very valuable yet complex undertaking, made all the more difficult by the fact that little research exists in this area. This groundbreaking report explores and seeks to improve our understanding of technological innovation in Canada’s health system, with the overall purpose of improving the system’s quality and ultimately the health of Canadians.

It does so by using the Conference Board’s tried and true Innovation Framework, which has six components:

- the environment in which innovation occurs (standards, regulations and health policies, availability of venture capital and skilled workers, culture, etc.);
- the creation of knowledge (an innovation process concerned with the generation of new knowledge or significantly improving existing knowledge);
- the diffusion of knowledge (an innovation process that deals with communication and sharing of knowledge);
- the transformation of knowledge (an innovation process involving the development of new or significantly improved products and processes and the adoption or adaptation of knowledge for specific purposes);
- the use of knowledge (an innovation process related to the delivery or implementation of new or significantly improved products or processes); and
- improved health system performance or value (the framework is grounded in the principle that innovation takes place only when new value is created).
The report compares Canada’s performance in the first five components against the top-10 Organisation for Economic Co-operation and Development (OECD) countries with high-performing health systems: Japan, Italy, France, Spain, Korea, Switzerland, Sweden, Finland, Austria and Norway. The United Kingdom was added because of its similarities to the Canadian system, and the United States because of its proximity to Canada. (Both the U.K. and the U.S. are also members of the OECD.)

**The evidence shows that there is little collaboration among universities and business enterprises in Canada, a distinct disadvantage to both parties.**

In terms of our innovation environment, the report finds that Canada compares unfavourably in terms of the number of university graduates with advanced research qualifications in the health and life sciences sectors. We have 29 per 1 million capita, compared with the average of 60 per 1 million capita for the top 10 OECD countries examined. Canada ranked second to last (ahead of Italy) on this indicator. Our venture capital investment in health as a percentage of gross domestic product (GDP) is approximately eight times smaller than that of the United States. Moreover, Canada’s venture capital investment as a proportion of GDP has shown no significant increase from 2003 to 2005.

Optimistically, a more recent survey of Canadian business leaders places Canada’s intellectual property regime in sixth place among the 13 countries studied in this report. And new initiatives at Health Canada have been effective in reducing review times, although many submission reviews of pharmaceuticals, biologic drugs and medical devices are still not meeting internationally competitive targets.

In terms of the creation of knowledge, Canada enjoys strong public investments in health-related R&D compared with the other OECD countries. Our weak point is that only about 41 per cent of all health-related R&D is funded by domestic and foreign industry, with foreign investment being particularly low. This situation is not unique to the health sector; other sectors in Canada have comparable rates of R&D investments. Somehow, other countries have been able to encourage and attract higher rates of domestic and foreign industry participation in health-related R&D.

As for the diffusion of knowledge, Canada does not do well. Our universities—where the majority of health-related R&D is conducted in Canada—have markedly lower invention disclosures, patent applications, patents granted and licences executed than their counterparts in the U.S. and Europe. The number of health-related patent applications filed by Canadians in the United States Patent and Trademark Office was not able to be estimated; however, the number of these patents filed at the European Patent Office (EPO) in 2003 was 6.7 per 1 million people, compared with an average of 9.1 per 1 million people for the OECD comparator countries examined. (Of note is the fact that the number of patents filed with the EPO in 2003 represents a 4.4 per cent decrease from the number filed in 2000.)

The evidence presented in this report shows that there is little collaboration among universities and business enterprises in Canada, a distinct disadvantage to both parties. Business enterprises fund about 10 per cent of the research performed in Ontario’s universities, which attract the greatest amount of health R&D funded by business enterprises. On the positive side, Canadian researchers publish abundantly. Our experts appear to be holding to the “publish or perish” credo, for Canada produces a substantial number of health-related publications. In 2005, we produced 714 published articles per 1 million capita, compared with 527 per 1 million, on average, for the OECD comparator countries examined.

In looking at the transformation of knowledge in the Canadian health-care system, this report assessed Canada’s performance in developing new drugs, biologics and integrated health information systems. Understanding Canada’s performance in the latter area is critical because they are essential to enabling appropriate planning, introduction and management of other health innovations.

On the positive side, this report finds that Canada has a pharmaceutical pipeline that is competitive with global standards. The number of Canada’s drugs under development per capita is above the average in the other OECD comparator countries. We have the highest percentage
of drugs in clinical phase III and the lowest share of preclinical drugs compared with the pipelines found in the OECD comparator countries. The picture is quite different when one examines the development of integrated health information systems. Our average hospital expenditures on information technology are 1.5 per cent of operating budget, significantly lower than the 4.4 per cent for the OECD countries examined and the 4 per cent recommended by Canada Health Infoway in order to achieve the potential benefits in quality, access, and productivity.

At the national level, Canada’s investment of US$32 per capita is a strong initial federal commitment but is likely not enough to create interoperable electronic health records across 50 per cent of Canada as targeted. We are far from providing the majority of the population with electronic health records, lagging behind European countries in this regard, such as the Netherlands and the United Kingdom.

As for the use of knowledge, we are an average spender on therapeutic appliances and other medical durables, but we spend more than almost all of our comparators on pharmaceuticals and other medicinal non-durable goods. We are a net importer of pharmaceuticals, with a deficit of US$136 per capita. Of the countries examined, Finland is the only country with a larger per capita deficit. We also have a trade deficit in the medical devices industry.

Use of electronic medical records among primary care physicians per 100 physicians in Canada (23 per cent) was the lowest of the countries examined.

Primary care physicians in Canada have not enthusiastically adopted new information systems to support their practices. Although computer penetration among physicians in Canada is relatively high (88 per cent), and personal digital assistant penetration moderate (33 per cent)—both above average when compared with usage in other OECD countries—only about 65 per cent of Canadian primary care physicians use the Internet. This is well below Finland and Sweden’s share of web-savvy doctors (both at more than 90 per cent), and the 71 per cent average of the OECD comparator countries.

Use of electronic medical records among primary care physicians per 100 physicians in Canada (23 per cent) was the lowest of the countries examined. Furthermore, Canadian primary care physicians reported the lowest capability for accessing electronic medical records from outside their offices and sharing these records with other health practitioners outside their practices. Our physicians reported less routine use of external health information systems to carry out activities. In fact, Canadian physicians outshine their international counterparts in only one activity: accessing patient hospital records electronically.

Among the many suggestions as to where we should focus in order to boost our capacity for technological innovation in health, four stand out:

1. We need to develop a plan of action to strengthen our comparatively weak health innovation environment, based on a thorough understanding of the reasons behind our low score.

2. Given the high proportion of health research performed in universities, it is essential to promote more collaboration between universities and the business sector in order to boost the commercialization of knowledge.

3. We cannot lose sight of the fact that the transformation of knowledge into integrated health information systems is an essential step in the innovation process and is key to improved patient care. As such, these systems must be funded, adopted, and consistently used.

4. It is necessary to create valid indicators and consistent definitions aligned with international standards that will allow us to measure the innovation performance in the Canadian health systems, including progress in achieving the stated goals.

This report underscores the importance of technological innovation in Canada’s health system and sheds considerable light on its current state. It exposes our strengths and our weaknesses—some of which are glaring—and offers fact-based recommendations to help Canada develop the higher quality, more efficient, and safer health system that is more imperative than ever, given the challenges that we face today as well as those on the horizon.
CHAPTER 1

Innovation and High-Performing Health Systems

Chapter Summary

- Worldwide, technological innovation has addressed some fundamental challenges in health and health-care delivery. Many OECD countries have identified investing in and encouraging innovation as national priorities.
- Technological innovation can help improve the performance of health-care systems. However, it needs to be appropriately planned, implemented and managed in order to be successful.
- Using a select set of comparable health indicators covering health status, health-care outcomes, and health-care utilization and performance, Canada ranks 11th, far behind Japan, Italy, and France in overall health performance. These high-performing countries have used innovation to cope with challenges within their health-care systems.

INTRODUCTION

There are strong correlations among innovation, productivity, health, and wealth. Countries that are more innovative seem to be more productive, more competitive in the world economy, wealthier, and thus healthier than their less innovative counterparts. Although these correlations are not well understood yet, the OECD has been running a program since 2004 to gather evidence connecting biotechnology, innovation and health and to facilitate dialogue among OECD countries, many of which have identified investing in and encouraging innovation as national priorities. Much of the innovation in these countries is aimed at improving the affordability, quality, and efficiency of their health-care systems and improving the health of their populations. Without question, innovations in health and health care have addressed some fundamental challenges in the health field.

Countries that are more innovative seem to be more productive, more competitive in the world economy, wealthier, and thus healthier.

Some of the critical elements challenging our health-care system include demographic changes; dramatic rises in the incidence and prevalence of chronic diseases; increased public demand for safe, effective, and timely health-care delivery; and the fast pace and sometimes high price of technology. These challenges are not unique to Canada. Other OECD countries face similar pressures, but some of them have been able to cope better than we have. Conference Board research on health-care systems performance has determined that Canada is not among the top-performing countries with respect to health and health care. As such, we would do well to focus on innovation, which is vital for improving health systems.

1 The Conference Board of Canada, Healthy Provinces, Healthy Canadians.
Various innovations have advanced the health-care industry: pharmaceuticals and new diagnostic techniques and equipment have transformed the way we diagnose, treat, and cure illnesses. Yet much remains to be done. Inefficiencies still exist: a patient can have 10 different medical records in the system. Unsafe practices are not uncommon: wrong doses administered, and wrong medications given. After years of research, there are still many deadly diseases that have no cure. We continue to make decisions without the data to support them. Indeed, uncertainty looms large in our health-care system.

SOLUTIONS
Technological innovations offer many benefits and are an essential component of any strategy to bolster health system performance. They need to be appropriately planned, implemented and managed in order to be successful and cost-effective.

In recent years, health-care expenditures have been increasing at a rate far above those of inflation and provincial revenue growth. For example, the Canadian Institute for Health Information estimated the annual rate of growth of total health-care costs in 2005 at 6.4 per cent and at 5.8 per cent for 2006. Between 1985 and 2005 total per capita health spending rose by at least 50 per cent in all jurisdictions; although the biggest growth occurred in private spending, public spending has increased as well. The proportion of provincial government spending that goes toward health care has increased significantly over the last three decades; the overall average for provincial health spending now stands at 40 per cent, with some provinces approaching 50 per cent. Some policy analysts have argued that the area of health may be infringing on the availability of expenditures for other important public investments, such as education and infrastructure renewal.

Federal and provincial governments currently inject about $92 billion into the health system annually, which represents about 70 per cent of total health expenditures. The remaining 30 per cent, approximately $40 billion, is funded through private sources, including out-of-pocket expenses. Despite these investments, the Canadian health-care system, when compared with those of other OECD countries, is not a high-performing system.

CANADA’S PERFORMANCE IN HEALTH
In its 2006 report Healthy Provinces, Healthy Canadians, The Conference Board of Canada compared Canada’s state of health and its outcomes against those of other OECD countries. Although the main aim of the report was to compare the provinces’ performances, it also compared Canada with 23 OECD countries. This analysis was based on a total of 19 comparable health indicators covering health status, health-care outcome, and health-care utilization and performance. (See Appendix A for more information on the methodology of this analysis.)

Technological innovations offer many benefits and are an essential component of any strategy to bolster health system performance. They need to be appropriately planned, implemented and managed.

It is important to note that this analysis did not include indicators to assess determinants of health (e.g., income and social status, education, employment and working conditions, geography, culture). Certainly, the Conference Board recognizes the importance of these elements in determining the health status of populations, and it also recognizes the limitations of benchmarking and is aware that results depend a great deal on the quality or relevancy of the indicators selected. However, benchmarking is an effective tool that can be used prospectively to guide policy planning and drive change.
In the above-mentioned report, Canada ranked 11th, far behind Japan, Italy and France in overall health performance—based on indicators of health status, health-care outcomes and health-care utilization. (See Appendix A.) Of particular note is our poor showing despite the fact that Canada is the third-highest per capita spender on health care. Interestingly, these results are consistent with other Conference Board research in this area, including Understanding Health Care Cost Drivers and Escalators (2003) and How Canada Performs: A Report Card on Canada, which examined countries’ performance using an expanded set of indicators in the same categories.

Overall, Canada can be proud of the achievements made during the last 50 years. Canadians have experienced major improvements in their health, in great part as a result of new technologies (e.g., vaccinations, antibiotics, insulin). For example, a Canadian child born now can expect to live eight years longer on average than a child born in 1960. However, the overall ranking showed in Table 1 highlights that there is still room for improvement. Canada needs significant additional efforts to transform its health-care system into a high-performing health system—one that will be more responsive to the health needs of Canadians and will provide timely access to higher quality and safer services.

**FEATURES OF HIGH-PERFORMING HEALTH SYSTEMS**

Each country has its own approach to the development of its health-care system. Generally, these systems reflect the nation’s identity, its values, principles and priorities. In Canada, our health-care system is based on the Canada Health Act, which embraces values of equity and solidarity. There are three key components of high-performing health systems: people and culture, processes and structures, and technologies. (See Exhibit 1). These components can be organized and integrated in different ways, with the optimum arrangement producing a health system that delivers services that meet the societal goals. Although there is not a perfect recipe as to how to combine and organize these components, some systems yield better results than others.

High-performing health systems are those that organize their components to help their users to reach a higher health status and well-being (i.e., to live long, healthy and productive lives). Characteristics of this type of system include the following:

- outperforming comparable systems on major outcomes, while providing products and services of value to clients;
- actively adapting and innovatively responding to changes in the society and environment (e.g., demographics, technological developments or changes in patterns of disease); and
- enhancing the performance of the components of the system, while providing society with a rich quality of life.

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4 The Conference Board of Canada, Understanding Health Care Cost Drivers and Escalators.
5 Health Canada, “Canada’s Health Care System” [online].
6 These also apply to any social system.
8 The Conference Board of Canada, Unleashing Innovation in Health Systems [online].
Another important characteristic of high-performing health systems is that they set goals for each of their components to guide the journey towards excellence. Examples are as follows:

- **People and Culture**—a highly effective and productive workforce;
- **Processes and Structures**—integrated organizational processes and structures with clear and measurable goals; and
- **Technologies**—effective development, integration and use of technology.

Generally, these systems are highly innovative and get better value for money. Due to a high degree of integration and coordination, these systems achieve a fine balance between/among their components, which makes them very effective and efficient.

The Conference Board of Canada is facilitating networks and conducting research on all three components. Collectively, these networks and their sponsored research are designed to offer solutions that will lead to an integrated, high-performing health-care system in Canada.

However, given that the Conference Board’s Centre for Health Care and Innovation focuses on boosting technological innovation and commercialization capacity in health systems, this report centres on setting the foundations to explore and understand technological innovation in Canada’s health system. Nonetheless, the Centre understands that quality and productivity of our health-care system will depend on the health system’s ability to foster and effectively manage innovation across all three key components.9

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**The Conference Board of Canada is facilitating networks and conducting research that will lead to an integrated, high-performing health-care system in Canada.**

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**ABOUT THIS REPORT**

Following the guidance of the Conference Board’s Centre for Health Care and Innovation, this report seeks to explore and understand the role of innovation in the health system, particularly technological innovation. More specifically, this report:

- explores national indicators of technological innovation in health systems;
- compares Canada’s innovation performance with that of OECD countries with high-performing health systems;
- presents short case studies to demonstrate how technological innovation can contribute to improving health system performance; and
- provides some findings and lessons to strengthen Canada’s health innovation system.

Several data sources were consulted for the preparation of this report. A tremendous amount of effort was required to sift through national and international sources of data in three technology areas: drugs and biologics, health-care information, and medical devices. Some of the sources

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9 The Conference Board has proven the link between better innovation performance and better business performance. See *Exploring Canada’s Innovation Character*. 
consulted included OECD, Statistics Canada, Science Citation Index, Health Canada, Industry Canada, the Commonwealth Fund, the Canadian Medical Association, and The Conference Board of Canada’s e-Library.

The Conference Board’s Innovation Framework, presented in the next chapter, provided a structure to explore and understand technological innovation in health. Identifying the appropriate indicators in each area of the framework for this report, and collecting data and ensuring their comparability (where data were available), were major tasks. Although far from perfect, the data collected and presented in this report represent the best of what was available. This highlights the need to develop national and international indicators that would yield normalized and comparable data, contributing to more accurate analyses, which in turn would lead to a more effective understanding of how to improve on technological innovations in health systems.
Understanding
The Conference Board of Canada’s Innovation Framework

Chapter Summary
- Innovation occurs only when new value is created; change that does not lead to improved performance or services cannot be considered as “innovation.”
- Supported by an appropriate innovation environment, creation, diffusion, transformation, and the use of knowledge play a critical role in innovation systems and interact to improve health system performance (value).

OVERVIEW OF THE FRAMEWORK

The Conference Board of Canada has conducted extensive research in the field of innovation over the last decade. Based on this research, the Board has built an innovation framework that has been tested with leading scholars, policy experts, and business executives around the globe. It is grounded in the principle that innovation takes place only when new value is created. As such, a new or creative idea that is not transformed into some form of social or economic value is not considered “innovation.” In this way, innovation is best understood as a means by which societies, systems or organizations achieve social or economic value (e.g., increasing positive health outcomes).

The framework, presented in Exhibit 2, distinguishes six discrete components in three areas:
- **The backdrop:**
  - **Innovation Environment** refers to all the conditions that influence innovation and align inputs. Environmental conditions include culture and leadership, customer-influenced decision-making, standards and regulations, and the availability of venture capital and skilled workers. Health policies are also important, as they might have significant impact on these elements.
- **The innovation processes:**
  - **Creation of knowledge** refers to the generation of new knowledge or to significantly improving existing knowledge (through activities such as drug research and developing new programs).
  - **Diffusion of knowledge** refers to the communication and sharing of knowledge (through activities such as publishing, collaborating, teaching, transferring technology, training, participating in conferences, and interacting with patients and suppliers).
  - **Transformation of knowledge** refers to the development of new or significantly improved products and processes, adopting or adapting knowledge for specific purposes, and transforming knowledge (through activities such as prototyping, clinical testing, customizing, producing and assembling).
  - **Use of knowledge** refers to the delivery or implementation of new or significantly improved products or processes (through activities such as effectively
delivering new services, implementing innovative policies, launching new products and services, and applying knowledge).

- The innovation outcomes:
  - Improved Health System Performance (Value) refers to the creation or enhancement of social or economic value, improving organizational performance and having a positive impact (through, for example, improving the health of Canadians, enhancing health outcomes, improving quality of life, increasing efficiency of health-care services, reducing costs, and increasing revenue).\(^1\)

Because innovation systems are complex and dynamic, there are few, if any, neat boundaries among these components. In addition, because innovation systems operate within broader systems or environments (e.g., nations, regions, communities, organizations, work groups or individuals), this framework must be considered within the context of these broader systems.

Also, this framework should not be simply read in a clockwise manner. Substantial interactions and interconnections can exist between and among all components of the framework. For example, during the clinical testing of a new product (transformation), creative new ideas may be articulated (or diffused) by care providers and patients, and integrated into the product development process.

**INNOVATION PROCESSES**

Creation, diffusion, transformation, and use of knowledge play a critical role in innovation systems. Supported by the appropriate innovation environment, these components interact to improve health system performance (or value). Improved performance is the result of the successful interaction between all aspects of the framework. At the same time, improved performance affects the innovation environment itself, which then affects the ability of each of the other components to function, both independently and cooperatively. For example, if technological innovations by the private sector result in increased government tax revenues, then public sector investments in health-related research may increase as well.

**TECHNOLOGICAL VERSUS ORGANIZATIONAL INNOVATION**

Much of the literature on innovation stems from a science or engineering base. It addresses technological innovation, including the transformation of scientific and engineering creations into new medical devices, drugs, and biologics, and health-care information technologies.

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\(^1\) Note: Innovation is typically only one of several factors that influence the attainment of “value.”
Yet we know that technological innovation rarely occurs in isolation. It needs organizational innovation, which refers to transformed or improved production and delivery processes, and governance and organizational structures implemented either inside health systems or in organizations operating within health systems (e.g., academies of health sciences, governments, and health-care organizations).

Technological innovation rarely occurs in isolation. It needs organizational innovation, which refers to transformed or improved production and delivery processes, and governance and organizational structures.

The best new technologies are usually implemented only with the support of new or significantly improved processes and structures. Much of this is represented in the diffusion component of our framework. But organizational innovation also encompasses creating and transforming human systems, including the development of new management techniques, marketing approaches, supply-chain systems, or learning methods. Case Study 1 illustrates the benefits of organizational innovation.

**INNOVATION OUTCOMES**

Innovation outcomes or value in health systems have different meaning at different times for various stakeholder groups. Consider how economic and social value produced through innovation may be perceived by the different actors in health-care systems. (See Table 2.)

**APPLYING THE INNOVATION FRAMEWORK TO HEALTH CARE**

Table 3 illustrates how each component of the framework applies to an example in a health system context.

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**Case Study 1: Achieving Value Through an Innovative Management Model**

**MANAGEMENT MODEL FOR DRUG EXPENDITURE/UTILIZATION IN PERSONAL CARE HOMES (NURSING HOMES)—WINNIPEG REGIONAL HEALTH AUTHORITY**

The Winnipeg Regional Health Authority has 4,996 residents in personal care home beds (35 facilities providing 24-hour nursing care) who have their medications administered by private providers contracted by the Health Authority.

Up to and including fiscal year 2003–04, the health region had consistently experienced annual deficits in this expenditure area. Each facility had an individual contract with a drug provider. The Health Authority had relatively little influence over the relationship, but was directly responsible for paying drug expenditures for residents. Thus, there was little oversight of managing medication use or expenditure. Increasing financial pressures brought the impetus for change.

The Health Authority introduced an innovative and evidence-based management model that aims to ensure the appropriate use of drugs in personal care and to reduce overall expenditures in the area. Some elements of this management model included:

- establishment of regional contract pricing for high-volume drugs—selected high-cost, high-volume drugs in the program were tendered for commodity pricing;
- modifications of the contracting relationship that brought stronger accountability and improved transparency in the process—rather than having 35 untendered contracts, the health region issued a Request for Proposals and contracted with two private providers for the provision of pharmaceutical care and drugs to residents in the 35 homes;
- development of a personal care home drug formulary along with the automatic substitution for certain high-cost drugs, based on clinical evidence; and
- automation of drug dispensing to minimize drug returns and reduce the amount of time nurses spent on medication dispensing.

Following the implementation of this plan, the Centre for Health Policy in Manitoba conducted a study involving the Winnipeg Regional Health Authority facilities. The report included ratings on four drug-related quality indicators—all based on negative outcomes. The Authority’s facilities improved their performance by scoring below the provincial average on three indicators: poly-pharmacy rates, benzodiazepine use, and Beer’s Criteria drug use. In addition, drug costs for the PCH (Personal Care Home) Pharmacy Program are expected to be 6.7 per cent lower in 2007 than they were in 2004.
## Table 2
Stakeholder Outcomes

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<tr>
<th>Stakeholder</th>
<th>Economic</th>
<th>Social</th>
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<tbody>
<tr>
<td>Health-Care Organizations</td>
<td>• increased productivity and lowered operating costs</td>
<td>• improved health outcomes for patients, shorter waiting lists, and more satisfied health-care personnel</td>
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<td>Research-Based Organizations</td>
<td>• revenues from patents or new ventures</td>
<td>• a more highly educated population, diverse perspectives, and more informed discourse</td>
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<td>Businesses</td>
<td>• profit, either through increased revenue or reduced operating costs</td>
<td>• improved community relationships</td>
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<tr>
<td>Government</td>
<td>• increased productivity, or growth in overall gross domestic product (GDP)</td>
<td>• improved quality of life, or the overall wellness of a population</td>
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<tr>
<td>Communities</td>
<td>• new jobs, or improved income levels</td>
<td>• positive rating for various quality-of-life indicators (e.g., safe neighbourhoods, good health, sufficient health care, the best schools, improved services and facilities, a vibrant culture, a clean environment).</td>
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Source: The Conference Board of Canada.

## Table 3
Applying the Innovation Framework to the Health Field: Developing Better Artificial Joints

<table>
<thead>
<tr>
<th>Framework Component</th>
<th>Definition of Component</th>
<th>Illustration of Component (using the health field example)</th>
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<tbody>
<tr>
<td>Creation</td>
<td>Generating new knowledge or significantly improving existing knowledge (through activities such as investing in research and program development)</td>
<td>Two scientists in a Canadian university investigate new materials for artificial joints with the help of research funding from both government and business.</td>
</tr>
<tr>
<td>Diffusion</td>
<td>Communicating and sharing knowledge (through activities such as publishing, collaborating, transferring technology, training others, participating in conferences, and interacting with patients and suppliers)</td>
<td>The two scientists publish their findings in a peer-reviewed journal. As a result, a third scientist in Australia (doing comparable research) makes contact, and the three collaborate to further their research, utilizing the Internet and telehealth for many of their ongoing communications needs.</td>
</tr>
<tr>
<td>Transformation</td>
<td>Developing new or significantly improved products and processes, adopting or adapting knowledge for specific purposes, transforming knowledge (through activities such as prototyping, clinical testing, customizing, producing, and assembling)</td>
<td>The scientists develop their new materials to a mature stage. They engage engineers, technologists, surgeons, and potential patients to build prototype knee joints for testing and trials.</td>
</tr>
<tr>
<td>Use</td>
<td>Delivering or implementing new or significantly improved products or processes (through activities such as delivering services, implementing policies, launching and market testing new products and services, and applying knowledge to daily practices and operations and existing technology.</td>
<td>The new knee joint passes the testing and trials, and becomes the de facto standard used across Canada for a majority of new knee replacements.</td>
</tr>
</tbody>
</table>

(cont’d on next page)
### Table 3 (cont’d)
Applying the Innovation Framework to the Health Field: Developing Better Artificial Joints

<table>
<thead>
<tr>
<th>Framework Component</th>
<th>Definition of Component</th>
<th>Illustration of Component (using the health field example)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value (Improved Health System Performance)</td>
<td>Creating or enhancing social or economic value, improving organizational performance, having an impact (for example, improving the health of Canadians, enhancing health outcomes, increasing efficiency of health-care services, and growing revenue)</td>
<td>The new knee technology demonstrates superior tissue acceptance, allows patients faster recovery times, and yields longer-lasting performance. It also saves time and money in terms of the surgery.</td>
</tr>
<tr>
<td>Environment</td>
<td>Skilled People</td>
<td>The post-secondary education system would produce skilled scientists, materials engineers, and health system managers in sufficient numbers to contribute to such innovative developments.</td>
</tr>
<tr>
<td>Risk Capital</td>
<td></td>
<td>Governments, businesses, and venture capitalists would fund the necessary research, development, testing, trials, and commercialization activities.</td>
</tr>
<tr>
<td>Standards and Regulations</td>
<td>Various technical standards would help to drive the superior materials technology. The patent system would protect the intellectual property rights of the researchers, without unduly inhibiting the speed-to-market of the technology. Government regulations would be adaptable and responsive enough to quickly assess the safety of new products.</td>
<td></td>
</tr>
<tr>
<td>Customer-Influenced Decision Making</td>
<td>Surgeons and patients would be engaged in development work, especially at the transformation stage. As a result, governments, investors, and purchasers would accept the new technology and support improvements that are responsive to market demand.</td>
<td></td>
</tr>
<tr>
<td>Culture and Leadership</td>
<td>Various leaders and executives in the system, including surgeons, hospital administrators, university deans, and business partners, would be risk tolerant and entrepreneurial. They would also be willing to consider the new artificial joint technology, and to commit the necessary resources to help develop it.</td>
<td></td>
</tr>
</tbody>
</table>

Source: The Conference Board of Canada.
CHAPTER 3

Exploring Innovation in Health Systems

Chapter Summary

- Significant opportunities exist to strengthen the innovation environment, which includes the availability of skilled researchers, venture capital investment, and the strength of patent protection regimes and regulatory systems.

- The creation of knowledge is explored using available information on health-related R&D expenditures as well as on the funders and performers of R&D.

- Information on technology transfer activities, university–industry collaboration, publications, and patent applications illuminate how we diffuse knowledge.

- The transformation of knowledge is examined by analyzing Canada’s performance in the development of new drugs and biologics and the adoption of information technology and communication systems to support health care.

- A look at information technology and expenditures and international trade on medical goods sheds considerable light on how we use knowledge in Canada’s health-care system.

INTRODUCTION

This report attempts to understand innovation in the Canadian health-care system through the examination of several indicators in five of the six areas of the Conference Board’s Innovation Framework: the innovation environment, and the creation, diffusion, transformation, and use of knowledge. Canada’s performance on these indicators is assessed against that of a comparator group consisting of 12 countries. This group was selected as follows:

- Top-10 Countries with High-Performing Health Systems—The Conference Board of Canada report Healthy Provinces, Healthy Canadians\(^1\) identified these countries as having high-performing health systems. (See Appendix A, Table 2 for more details on the ranking). These countries are:

  1. Japan
  2. Italy
  3. France
  4. Spain
  5. Korea
  6. Switzerland
  7. Sweden
  8. Finland
  9. Austria
  10. Norway

\(^{1}\) The Conference Board of Canada, 2006, p. 9.
• The United Kingdom was added because of similarities with the Canadian system.
• The United States was included in light of its proximity to Canada.

A NOTE ON DATA GAPS AND OTHER LIMITATIONS

Analyzing the environment and conditions that facilitate technological innovation in health systems is a very complex undertaking. Among the various challenges encountered when doing this is the difficulty in establishing cause-and-effect relations between the introduction of innovations and subsequent outcomes. A key factor in this difficulty is the variety of elements that can affect health outcomes (e.g., societal changes, state of the economy, new diseases, eradication of diseases, behavioural changes). Moreover, the health system involves many sectors of society, including health care, academia and research, investors and business, governments, and communities. The understanding, application and resulting value of innovation vary widely across all these sectors.

Health systems that are focused on high performance are willing to make changes that lead to improved services and subsystems, and are therefore innovative.

It is made all the more difficult by the paucity of research available to assess such innovation; we therefore had to speculate to a certain extent on some of the findings. Despite the deficiency, we consider this research to be a very valuable endeavour, and in fact we believe that this work is groundbreaking. The analysis of the selected indicators provides a preliminary exploration of the Canadian innovation environment, and of our ability to create, diffuse, transform, and use new products and knowledge in health care. Throughout the report, two challenging issues emerge as areas of particular concern: determining value, and the general perception of technology as a cost only. A brief discussion of these follows.

DETERMINING VALUE

Determining value in the field of health is extremely challenging. Nevertheless, there are some cases in which technologies have been very valuable and have resulted in increased efficiency and cost-effectiveness of health systems. For example, information technologies, advances in surgical techniques, and the development of some drugs have dramatically improved our ability to manage health systems, have shortened in-hospital treatment time, and have led to cost savings that are obvious to all.

However, determining value is a formidable task, as it entails tracking outcomes—sometimes for long periods—and assigning cause-and-effect relations that can be difficult to prove. However, overall, we believe that there is a positive correlation between technological innovation and a high-performing health system. Why? Health systems that are focused on high performance are willing to make changes that lead to improved services and subsystems, and are therefore innovative.

PERCEPTION OF TECHNOLOGY AS A COST

Many decision makers inside the health system view technology as a cost driver, focusing less on the potential benefits of technological innovation. This perspective places serious limitations on discussions about how technological innovation might contribute to, or even drive, a high-performing health system. Against a backdrop of rapidly rising health-care costs and their impact on governments’ capacity to address other urgent priorities, decisions makers may be reluctant to test this perception.

EXPLORING THE INNOVATION ENVIRONMENT

This section explores the availability of skilled workers (in this case, advanced research graduates in health), the availability of risk capital, and standards and regulations (through the effectiveness of patent regimes and the speed and efficiency of the regulatory system). Discussion of the other important elements in the innovation environment (culture and leadership, and customer-influenced decision making) has not been included here because of the lack of indicators and comparative data. More research on these topics is therefore recommended.
The Conference Board of Canada

Innovation Environment

Innovation environment consists of the existing elements and overarching conditions that influence innovation. Environmental conditions include culture and leadership, customer-influenced decision making, standards and regulations, and the availability of risk capital and skilled workers.

AVAILABILITY OF SKILLED RESEARCHERS

The capacity to create and diffuse knowledge is a necessary condition for innovation. This capacity is defined, in part, by the availability of qualified technical and professional human resources to engage in the creation, diffusion and transformation of knowledge. This group of qualified personnel includes the technical and professional individuals who participate in assessment and regulatory activities that are so fundamental to support and foster innovations.

To create knowledge and transform it into useful products and services, it is essential to have access to appropriate funds. Venture capital investments are a common source of funds.

The number of university graduates with advanced research qualifications (ARQs) in the health and life sciences sectors is an important indicator of the country’s capacity to create and diffuse advanced knowledge in these fields. Chart 1 presents the number of these graduates (per 1 million capita) in the 12 comparator countries.

In 2003, the number of health-related ARQ graduates in Canada (29 per 1 million capita) was below the median and below the top-10 OECD countries’ average (60 per 1 million capita). In addition, Canada has demonstrated relatively low growth in the number of health-related ARQ graduates per 1 million capita since 1999.

Chart 1
Graduates With Advanced Research Qualifications in Health-Related Sectors (per million capita)

<table>
<thead>
<tr>
<th>Country</th>
<th>1999</th>
<th>2001</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switzerland</td>
<td>180</td>
<td>140</td>
<td>120</td>
</tr>
<tr>
<td>Sweden</td>
<td>120</td>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>Finland</td>
<td>80</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>United Kingdom*</td>
<td>60</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>Spain</td>
<td>40</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>Korea</td>
<td>20</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Japan</td>
<td>15</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Norway</td>
<td>10</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>France</td>
<td>6</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>United States</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Canada*</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Austria</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Italy</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

*Data are unavailable for 2001.
**1999 data are incomplete.

AVAILABILITY OF VENTURE CAPITAL INVESTMENT

In order to create knowledge and transform it into useful products and services, it is essential to have access to appropriate funds. Although venture capital is not the only source of funds—for example, businesses in Japan and Korea tend to rely more on debt—venture capital investments are a common source of funds to develop innovations in life and health sciences in the majority of OECD countries. Therefore, assuming all other innovation factors are equal, we can extrapolate that the higher the investment, the higher the intensity of the start-up activities. Chart 2 compares recent health-related venture capital investments in Canada and the U.S., in terms of percentage of GDP. In 2005, Canada (0.0331 per cent of GDP) lagged the United States (0.0516 per cent of GDP), and showed marginal growth since 2003 (0.0327 per cent of GDP).

Chart 3 compares the health-related venture capital for Canada and the U.S. in 2003 and 2005, in terms of average size of investment, and speaks to the quality of start-up activities. (Note that specific data are not reported for venture capital investments in medical/biotech software in the United States.) Venture capital firms carry out
careful due diligence on start-up companies and make investment based on the risk–reward characteristics of these companies—larger deal sizes suggest greater reward potential for the risk undertaken.

Unlike the United States, Canada has seen an increase in the average size of investments since 2003, particularly in the health-care category where the size of these investments has more than tripled. However, in 2005, despite marked growth of 33 per cent since 2003, the average deal size of biopharmaceutical venture capital investment in Canada (US$1.2 million) was significantly less than in the United States (US$10.3 million). Canada still lags significantly behind its southern neighbour, but this sizable increase in investment may indicate a greater confidence on the part of venture capitalists, many of them from the United States, in the future growth of this sector in Canada.

**STANDARDS AND REGULATIONS**

**Strength of Patent Protection Regimes**

Patent protection regimes are a key component of intellectual property rights and therefore have a significant effect on innovation. Intellectual property protection can encourage creativity by ensuring a fair return to inventors on their investments. However, if these rights are too restrictive, they can stifle knowledge diffusion and the broader use of ideas and innovations. The challenge is to strike a balance between protecting the rights of knowledge creators and encouraging the broad dissemination and use of that knowledge.3

Evidence suggests that a strong patent protection regime contributes to innovation.4 One of the most widely used and accepted standards for measuring such regimes is the Ginarte-Park index.5 It measures the protection level offered by the law and is particularly relevant to health-related products and processes.

Specifically, the index measures the protection level of five components of national patent laws. Each component is rated between 0 (no protection) and 5 (maximum protection); the sum of these scores is the final rating. The five components are as follows:

- **Coverage**—refers to the “patentability” of inventions, and is measured by the patentability of seven items: pharmaceuticals, chemicals, food, plant and animal varieties, surgical products, micro-organisms, and utility models;

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Membership in international agreements—indicates willingness to provide national, nondiscriminatory treatment to foreigners (e.g., participation in international patent treaties);

- Loss of protection—measures the level of risk imposed by a country’s patent law that could lead to a forfeiture of a patent right;
- Enforcement—measures the adequacy of patent enforcement mechanisms; and
- Duration of protection—measures the length of the patent term.

The World Economic Forum recently asked business leaders in 125 nations to rate intellectual property protection in their country. Canada ranked 16th in this survey.

Based on the rating system of the Ginarte-Park index, Canada is relatively weak in the area of patent protection, compared with the 12 comparator countries. (See Chart 4.) It should be noted that the results represent the Canadian patent regime as it was known in 1995. Since then, the Canadian government has introduced some changes. For instance, recent modifications in the regulation of pharmaceuticals now call for eight years of data protection for clinical test data generated to approve a new medicine in Canada. This change also applies to medicines that have been the subject of pediatric clinical trials, with an additional bonus of six months of data protection. Likewise, comparator countries may also have introduced modifications in their systems since 1995.

The World Economic Forum recently asked more than 11,000 business leaders in 125 nations to rate intellectual property protection in their country. Canada ranked 16th in this survey (sixth place if we compare the results of the comparator group for this study), which represents a decline from its 13th position in 2005–06. The top three places in the 2006–07 survey were held by Switzerland, Finland and Sweden.

**Speed and Efficiency of the Regulatory System**

The speed and efficiency with which medical devices and therapeutics are able to pass through the regulatory process affect the ability of a pharmaceutical, biotechnology or medical device company to move innovative products from the transformation stage to the use stage (i.e., selling innovative products in the market). The number of days it takes new pharmaceutical and biologic drugs and medical devices to be reviewed depends on Health Canada’s performance during the review process. Health Canada has set target times for completion of reviews, and these vary by product class. For instance, target review times for biologic drug submissions are significantly longer than for all classes of medical devices. Although the federal department has set internationally competitive performance targets for its review times, a significant number of new-product reviews still experience delays. (See Chart 5.)

Chart 5 indicates the percentage of product submissions (new pharmaceutical drugs, new biologic drugs and medical devices) to Health Canada that were reviewed on time in 2004, 2005, and 2006, regardless of the outcome of the decision (market authorizations, pending authorizations, refusals and interim decisions). (Note that 2006 data were not available for medical devices.)

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7 Health Canada, *How Drugs Are Reviewed in Canada* [online].
As seen in the chart, recent initiatives implemented by Health Canada have helped to improve review performance, which has, indeed, improved significantly since 2004 in all three areas. However, challenges remain, especially regarding the submissions for new biologics. Although more than 70 per cent of new pharmaceutical drug and medical device reviews were completed within the target time, only about half of the new biologic drugs reviews were within the range in 2006.

**Recent initiatives implemented by Health Canada have helped to improve review performance, however, challenges remain.**

These results are consistent with findings of other international reports on this topic. In a recent study by the United Kingdom’s Pharmaceutical Industry Competitiveness Task Force, titled *Competitiveness and Performance Indicators 2005*, Canada’s average time for regulatory approval was longer than that of most countries examined (except Japan) for the latest data period, 1999–2003.

**DISCUSSION: EXPLORING THE INNOVATION ENVIRONMENT**

The main findings of this analysis can be summarized as follows:

- The number of health-related ARQ (e.g., Ph.D.) graduates in Canada is 29 per 1 million capita, compared with the average of 60 per 1 million capita for the comparator countries examined. Canada ranked second to last (ahead of Italy) on this indicator.
- Venture capital investment in health as a percentage of GDP in Canada lags behind that of the United States. The average size of health-related venture capital investments in Canada is approximately eight times smaller than those in the United States. Moreover, Canada’s growth in venture capital investment as a proportion of GDP has shown no significant increase from 2003 to 2005.
- An assessment of the patent protection regimes at the end of the 1990s, using the Ginarte-Park index, showed that Canada was relatively weak in the area of protection of patents compared with the 12 other comparator countries examined in this research. A more recent survey of Canadian business leaders places...
Canada’s intellectual property regime in 16th position among 125 nations (sixth place if we compare the results with the comparator group for this study). This newer assessment, although more positive, represents a decline from Canada’s 13th position in 2005–06.

- New initiatives at Health Canada have been effective in reducing review times for pharmaceutical drugs and biologic drugs and medical devices. However, a significant number of these innovations are still not meeting internationally competitive targets.

These findings suggest that there are substantive opportunities for improvement in our current innovation environment. But strengthening the innovation environment is not an easy task. It entails achieving transformations in areas such as cultural attitudes and behaviours (including a move to greater risk tolerance), regulatory policies and procedures, infrastructure, and communications systems. Modifying governance systems and structures might also have a major impact on the innovation environment, and we recommend further research in this area.

We should also investigate strategies to:
- ensure an appropriate supply and distribution of university spaces to educate people with advanced research qualifications in the health and life sciences;
- assess opportunities to overcome the reluctance of businesses and venture capitalists to invest and actively participate in the development of technologies that cannot be marketed freely (due to their application to an insured health-care service, such as surgery or a diagnostic procedure); and
- harmonize the multiple and conflicting regulatory regimes across all jurisdictions in Canada.

It will not be possible to become a highly innovative country with a high-performing health system unless we can compete globally for more skilled workers and capital sources. And to be able to compete globally, we will have to focus on building a more supportive health innovation environment. Canada’s National Blood Standards, presented as Case Study 2, provides an encouraging example. By creating the infrastructure and facilitating a national, consensus-based standard for blood safety, the Canadian Standards Association has standardized regulation and has created a common reference for the management and regulation of blood safety. These achievements have attracted international interest.

### Case Study 2: Transforming the Environment—Use of a Consensus Standard With Regulation to Improve the Blood System

**CANADIAN STANDARDS ASSOCIATION: CANADA’S NATIONAL BLOOD STANDARDS—A NATIONAL BLOOD MANAGEMENT FRAMEWORK TO ENHANCE BLOOD SAFETY**

The Canadian Standards Association’s (CSA) standard for the management of blood and blood components represents an innovative way to gather, organize, distribute, and apply technological knowledge to improve health-care outcomes. The Standard, Z902-04 Blood and Blood Components, was developed to be a comprehensive tool that would work across the traditional boundaries of professional, political, and geographic jurisdictions, in the interests of patient, staff, and donor safety.

Although it was developed by CSA, a not-for-profit, non-governmental standards development organization, Z902 was written so that it could be referenced in regulation, thus providing governments at every level across the country with a common reference for the management and regulation of blood safety.

Z902 had its origins in the recommendations of the Krever Commission, which investigated transfusion-related HIV and hepatitis C infections in the 1970s and 1980s. One recommendation was for Health Canada to develop a national, consensus-based standard for blood safety. Health Canada commissioned CSA to develop this document.

The consensus process for developing this standard paved the way for “knowledge transformation” and “use” by virtue of the fact that the input came from the health-care professionals, blood suppliers, patients, and regulators that will use or be affected by the standard. This input helped to ensure acceptance and use of the final product. Depending on the audience, the standard is being tailored to be integrated in regulations, hospital procedures, educational materials, etc.

Because this is a recent standard, its long-term value has yet to be determined; however, responses to date indicate that it is meeting the needs of a wide range of stakeholders, and its benefits have already been seen in our health-care system. Canada has also attracted international interest for this groundbreaking approach to improving the blood system through a mix of regulation and consensus standards.
This section focuses on how health-related R&D is funded and where it is performed. The comparison of Canadian data with comparator countries’ data reveals significant differences in structure and financing of health-related research.

**EXPENDITURES ON HEALTH-RELATED R&D**

All R&D expenditure is expected to result in the creation of knowledge, and higher levels of expenditure are expected to yield more results. Typically, research funded by governments is basic research (as opposed to applied research). Basic research has a double effect in innovation processes: it contributes directly to the creation of knowledge and it can also influence the diffusion of knowledge (e.g., a researcher publishes breakthrough findings concerning the human genome).

Chart 6 examines total public expenditure on health-related R&D through direct investments in R&D, higher education, tax deductions, credits, and other indirect support private sector companies receive from the public sector. In 2003, total public expenditure on health-related R&D (US$52 per capita at PPP) in Canada was the median and above the top-10 OECD average (US$43 per capita at PPP). Of the 13 countries examined in this analysis, Canada demonstrated the greatest proportional increase (108 per cent) in total public expenditure on health-related R&D per capita between 1998 and 2003.

Chart 7 compares direct federal/central government funding of “research aimed at protecting, promoting and restoring human health, broadly interpreted to include health aspects of nutrition and food hygiene. It ranges from preventative medicine, including all aspects of medical and surgical treatment both for individuals and groups and provision of hospital and home care, to social medicine and pediatric and geriatric research.”

As with public expenditure on R&D, expenditure on pharmaceutical industry R&D is an input to the innovation system, typically contributing to the creation of knowledge. Generally, the R&D performed by business is applied research (rather than basic research typically performed by universities). Applied research also contributes to the diffusion and transformation of knowledge (e.g., a university research lab and pharmaceutical firm working together on pre-clinical research).

Chart 8 compares expenditures in R&D activities (irrespective of the source of funding) undertaken by the pharmaceutical industry in order to develop new compounds to correct somatic or psychic dysfunction or to improve individuals’ state of health.

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8 Purchasing Power Parity (PPP) is a rate such that a representative basket of goods in country A costs the same as in country B if the currencies are exchanged at that rate.

9 OECD, Frascati Manual.

10 OECD Health Data 2006. This definition corresponds to the UN Statistics Division (Class 2423); this class includes the manufacture of:

- pharmaceutical preparations for human or veterinary use: generic or proprietary preparations; preparations available to the general public or controlled by the health system; ampoules, tablets, capsules, vials, ointments, powders or solutions; botanical products ground, graded, milled or otherwise prepared;
- surgical dressings, medicated wadding, fracture bandages, catgut, and other prepared sutures;
- cements used in dentistry; and
- chemical substances used in the manufacture of pharmaceuticals: antibiotics, endocrine products, basic vitamins; opium derivatives; sulpha drugs; serums and plasmas; salicylic acid, its salts and esters; glycosides and vegetable alkaloids; chemically pure sugar, etc.
In 2004, expenditure on pharmaceutical industry R&D in Canada reached US$28 PPP per capita, which locates it at the median and below the average of comparator countries (US$42 PPP per capita). With the exceptions of Korea and Spain, Canada demonstrated the greatest increase (44 per cent) in expenditure on pharmaceutical industry R&D per capita between 1998 and 2004.

**Funders and Performers of Health-Related R&D**

**Funders.** Domestic business enterprises are the largest funders of health-related R&D in Canada, providing about 28 per cent of total expenditures. Federal and provincial governments are the second-largest source of funding, providing about 26 per cent, closely followed by higher education, which provides 25 per cent. It is important to note, however, that over 80 per cent of the public (government) funding goes to support health research at early R&D stages, while over 85 per cent of private/non-profit sector funding supports drug development. Domestic and foreign business enterprises finance about 41 per cent of all health-related R&D.

**Performers.** Canadian universities, including their affiliated teaching hospitals, and domestic business enterprises are the largest performers of health-related R&D in Canada. Table 4 provides a breakdown of domestic expenditures on health-related R&D by performing and funding sectors in Canada.

Chart 9 highlights some differences when we compare Canada’s health R&D funding profile with that of other OECD countries. Given that expenditures on health-related R&D by performing and funding sectors were not readily available for the comparator group, we assessed Canada’s expenditures against the average expenditures of high-income countries (consisting of the original comparator group plus 11 additional countries). Interestingly, domestic business enterprises play a much more significant role in funding research within high-income countries, accounting for 45 per cent on average of health R&D. In Canada, the domestic business enterprise sector contributes 28 per cent of total health R&D funding. Although Canada receives above-average funding from foreign business enterprise,

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12 High-income countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Korea, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States.

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it is not enough to compensate for the relatively lower contributions from domestic business.

Comparison of Canada’s health R&D performance profile to that of the average in high-income countries brings to light other major differences. For example, Chart 10 shows that Canada’s higher education sector is significantly more involved in performing health R&D than this same sector in other high-income countries.

**DISCUSSION: EXPLORING THE CREATION OF KNOWLEDGE IN HEALTH SYSTEMS**

Based on 2004 data, key lessons of the exploration of creation activities can be summarized as follows:

**Funding Health-Related R&D**

- Total public expenditure on health-related R&D in Canada was slightly higher (US$52 PPP per capita) than in the comparator countries examined (US$43 PPP per capita).
- Health-related R&D in federal/central government budgets (GBAORD) was higher in Canada (US$27 PPP per capita) than in the comparator countries examined (US$14 PPP per capita).
- The domestic business enterprise sector plays a much less significant role (28 per cent of all funding) in funding research within Canada than in the comparator countries (45 per cent).
- Expenditure on pharmaceutical industry R&D was much lower in Canada (US$28 PPP per capita) than in the comparator countries examined (US$42 PPP per capita).

**Data are unavailable.

| Chart 8
Expenditure on Pharmaceutical Industry R&D (US$ PPP; per capita) |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
</tr>
</tbody>
</table>

Table 4
Canadian Expenditures on Health-Related R&D, by Performing and Funding Sectors, 2004 (C$ millions)

<table>
<thead>
<tr>
<th>Funding Sector</th>
<th>Performing Sector</th>
<th>Federal Government</th>
<th>Provincial Government</th>
<th>Business Enterprises</th>
<th>Higher Education (including teaching hospitals)</th>
<th>Private, Non-Profit</th>
<th>Total</th>
<th>Funder's Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>Federal</td>
<td>182</td>
<td>0</td>
<td>12</td>
<td>882</td>
<td>8</td>
<td>1,084</td>
<td>19.4</td>
</tr>
<tr>
<td></td>
<td>Provincial</td>
<td>0</td>
<td>45</td>
<td>2</td>
<td>332</td>
<td>12</td>
<td>391</td>
<td>7.0</td>
</tr>
<tr>
<td>Business Enterprise</td>
<td>Domestic</td>
<td>0</td>
<td>0</td>
<td>1,249</td>
<td>289</td>
<td>9</td>
<td>1,547</td>
<td>27.8</td>
</tr>
<tr>
<td></td>
<td>Foreign*</td>
<td>0</td>
<td>0</td>
<td>686</td>
<td>33</td>
<td>1</td>
<td>720</td>
<td>12.9</td>
</tr>
<tr>
<td>Higher Education (including teaching hospitals)</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1,409</td>
<td>0</td>
<td>1,409</td>
<td>25.3</td>
</tr>
<tr>
<td>Private, Non-Profit</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>400</td>
<td>23</td>
<td>423</td>
<td>7.6</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>182</td>
<td>45</td>
<td>1,949</td>
<td>3,345</td>
<td>53</td>
<td>5,574</td>
<td>100</td>
</tr>
</tbody>
</table>

Performer’s Share (%)

| 3.3 | 0.8 | 35 | 60 | 1.0 |

Performing Health-Related R&D

- Compared with the higher education sector in other high-income countries, Canada’s sector is significantly more involved in performing health R&D, which is predominantly basic research. The higher education sector, including teaching hospitals, performs 60 per cent of all health-related R&D, while business performs 35 per cent and governments perform approximately 4 per cent.

Compared with other OECD countries, Canada allocates equivalent public investments in health-related R&D. However, only about 41 per cent of all health-related R&D is funded by domestic and foreign industry, with foreign investment being particularly low. This pattern of R&D investments is not unique to the health sector; it is true of other sectors in the Canadian economy. However, other countries have been able to encourage and attract higher rates of domestic and foreign industry participation in health-related R&D.

Unlike the situation in Canada, in the average high-income countries it is the business enterprise sector that performs the majority of health R&D.

As noted earlier, research conducted at universities is predominantly basic research. The performance of basic research is the first step in the discovery process, but applied research, typically performed by business enterprises, is equally important. Industry participation in academic R&D is shown to enhance the chances of successful transformation into real goods or services. This might be more important in health-related industries, which are R&D-intensive (for example, the average R&D-to-sales ratio for pharmaceutical firms is 8.3 per cent, second only to information technology firms).13

Interestingly, and unlike the situation in Canada, in the average high-income countries (an expanded comparator group used when data for the original group were not readily available), it is the business enterprise sector that performs the majority of health R&D. Typically, applied research is performed by the business enterprise sector and is necessary to transform scientific discoveries gleaned from basic research into marketed products and therapies that benefit patients. The greater share of health R&D performed by the higher education sector in Canada gives rise to a few questions: Is Canadian research less focused on commercialization? And do Canadian public sector investments in R&D shut out private R&D spending? More research is required to answer these questions.

13 Industry Canada analyses of Statistics Canada data.
Given the high proportion of health research carried out in Canadian universities (about 60 per cent of total health-related R&D in Canada), this section focuses on the performance of universities in several areas: their ability to diffuse ideas, their ability to attract private sector interest and collaborate with this sector, and the number of health-related publications produced by their academics. In addition, we will examine how Canada fares against the comparator countries in terms of health-related patent applications.

**Chart 10**
Proportion of Health Research Performed by Existing Research Infrastructures in Canada (2004) and High Income-Countries (2003) (per cent)


**Exploring the Diffusion of Knowledge**

Diffusion of knowledge refers to the communicating and sharing of knowledge through activities such as publishing, collaborating, teaching, transferring technology, training, participating in conferences, and interacting with patients and suppliers.

**Universities’ Ability to Diffuse Ideas**
Technology transfer activities (e.g., the number of invention disclosures, patent applications, patents granted, licences executed) serve as good indicators to measure the ability to diffuse new knowledge. The Association of University Technology Managers (AUTM) in the United States and the Association of European Science and Technology Transfer Professionals (ASTP) recently conducted a survey of the technology transfer activities of their members. The Milken Institute—a publicly supported independent think-tank in the United States—collected, normalized, and analyzed data from these surveys to compare the performance of American, Canadian, and European universities in technology transfer. Several top-performing European universities did not participate in the ASTP survey used to collect the primary data; consequently, the European universities show lower averages than expected. Despite this factor in Canada’s favour, Canadian universities registered lower performances in all categories than their American and European counterparts. (See Table 5.)

Compared with American universities, universities in Canada report about 35 per cent of the number of inventions per million dollars invested in research, and about 43 per cent compared with European universities. The differences are even more dramatic for patent applications and patents granted, where Canadian universities show only about 11 per cent of the number of patent grants obtained by American universities. Given that invention disclosures, patents, and licences are critical to the diffusion and commercialization process, one might infer that Canadian universities are less focused on commercialization than universities in the U.S. and Europe are. Although the difference in performance is less striking in terms of licences executed, Canada remains below U.S. and European benchmarks. And, considering that Canadian universities perform a higher proportion of
Health-related research relative to universities in other OECD countries (as shown in Chart 10), these survey results are alarming.

**UNIVERSITY–INDUSTRY COLLABORATION**

Understanding the level of collaboration between universities and industry provides insight into the importance of partnerships as a mechanism for transforming ideas into new products and services and sharing the risk related to R&D. One way to assess university–industry collaboration in health-related R&D is to look at the ratio of R&D funded by business enterprise and performed by the higher education sector. (See Chart 11.)

In 2003, Ontario’s higher education institutions had the greatest amount of health R&D funded by business enterprise, which represented only about 10 per cent of their total funding.

From this chart, it can be concluded that little collaboration occurs between universities and business enterprises in Canada. In 2003, Ontario’s higher education institutions had the greatest amount of health R&D funded by business enterprise (C$135 million), which represented only about 10 per cent of their total funding. Quebec’s higher education institutions obtained C$60 million from business enterprises, representing only about 7 per cent of the total health-related R&D funding in the province.

**HEALTH-RELATED RESEARCH PUBLICATIONS**

Publications are one of the major outputs of scientific research, and most come from the academic sector. The number of scientific publications in areas of health and life sciences can be used as an indicator for the diffusion of knowledge.
To gauge the output of comparator OECD countries and Canada, Chart 12 compares the per capita number of articles published in scientific journals throughout the world (in a given year) on 67 health and life science–related topics.14 Articles were credited to a particular country based on the “country of author” field in the Science Citation Index record.

In 2005, the number of health-related research publications was 714 per 1 million capita in Canada, which was above the median and average of the comparator OECD countries. With the exceptions of Korea and Norway, Canada demonstrated the greatest increase (18 per cent) in the number of health-related publications per 1 million capita between 2002 and 2005.

In 2003, the number of health-related EPO patent applications from Canada was below the median and below the OECD comparator countries’ average.

HEALTH-RELATED PATENT APPLICATIONS
Measuring the number of patents provides insight into how the health research is protected and commercially pursued. It also helps to understand how knowledge is created and diffused.

Chart 13 depicts the per capita number of health-related patent applications received by the European Patent Office (EPO). Similar data on patent applications filed at the Japanese Patent Office (JPO) and the United States Patent and Trademark Office (USPTO) were not available, and therefore were not included in this assessment. Perhaps a look at the Canadian patent applications in the USPTO might reveal a higher number of applications per million capita if there is a tendency to file more locally. For the creation of Chart 13, patents were credited to a particular country based on the inventor’s country of residence. The year refers to the application date of the patent.15

In 2003, the number of health-related EPO patent applications from Canada (6.7 per 1 million capita) was below the median and below the OECD comparator countries’ average (9.1 per 1 million capita). With the exception of Spain, Canada’s growth was the lowest. In fact, the number of Canada’s health-related EPO patent applications fell by 4.4 per cent between 2000 and 2003.

DISCUSSION: EXPLORING THE DIFFUSION OF KNOWLEDGE
Key lessons from the exploration of diffusion activities in the Canadian health-care system can be summarized as follows:

- Canadian universities do not compare well with American and European universities in their ability to diffuse knowledge. Canadian universities have significantly lower invention disclosures, patent applications, patents granted, and licences executed than their counterparts in the U.S. and Europe.
- Little collaboration occurs between universities and business enterprises in Canada. In 2003, Ontario’s higher education institutions had the greatest amount of health R&D funded by business enterprise, which represented only about 10 per cent of their total funding. Next in line, Quebec’s higher education institutions received less than half of that amount (C$60 million). Within Canada, over 80 per cent of higher education health R&D funded by business enterprise takes place in Ontario, Quebec, and Alberta.
- Canada produces a substantial number of health-related publications. In 2005, we produced 714 per 1 million capita, compared with 527 per 1 million, on average, for the OECD comparator countries examined.

14 Sample of health and life sciences–related topics: biochemistry and molecular biology; neurosciences; oncology; cell biology; clinical neurology; pharmacology and pharmacy; surgery; physiology; genetics and heredity; immunology; cardia and cardiovascular systems; radiology, nuclear medicine and medical imaging; biotechnology and applied microbiology; endocrinology and metabolism; microbiology; chemistry, organic; psychiatry; medicine, general and internal; hematology; pediatric; pediatrics; biophysics; peripheral vascular disease; respiratory system; biochemical research methods; toxicology; engineering, biomedical; medicine, research and experimental; infectious diseases; orthopedics; spectroscopy; urology and nephrology; biology; gastroenterology and hepatology; obstetrics and gynecology; nutrition and dietetics; rheumatology; ophthalmology; developmental biology; transplantation; pathology; virology; reproductive biology; anesthesiology; chemistry, medicinal; nursing; health care sciences and services; health policy and services.

15 N.B.: The “priority date” (versus “application date”) may be a preferred indicator.
Canada does not seem to score high on diffusion of knowledge. The number of health-related patent applications filed in the European Patent Office (EPO) in 2003 was 6.7 per 1 million capita, compared with 9.1 per 1 million capita for the OECD comparator countries examined. Furthermore, Canada’s health-related EPO patent applications per 1 million capita decreased by 4.4 per cent between 2000 and 2003.

University–Business Sector Relationship

Canadian universities do not seem to be as focused on technology transfer activities and commercialization as their counterparts in the United States and Europe. This might be the result of:

- weak links between academic researchers and the business sector;
- university research agendas not strongly linked to market needs (research agendas in Canadian universities seem to be driven mainly by researchers’ preferences, and not sufficiently tied to market and commercial potential); or
- university researchers’ perception of their role in fulfilling the university research mission (this mission generally entails engaging in basic and applied research to create knowledge, but does not necessarily extend to the commercialization of that knowledge).

Research-granting agencies are increasingly devoting efforts to educate university researchers on the value of commercialization, while academic centres have created technology transfer offices to support their researchers on these tasks.

Ontario, Quebec, Alberta and British Columbia have been able to build the required infrastructure in their academic health centres to more successfully attract business enterprises. However, this has led to only modest collaboration between academia and industry in health-related fields, perhaps because of difficulties in dealing

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Chart 12

Number of Health-Related Research Publications
(per million capita; by country of author)

<table>
<thead>
<tr>
<th>Country</th>
<th>2002</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>1400</td>
<td>1200</td>
</tr>
<tr>
<td>Finland</td>
<td>1200</td>
<td>1000</td>
</tr>
<tr>
<td>Norway</td>
<td>1000</td>
<td>800</td>
</tr>
<tr>
<td>United States</td>
<td>800</td>
<td>600</td>
</tr>
<tr>
<td>Canada</td>
<td>600</td>
<td>400</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>400</td>
<td>200</td>
</tr>
<tr>
<td>France</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>Italy</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>Japan</td>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td>Korea</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>Spain</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Australia*</td>
<td>5</td>
<td>2.5</td>
</tr>
<tr>
<td>Switzerland*</td>
<td>2.5</td>
<td>1.25</td>
</tr>
</tbody>
</table>

*Data are unavailable.
Sources: The Conference Board of Canada, based on Science Citation Index (SCI); OECD Health database, 2006.

Chart 13

Health-Related Patent Applications
(per million capita; by country of inventor)

<table>
<thead>
<tr>
<th>Country</th>
<th>2003</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>United States</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>France</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>Finland</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Japan</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Norway</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Canada</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Italy</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Korea</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Spain</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Australia*</td>
<td>0.5</td>
<td>0.25</td>
</tr>
<tr>
<td>Switzerland*</td>
<td>0.25</td>
<td>0.125</td>
</tr>
</tbody>
</table>

*Data are unavailable.
The Conference Board of Canada

The benefits of public–private research collaboration span well beyond project success, intellectual property produced, and the number of new companies created.

Finding and adopting appropriate governance models for these collaborations has always been a challenge. But very effective governance models for public–private partnerships have emerged, transforming the way we evaluate, plan and deliver health services. (See Case Study 3 for a Canadian example.) Some of these models might be of use in health research partnerships.

Benefits of University–Business Sector Collaboration

Conference Board research has shown that the benefits of public–private research collaboration span well beyond project success, intellectual property produced, and the number of new companies created. Other substantial benefits to university researchers include the development of new academic fields and programs; more interactions between students and industry (often resulting in employment); exposure to a range of different perspectives that might generate new ideas; and access to physical materials, audiences and facilities otherwise impossible to reach. Businesses also derive additional benefits, which include improvement of their visibility and reputation (a key element for their national and global competitiveness), upgrades of their scientific and research capabilities, and identification of new ideas and potential business opportunities. Case Study 4 presents a success story in public–private collaboration in health research.


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**Case Study 3: Public–Private Collaboration That Spawns Innovation**

**NSERC SYNERGY AWARD FOR INNOVATION: UBC BURT LAB/ANGIOTECH COLLABORATION LEADS TO IMPROVED HEART-DISEASE TREATMENT**

A breakthrough in treating people with coronary heart disease is helping to provide treatment to millions of people worldwide. Along the way, its cumulative impact has made British Columbia a significant biotechnology and pharmaceutical hub in Canada.

It all began with a meeting between Dr. Helen Burt, a University of British Columbia (UBC) researcher in the Faculty of Pharmaceutical Sciences, and Dr. William Hunter, Angiotech president and chief executive officer. At the time, Dr. Hunter was completing his medical internship and had an interest in researching diseases that were dependent on angiogenesis (the formation of new blood vessels) and their treatment. Since 1992, Dr. Burt’s research laboratory (the “Burt Lab”) and Vancouver-based Angiotech Pharmaceuticals Inc. have collaborated on the design and development of polymeric drug delivery systems, “drug-loaded” surgical implants, and medical devices. Paclitaxel, Angiotech’s primary drug of interest, has been the major research and development focus of the partnership.

Paclitaxel is a water-insoluble drug that Angiotech’s founders discovered could inhibit important cellular mechanisms involved in angiogenesis, inflammation, and scar formation. Dr. Burt then developed a polymer-based carrier that allowed the drug to be delivered efficiently in the body. The collaboration led to the first product, Taxus, a Paclitaxel-eluting coronary-stent system for the treatment of coronary heart disease. In the first 18 months after its launch in the United States, the product was implanted in more than two million patients.

The Burt Lab has since collaborated with Angiotech to develop several other novel controlled-release drug-delivery systems. In partnership with Angiotech, the Burt Lab has assisted in the development of two technologies representing two patent families with 43 patents in 26 countries. It has led to the training of many undergraduate and graduate students and post-doctoral fellows, created employment opportunities for graduates, and enhanced research funding for UBC’s Faculty of Pharmaceutical Sciences and Faculty of Medicine. Angiotech has achieved many benefits as well. It has grown to become a global specialty pharmaceutical and medical device company with 14 facilities in six countries and more than 1,500 employees.

The highly successful partnership is an outstanding example of a multidisciplinary achievement encompassing engineering, biomaterials, drug delivery, and clinical research. Their successes have earned the partners a 2006 NSERC Synergy Award for Innovation from the Natural Sciences and Engineering Research Council (NSERC), Canada’s largest science and engineering granting agency.

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Diffusion Channels

Canadians seem to be actively involved in knowledge diffusion, especially through academic publications, conferences, and formal and informal information sharing (e.g., federal/provincial/territorial committees). Greater emphasis has recently been placed on striving to better understand what it takes to effectively disseminate knowledge and improve knowledge transfer in health. So far, it is uncertain whether investing in direct transfer between and among jurisdictions is the best way to leverage innovation in the health field. More research is needed to determine which types of collaboration will most effectively diffuse knowledge in the health system.

International trade and foreign direct investments are also important channels of knowledge for Canada. They facilitate the diffusion of ideas and technology. Yet, research suggests that foreign firms face higher barriers to trade in Canada than in any of the other comparator countries.18

It is interesting to note that Sweden has high scores on many of the indicators explored. A world leader in innovation, Sweden is considered to have one of the strongest innovation systems in the world. A recent analysis conducted by the European Union,19 using the European Innovation Scoreboard,20 found that Sweden had the highest innovation performance of all the countries compared. Among the strengths of the Swedish innovation system are a stable macroeconomic environment, a well-educated workforce, a handful of R&D-intensive multinational corporations, ambitious public investment in activities related to innovation, and state-of-the-art research initiatives and educational activities.

Canadians seem to be actively involved in knowledge diffusion, especially through academic publications, conferences, and formal and informal information sharing.

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Case Study 4: Capital Health (Edmonton, Alberta)—Innovation Through the Implementation of a Governance Model in a Public–Private Sector Partnership

Historically in Alberta, a vendor–hospital procurement partnership was “governed” in a very ad hoc fashion. Hospital institutions focused mainly inwards, providing resources and controlling activity to achieve necessary patient care. To a large extent hospitals were considered “technology takers,” in that they purchased technology from the vendor community as it became available. Today, technological development is more sophisticated than ever, and the interaction between hospitals, researchers, and vendors is essential to achieve next generations of innovation in health care.

Capital Health has created a new strategic and innovative model for the interaction between public and private sectors. A formal contractual partnership model provides a new way of doing business between a private global vendor and manufacturer of medical devices and a leading public health authority. This allows for synergistic activities between two organizations that were not originally anticipated and would not have been possible under a traditional transactional relationship. The activities include leveraging the vendor’s industry knowledge, training, education, year-long internships within global R&D initiatives, collaborative research, development, and commercialization.

In this strategic partnership model, the governance structure consists of a formal executive committee and several subcommittees. Executives from both organizations sit on this Executive Governance Committee. This committee is responsible for:

- managing, guiding and promoting the overall relationship;
- overseeing specific elements of the relationship and tracking deliverables against work plan for each activity;
- creating awareness of the relationship through public displays and interactive storyboards;
- facilitating timely opportunities to mobilize new joint initiatives;
- tracking compliance and service levels; and
- providing guidance to the other committees.

Subcommittees are responsible for meeting deadlines for deliverables and are accountable to the Executive Government Committee for achieving projects. A formal structure requires information updates to be communicated and documented routinely (daily to quarterly, depending on the initiative) to help push the partnership agenda. Subcommittees include the Technology Leadership Committee, Research Steering Committee, Operations Sub-committee and Technology Integration Sub-committee.

Within this governance structure, there is also a reporting mechanism to the executive management of both founding organizations. Benefits to both organizations are measured based on a balanced scorecard that tracks completion of intended objectives and detailed action plans with status updates and accountabilities. Quantifiable indicators are tracked quarterly. Success is also measured through tracking of ongoing research initiatives and educational activities.

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20 The European Innovation Scoreboard is a measuring tool designed by the European Union to assess innovation performance of its members.
EXPLORING THE TRANSFORMATION OF KNOWLEDGE

This section focuses on Canada’s performance in developing new drugs, biologics, and integrated health information systems. The transformation or adaptation of knowledge into these improved products is an essential step to ensure that the resulting innovations are safe and will meet the needs of the end users. Because integrated health information systems are essential to enable appropriate planning, introduction and management of other health innovations, understanding Canada’s performance in this area is critical.

Canada seems to have a pharmaceutical pipeline that is in line with global standards. This demonstrates above-average performance in transforming knowledge into usable products.

DEVELOPING NEW DRUGS AND BIOLOGICS

Biologic and pharmaceutical drug development is a complex and costly process that can lead to the development of innovative medicines and vaccines.

The proportion of pharmaceuticals under development at the various stages in the pipeline speaks to various countries’ performance in transforming knowledge into commercial products (i.e., drugs and biologics), and characterizes the commercial potential of the pharmaceutical/biopharmaceutical sector in the next 5 to 10 years. Chart 14 illustrates the relative contribution of drugs under development by stage of development (i.e., preclinical, clinical I, clinical II, clinical III) for eight countries, including Canada.

The drug development pipelines of the various countries are basically similar in that most drugs are in the preclinical stage, with only 5 to 10 per cent in clinical phase III. Canada is somewhat of an exception, as it has the lowest share of drugs in the preclinical phase (31.5 per cent) and the highest share of drugs in phases II (37 per cent) and III (14 per cent). Assessment of these findings should consider the following factors:

- The likelihood of drug’s gaining approval varies widely for each phase: Less than 0.01 per cent of the compounds undergoing laboratory screening and 20 per cent of drugs in phase I make it to market, while this proportion increases to 50 per cent of phase II drugs and to 80 per cent of phase III drugs. Thus, the higher share of drugs in clinical phases II and III might be an advantage, indicating that Canada has a better chance than the comparator countries to bring a higher proportion of the pipeline to the market as approved pharmaceuticals.
- However, given that clinical trials are more often conducted by multinational organizations in several countries simultaneously, Canada might not completely realize the benefits of the high number of drugs in clinical phases II and III.
- As well, overall, the drug development pipeline is unpredictable, and new compounds or drugs might be added anytime.

Chart 15 provides the number of drugs under development in the pharmaceutical pipeline per capita in a particular country. Canada seems to have a pharmaceutical pipeline that is in line with global standards, with 7.8 drugs under development per million capita. This demonstrates above-average performance in transforming knowledge into usable products. Note that the United States, although occupying the second position after the United Kingdom, still leads (by a huge margin) the “drugs under development” category in terms of the absolute number, with...
about 3,150 drugs under development (the U.K. follows with approximately 843).

**HOSPITAL EXPENDITURE ON INFORMATION TECHNOLOGY**

Hospital spending on information technology (IT) drives the use of advanced applications and services to disseminate medical information, gain efficiency, and improve patient care. Patient clinical information systems at health professionals’ offices create new opportunities for regional and national interoperable health information systems.

Chart 16 shows the average expenditure for localized information and communication technology (including hardware, software, services, and personnel) as a share of total hospital costs for nine countries.\(^{23}\)

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**Hospital spending on information technology drives the use of advanced applications and services to disseminate medical information, gain efficiency, and improve patient care.**

Clearly, a tremendous gap exists between Canada and many of the other countries presented in the chart. According to recent surveys from the European Commission and Healthcare Information and Management Systems Society (HIMSS), average hospital expenditure on IT as a share of operating budget in Canada is 1.5 per cent, which is well below the median of the sample and well below the average of the OECD comparator countries in 2005 (4.4 per cent). Most European countries are decided leaders on this front, with Italy, Sweden and the U.K. allocating over 5 per cent of hospital budgets to IT.

**INTEROPERABLE INFORMATION SYSTEMS**

Medical records—the systematic documentation of patients’ medical history and care—are an integral element of any clinical practice. Electronic medical records (EMRs) are medical records in digital format, typically generated and maintained by one care provider (e.g., physician’s office) or institution (e.g., hospital, family practice centre). These electronic systems allow for more efficient use and management of point-of-care patient information, but they have limited connectivity. Electronic health records (EHRs), on the other hand, are better equipped to support more comprehensive and integrated care. EHRs are typically made up of health information from many locations and/or sources, including EMRs, and laboratory, public health, surveillance, and digital imaging electronic systems. The use of EHRs allows physicians, other health providers, and administrators to record, manage, and exchange patient information and thereby to improve patient safety, as well as boost the efficiency of the health system.

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\(^{23}\) Data for the other comparator countries were not available.
Chart 17 describes the financial resources (cumulative and per capita) allocated for the transformation of “islands” or localized health information technologies into a more integrated or interoperable health information system. The graph provides absolute and relative estimates of total investments in U.S. dollars (as of 2005) in national initiatives to develop an interoperable health information system for six OECD countries. The left side of the graph shows total investments per capita, while the right side shows total cumulative investments.

Through Canada Health Infoway—an independent, not-for-profit organization whose members are Canada’s 14 federal, provincial and territorial deputy ministers of health—Canada has invested since 2001 approximately US$1 billion to develop a more interoperable health information system. With the exceptions of the United Kingdom and Germany, Canada has invested more than any other country in the sample. Canada’s national investment of US$32 per capita positions it ahead of all countries except the United Kingdom, which has a total investment of US$193 per capita.

Through Canada Health Infoway, Canada has invested since 2001 approximately US$1 billion to develop a more interoperable health information system.

Canada’s investment signifies the federal government’s strong initial commitment, but falls short of the required investment to establish EHRs for all Canadians. (A report commissioned by Infoway found that a total cumulative investment of about $10 billion would be necessary to accomplish this task.24) It is also lower than the investments made by the Department of Veterans Affairs and Kaiser Permanente, two landmark organizations in the United States that have been able to transform their practices and implement successful EHRs. They have allocated about US$300 and US$490 per capita respectively for the development and implementation of these systems—well above the investments shown in Chart 17, including those made in the United Kingdom.

Table 6 details the scope, nature, and intensity of initiatives to develop an interoperable health information system for six OECD countries.

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24 Booz Allen Hamilton, Canada Health Infoway’s 10-Year Investment Strategy.
The projects vary in terms of the three characteristics (scope, nature, and intensity). All countries except Canada and Germany are relying on more than one technology platform to achieve their desired system. Germany is using EHRs and “smart” health cards (cards with microchips) as the main technology platform for health information technology integration. Canada is focusing mainly on EHRs. Meanwhile, Infoway is investing in registries, diagnostic imaging, drug information systems, laboratory information systems, telehealth, and public health surveillance programs that contribute towards the implementation of integrated electronic health record solutions.

### DISCUSSION: EXPLORING THE TRANSFORMATION OF KNOWLEDGE

Key findings from the exploration of the transformation of knowledge in the Canadian health-care system can be summarized as follows:

- Canada has the highest percentage of drugs in phase III and the lowest percentage of preclinical drugs, compared with the nature of pipelines found in the OECD comparator countries.
- The number of Canada’s drugs under development per capita is above the average for the other OECD comparator countries.
- In Canada, average hospital expenditures on information technology represent 1.5 per cent of operating budget, significantly lower than the 4.4 per cent for the OECD countries examined and the 4 per cent recommended by Infoway in order to achieve the potential benefits in quality, access and productivity.
- In terms of developing an interoperable health information system, Canada’s national investment of US$32 per capita is a strong initial federal commitment, but it is likely not enough to create interoperable EHRs across 50 per cent of Canada, as desired.

Compared with other players, Canada seems to have a pharmaceutical pipeline that is competitive with global standards. And certainly, several factors—the above-average number of drugs under development per capita, the higher share of drugs in clinical II and III stages, the relatively inexpensive labour and low benefit and utilities costs in Canada—indicate that this sector is poised to continue growing. Furthermore, a recent analysis by KPMG ranks Canada number one among the G7 countries as the most cost-competitive investment location in the

---

Table 6

<table>
<thead>
<tr>
<th>Scope, Nature and Intensity of Development Initiatives</th>
<th>Australia (HealthConnect)</th>
<th>Canada (Infoway)</th>
<th>Germany (Better IT for Better Health)</th>
<th>Norway (More Health for each bit…)</th>
<th>United Kingdom (National Programme for IT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of expected completion</td>
<td>Undefined</td>
<td>2009</td>
<td>2006</td>
<td>2007</td>
<td>2014</td>
</tr>
<tr>
<td>Type of technology used</td>
<td>EHRs, point-to-point messaging</td>
<td>EHRs and supporting technologies</td>
<td>Smart health card</td>
<td>EHRs, Norwegian Health Net</td>
<td>Integrated care record service, electronic appointments, electronic prescription transmission, infrastructure/network</td>
</tr>
</tbody>
</table>

Notes: IT = information technology; EHR = electronic health record

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pharmaceuticals industry sector. However, some have expressed concerns that Canada’s approach to intellectual property, regulation of drugs, and legislation governing the pharmaceutical industry, including taxation, might hinder the sector’s ability to continue growing.

Despite the benefits of information and communication technologies, the IT budgets of our health-care organizations are still below those in high-performing OECD countries.

The picture is quite different when one examines the application of IT in health care. Canada has not placed sufficient importance on supporting the development and use of health information systems. Despite the strong evidence of the benefits of information and communication technologies, the IT budgets of our health-care organizations are still below those of health-care organizations in high-performing OECD countries. Moreover, unlike in some European countries (e.g., the Netherlands, the U.K.), where the majority of their population has an EHR, only a few individuals in Canada have one. This is very disconcerting, as there is abundant evidence that electronic health records can:

- strengthen the ability to disseminate and support best practices and evidence-based medicine across the health-care system (e.g., track care against optimal treatment protocols, support disease management programs);
- help prevent medication errors; and
- support better management of services (i.e., ensure that resources are spent wisely).

Canada is moving in the right direction, but it needs to reaffirm its commitment. A recent evaluation of Infoway concluded that the organization is making “reasonable progress towards meeting its goal of an interoperable EHR across 50 per cent of Canada (by population) by the end of 2009.” However, Infoway’s undercapitalization is jeopardizing its ability to attain this goal. Case Study 5 presents some of the advances that Infoway has introduced in diagnostic imaging systems.

**Case Study 5: Adapting Diagnostic Imaging Technologies to Create Value in Health Care**

**CANADA HEALTH INFOWAY: BETTER HEALTH CARE THROUGH DIAGNOSTIC IMAGING SYSTEMS**

Canada Health Infoway’s Diagnostic Imaging (DI) Program is focused on the implementation of DI solutions that feature electronic distribution of DI results to all facilities. This program will refer any study, anytime, anywhere to community physicians and specialists over a high-speed network. The DI systems integrate a single or multiple Picture Archiving Communications System (PACS) to a shared DI Repository.

The DI Program has made excellent progress to date, having completed DI projects in three jurisdictions: Ontario’s Thames Valley, Nova Scotia, and BC’s Fraser Valley and Interior Health Authority are now 100 per cent filmless. The filmless state in Canada is now estimated to be at 53 per cent. However, with the 14 additional repository projects underway across eight jurisdictions, Canada should achieve an 85 per cent filmless state by 2009.

In 2006, a PACS survey that captured the opinions of radiologists (n = 78) and referring physicians (n = 146) across four projects in three jurisdictions (British Columbia, Nova Scotia, Ontario) found that PACS has improved physician efficiency, report turnaround time (TAT), and quality of patient care. The majority of radiologists (87 per cent) and referring physicians (73 per cent) indicated that PACS has improved their efficiency. Report TAT has also improved since the implementation of PACS, according to 87 per cent of radiologists and 65 per cent of referring physicians. One project (22 sites) showed that average report TAT decreased post–PACS implementation by 41 per cent. PACS also appears to have a positive impact on patient care. Of referring physicians, almost two-thirds stated that PACS has improved their ability to make decisions regarding patient care, 80 per cent reported that PACS has reduced the time they must wait to review an exam/report, 43 per cent indicated that PACS has reduced the number of patient transfers between facilities due to the new ability to share images and consult remotely, and 58 per cent believed that PACS had reduced the number of exams reordered because the exams were not available (lost or located elsewhere) when they needed them. Clearly, these DI systems are contributing to better health-care delivery to Canadians.
EXPLORING THE USE OF KNOWLEDGE

This section focuses on Canada’s uptake of new technologies. More specifically, it assesses Canadian expenditures on pharmaceuticals and other medicinal non-durables and therapeutic appliances. In addition, an examination of the adoption and use of IT in health-care organizations is presented.

EXPENDITURES ON MEDICAL GOODS

The choice to adopt and use innovative technologies requires careful assessment. Innovative technologies contribute to creating value for health systems only if processes and structures are in place to ensure that the anticipated value is indeed derived from the use of such technologies.

Chart 18 compares total expenditures on pharmaceuticals and other medical non-durables (comprising pharmaceuticals such as medicinal preparations, branded and generic medicines, drugs, patent medicines, serums and vaccines, vitamins and minerals, and oral contraceptives) among the OECD comparator countries and Canada. (Note: These data include both innovative and non-innovative products.)

In 2004, total expenditure on pharmaceuticals and other medical non-durables in Canada was US$559 PPP per capita, which is above the median of the sample and above the average of the comparator OECD countries (US$425 PPP per capita). Canada has demonstrated an overall 60 per cent increase in total expenditures since 1998, behind Korea, the United States, Spain, and Norway.

Chart 19 compares total expenditures on therapeutic appliances and other medical durables. This category comprises a wide range of medical durable goods such as glasses, hearing aids, and other medical devices. Also included are orthopedic appliances and other prosthetics, as well as medico-technical devices, such as wheelchairs.

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28 OECD Health Data 2006.
30 OECD Health Data 2006.
In 2004, total expenditures on therapeutic appliances and other medical durables in Canada was US$72 PPP per capita, which is about the median of the sample and below the average of the OECD comparator countries (US$80 PPP per capita). With the exceptions of the United States and Spain, Canada demonstrated the lowest growth (18 per cent) on this indicator between 1998 and 2004.

In 2004, Canada’s international balance of trade in the pharmaceutical industry was a deficit of US$136 per capita. This figure is below average of the OECD comparator countries.

INTERNATIONAL TRADE IN MEDICAL GOODS
The balance of trade is the difference between the value of exported products and the value of imported products. If a country’s imports exceed exports, a trade deficit exists; if a country’s exports exceed its imports, a trade surplus exists. International balance of trade is not a good indicator of innovation. However, because medical goods are typically high-value goods that have resulted from many years of research, a positive correlation between innovation and export value could be assumed. A balance of trade in the medical goods industry can therefore be used as an indication of a country’s industry performance in the creation, commercialization, and ultimately export of new products. Significantly improved medical products may have a positive effect on export prices and, therefore, on export value.

Chart 20 presents the international balance of trade in pharmaceuticals and other medical non-durables for Canada and the comparator countries. In 2004, Canada’s international balance of trade in the pharmaceutical industry was a deficit of US$136 per capita. This figure is below the median of the sample and below the average of the OECD comparator countries (surplus US$163 per capita). Countries such as Sweden, the United Kingdom, France, and particularly Switzerland have demonstrated consistent surplus growth in international balance of trade in the pharmaceutical industry per capita since 1998. Canada has not fared as well, with deficit growth of 111 per cent between 1998 and 2004.

As seen in Chart 21, Canada’s international balance of trade in the medical devices industry per capita has remained somewhat constant since 2000. In 2005, it showed a deficit of approximately C$59 per capita.

INFORMATION TECHNOLOGIES
Wide use of EHRs and other core information and communication technologies enable health professionals to better manage and share clinical information, improve efficiency, and enhance patient care.31

Chart 22 shows the percentage of physicians reporting use of core information and communication technologies in a patient care setting, in 2004. Notable findings, expressed per 100 physicians in Canada, are as follows:
- use of Internet: 65 per cent—below the median and the average (71 per cent);
- use of personal digital assistant (PDA): 33 per cent—above the median and the average (6 per cent); and
- use of computer: 88 per cent—below the median, above the average (84 per cent).

An interoperable health information system can facilitate use of external medical services and access to medical information by physicians, health-care providers and patients.

Chart 23 presents the results of a Commonwealth Fund survey conducted among 6,000 physicians across seven countries. This survey estimated, among other things, the proportion of primary care physicians in each country who use electronic medical records.

This chart shows Canada’s weak performance in this area. Only 23 per cent of primary care physicians use these information systems, which was the lowest proportion among the countries examined.

INTEROPERABLE INFORMATION SYSTEMS
An interoperable health information system can facilitate use of external medical services and access to medical information by physicians, health-care providers and patients. The level of access in these groups corresponds

31 Use of information technologies will also create new opportunities for regional and national interoperable health information systems.
to the penetration of core technologies (e.g., computers, PDAs, Internet, EMRs) and the transformation of localized IT into an interoperable information system or electronic health record.

Chart 24 shows the percentage of physicians that can access and share electronic medical records. Only 6 per cent of Canadian primary care physicians can share records electronically with clinicians outside of their practices, 11 per cent can access records from outside the office, and 6 per cent can provide patients with easy access to their records. Of the countries examined, Canada reported the lowest capability among its primary care physicians for accessing and sharing medical records.

Chart 25 shows the percentage of physicians reporting routine use of external health information systems to carry out four different activities. In keeping with the results for other technology-use indicators, Canadian physicians reported less routine use of external health information systems to carry out activities than their comparator counterparts. Only 8 per cent of Canadian primary care physicians routinely order tests electronically, 11 per cent routinely prescribe medication electronically, 27 per cent routinely access patient test results electronically, and 15 per cent routinely access patient hospital records electronically. This last activity is the only one where Canadian physicians appear to be ahead of some of their international colleagues.

Of the countries examined, Canada reported the lowest capability among its primary care physicians for accessing and sharing medical records.

**DISCUSSION: EXPLORING THE USE OF KNOWLEDGE**

Key lessons from the exploration of use of knowledge can be summarized as follows:

- In 2004, Canada’s total expenditure on therapeutic appliances and other medical durables was US$72 PPP per capita, which represents average spending when benchmarked against the comparator countries.
- In 2004, Canada’s total expenditure on pharmaceuticals and other medicinal non-durable goods was US$559 PPP per capita, more than almost all of its comparators.
- Canada is a net importer of pharmaceuticals, with a deficit of US$136 per capita. This situation potentially deprives Canada of dollars that could be reinvested in further research and development. Of the countries examined, Finland is the only one with a per capita deficit larger than Canada’s.
- In 2005, Canada’s trade deficit in the medical devices industry was approximately C$59 per capita; its overall balance has remained somewhat constant since 2000.
Computer penetration among physicians in Canada is relatively high (88 per cent), and PDA penetration is moderate (33 per cent)—both above average when compared with rates in the benchmark countries. However, only about 65 per cent of Canadian primary care physicians use the Internet, which is well below the more than 90 per cent in Finland and Sweden and the 71 per cent average of the OECD comparator countries.

- Of the countries examined, Canada ranked lowest (23 per cent) in its use of electronic medical records among primary care physicians per 100 physicians. Furthermore, Canadian primary care physicians reported the lowest capability for accessing EMRs from outside their offices and sharing these records with other health practitioners outside their practices.

- Canadian primary care physicians reported less routine use of external health information systems to carry out activities than physicians in the comparator countries. The only activity where Canadian physicians outperformed their international counterparts was accessing patient hospital records electronically.

**Understanding Use of Pharmaceuticals**

There are three reasons a given country might spend more than another country on pharmaceuticals:

- it consumes a greater volume of pharmaceuticals;
- its prices are higher; or
- a more expensive drug mix is consumed.

The United States consumes about 20 per cent less drugs for nine major therapeutic areas, but the price of some drugs can be up to 60 per cent higher than in other industrialized countries. Also, Americans are early adopters of new drugs, which are generally more expensive than established drugs. Not surprisingly, then, given these factors, the United States shows the highest expenditures.

Drugs have been the fastest-growing component of Canadian health care during the past 25 years. In fact, they now are the second-largest component of total health expenditures, after hospitals. (Although hospitals have seen a decrease in share, they still represent the largest component of health-care expenditures in Canada.) Canadians seem to be most willing to prescribe and consume new and improved drugs, which presents a good market opportunity for manufacturers. Because total drug expenditures have risen faster than total health expenditures, there has been a resulting increase in the share of total health

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expenditures allocated to drugs, from 8.4 per cent in the late 1970s to a forecasted 17 per cent in 2006.\textsuperscript{33}

Drug prices and the rate of utilization are the two major factors behind increased drug expenditures, particularly spending on prescription drugs.\textsuperscript{34} A variety of price indices show that the prices of existing drugs have been relatively stable for the past 12 years, and Canada’s Patented Medicines Pricing Review Board has confirmed this stability by reporting that the prices of patented medicines in Canada are aligned to international prices. In fact, the price of branded drugs in Canada is up to 60 per cent lower than in the United States.\textsuperscript{35} Increased costs are primarily the result of new drugs being substituted for older ones, as they are typically introduced at higher costs than the costs of products they displace.

Little effort has been made to ensure proper use and management of pharmaceuticals, which would be more in line with the goals of innovative and high-performing health systems.

Increased costs can also be a consequence of increased rate of utilization, which might result from demographic changes and modifications in the prescribing habits of physicians. Until now, our health-care system has focused on controlling costs mainly through limiting access to drug innovations. Very little effort has been made to ensure proper use and management of pharmaceuticals, which would be more in line with the goals of innovative and high-performing health systems. There are, however, some initiatives across the country that are starting to make a difference in this area. (See case studies 1 and 6.)

**UNDERSTANDING USE OF INFORMATION SYSTEMS IN HEALTH**

Primary care physicians in Canada have not enthusiastically adopted new information systems to support their practices. A study commissioned by Infoway,\textsuperscript{36} which examined IT in primary care practices in leading countries, found that over 90 per cent of physician offices in England, Scotland, Denmark, Sweden, Norway, the Netherlands, Austria, Germany, New Zealand, and Australia use computers for some aspects of patient care, compared with only 20 per cent in Canada.\textsuperscript{37} A number of factors have influenced the uptake of these technologies over

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\textsuperscript{33} Canadian Institute for Health Information, *National Health Expenditure Trends, 1975–2005* [online].

\textsuperscript{34} The Conference Board of Canada, *Understanding Health Care Costs Drivers and Escalators*.

\textsuperscript{35} McKinsey & Company, *Accounting for the Cost of Health Care in the United States*.

\textsuperscript{36} Protti, *IT in General Practice* [online].

\textsuperscript{37} www.cma.ca/multimedia/CMA/content_images/Inside_CMA/Future_Practice/English/2006/November/IT_in_general_practice.pdf.
the past two decades in these countries, including the existence of a national IT health strategy and a central body in charge of achievement of targets; available financial support from governments; financial incentives or quality targets that can be reached easily only with use of automated records; certification of vendor systems; and appropriate change management support.

Successful IT systems are generally developed with the contribution of the users. Health-care administrators and clinicians have to be part of the process.

Canadian jurisdictions have already adopted some of these influential elements. For example, financial support is available in Alberta, Ontario, Quebec, Nova Scotia, and British Columbia to compensate physicians for purchasing a computer system; a national IT health strategy exists and a central body (Infoway) is mandated to implement that strategy; a vendor accreditation system already exists in Alberta and Ontario; and Infoway is currently working towards a pan-Canadian standards-based environment where EHR solutions can be tested and assessed. However, if health care in Canada is to be modernized and transformed through health information systems, significant financial investments at various levels need to be made, and stakeholders, especially physicians, must be much more involved.

Successful IT systems are generally developed with the contribution of the users. Health-care administrators and clinicians have to be part of the process. And the time to get everyone on board is now. Our health-care system is in serious need of practices that are safer and more cost-efficient, coordinated, and productive. All this can be attained with the assistance of appropriate clinical information systems.

We have yet to see the results of the work of Infoway. There are, however, some success stories at the regional and provincial levels. Alberta, for example, is making

Case Study 6: McGill University Health Centre—an Innovative Application of Health Technology Assessment

In June 2002, the McGill University Health Centre (MUHC), a merger of five hospitals affiliated with McGill University, launched a Health Technology Assessment (HTA) program.

The objective of HTA is to inform health-care policy through consideration of such issues as efficacy, safety, cost-effectiveness, budget impact, ethics, legal issues, and opportunity costs related to the acquisition and use of health technologies. Up until now, HTAs have been created mostly at the national or regional level. However, in the Canadian health-care system the majority of decisions on the use of technologies are made at the hospital level. MUHC created the Technology Assessment Unit (TAU) in response to the need of the hospital for scientifically evaluated evidence and a transparent process for its interpretation into fair policy recommendations on the acquisition and use of technologies. TAU has two components:

- professional staff who access the relevant published information, update and critically evaluate it, and synthesize it for presentation to the Policy Committee; and
- the Policy Committee, made up of institutional representatives (doctors, nurses, patients, administrators, etc.). In addition, for each study one or two leading representatives of the departments affected by the decision are involved. This committee has the role of reviewing the evaluation produced by the professional staff and making recommendations to the administration on whether the technology should be adopted.

TAU’s goal is to assess the usefulness of both new and old equipment, drugs, and procedures used by health-care professionals to make sure the hospital gets the best value for its limited money. Of the 18 reports submitted in its first three years of operation, all recommendations from the assessments have so far been accepted by hospital administration. Although saving has not been the primary objective, the budgetary savings to MUHC are estimated to be at least $3 million each year.

38 Protti, IT in General Practice [online].
The Conference Board of Canada

great progress in achieving its goal of province-wide EHRs by January 2008. To date, great efforts have been made by Edmonton’s Capital Health region to build netCARE, an EHR that is being used by 5,200 health-care professionals per month and about 11,000 health-care professionals over the course of its implementation. It provides demographic information, care history, lab results, drug information, knowledge tools, immunization history, home care, a chronic disease model, digital imaging, e-signatures, and cross-cancer lab services. The province has been very successful at helping physicians to introduce IT in their clinics, building the foundation for them to participate in this health information system. Users of netCARE praise it highly; it is reducing duplication (47 per cent fewer tests) and saving time (as reported by 68 per cent of those surveyed). An evaluation of netCARE reported that 76 per cent claimed the system was useful in their work.

Health Link, a province-wide nurse-line centre, is another initiative of the Government of Alberta that is providing great value to the population of this province. (See Case Study 7.)

Case Study 7: Capital Health, Alberta—Health Link Answers Call for More Appropriate Use of Health System

Capital Health Link was the first regional health advice and information service in Alberta and the first fully integrated nurse line service delivered by a public provider in Canada. Health Link uses state-of-the art communication technologies, including a sophisticated telephony system and call management software, standardized electronic medical databases, web products, and electronic client records.

Public usage of Capital Health Link increased rapidly. The service was launched in September 2000 and received 250,000 calls in its first year—double the number projected. In 2003, Capital Health and Calgary Health Region developed and launched a province-wide service, with funding from the Health Canada Primary Health Care Transition Fund. By 2006, Health Link Alberta was receiving over one million calls per year.

Health Link Alberta telephones are answered 24 hours a day, seven days a week by registered nurses who use evidence-based protocols to provide health advice that is appropriate to reported symptoms. Non-clinical information and referral staff respond to requests for information and appointment booking, thereby ensuring the most effective and efficient use of professional staff. The Health Link infrastructure offers additional opportunities to use technology to enhance service delivery that goes beyond “people on the phone.” Integration of the telephone service with the web and other communication technology enable Health Link to offer multi-channel access to services, such as two websites that offer general health information and regional service information.

39 Weatherill, “Accelerating Primary Care in Alberta Conference.”
Conclusion

Chapter Summary

- A plan of action to strengthen our comparatively weak health innovation environment needs to be developed based on a thorough understanding of the reasons behind Canada’s weak performance in this vital area.

- In terms of innovation, fundamental differences exist between Canada and the comparator countries. Far more health research takes place in Canadian universities rather than in the private sector or in government, and universities here fund more health research than universities abroad. Both factors could lead to less focus on market potential and needs.

- Due to the value of integrated information systems for patient care management and for the appropriate planning, introduction and management of other health innovations, more effort must be directed towards improving the adoption and use of these systems in Canada.

- Establishing appropriate indicators to assess innovation and its impact is key to achieving effective health systems.

There can be no doubt that technological innovation in health care is vitally important. Strong linkages exist among innovation, productivity, wealth, and health; and Canada, like other OECD countries, is taking note and taking steps to boost innovation and the conditions that foster it.

Many products that make us comfortable, productive, healthy, and safe have been discovered or invented by Canadians. The benefits of these inventions are enjoyed by people everywhere—a true contribution to worldwide well-being.

Although Canada has not fared well on some of the indicators of this international comparison, we have a strong tradition of health innovation. Many products in modern life that make us comfortable, productive, healthy, and safe have been discovered or invented by Canadians: electric wheelchairs, heart pacemakers, the meningitis C vaccine, electron microscopes, insulin, Pablum, and most recently, a vaccine against the Ebola virus. The benefits of these inventions are enjoyed not only by Canadians, but by people everywhere—a true contribution to worldwide well-being.
FOUR FOCUS AREAS

The aim of this report is to assess Canada’s strengths and weaknesses with regard to technological innovation and the environment in which it occurs. To address our weaknesses and to “push the innovation envelope” further, we have chosen four focus areas where improvement is most needed.

1. WE NEED TO DEVELOP A PLAN OF ACTION TO STRENGTHEN OUR COMPARATIVELY WEAK HEALTH INNOVATION ENVIRONMENT BASED ON A THOROUGH UNDERSTANDING OF THE REASONS BEHIND OUR LOW SCORE.

The Canadian innovation environment is facing challenges. We have difficulties accessing skilled people and venture capital, and establishing effective regulation/patent regimes and timely and efficient regulatory systems, all of which are fundamental to technological innovations. Skilled workers are at a premium, and Canada finds itself competing against other developed countries for them. These workers are necessary, not only to create knowledge, but also to increase government regulatory capacity. Canada lags behind the United States in particular in terms of venture capital investments, making it difficult for researchers to transform their knowledge into products here.

Strong intellectual property protection is important to stimulate R&D investments and the inflow of foreign knowledge resources and assets. Compared with the systems in other OECD countries, Canada’s patent protection system does not appear to be as effective at striking that necessary balance between protecting the rights of knowledge creators and encouraging the broad dissemination and use of that technology. What’s more, we appear to be losing ground in this area. Further complicating this issue is the great variability in the interpretation and application of the acts, regulations, and policies governing the management and commercial exploitation of intellectual property across federal and non-federal R&D institutions and agencies. Intellectual property policies of university and research organizations also vary widely across the country, creating significant challenges for those trying to establish multi-institutional R&D networks and alliances, which are essential to creating, diffusing, transforming, and using knowledge.

Because the innovation process relies on the diffusion and exploitation of knowledge, a regulation that is unfriendly to innovation might limit the ability of a country, a system, or an organization to access that knowledge. (Unfriendly regulation is regulation that is not timely or is too cumbersome.)

The challenges that we are mentioning are not exclusive to the health sector; other sectors in Canada have also experienced them. Yet, in terms of health, these issues in particular must be addressed:
- ensuring an appropriate supply and distribution of university spaces to educate people with advanced research qualifications in the health and life sciences;
- assessing opportunities to overcome the reluctance of businesses, including venture capitalists, to invest and actively participate in the development of technologies that cannot be marketed freely (due to their application to an insured health-care service, such as surgery or a diagnostic procedure); and
- harmonizing the multiple and conflicting regulatory regimes across all jurisdictions in Canada.

We have difficulties accessing skilled people and venture capital, and establishing effective regulation/patent regimes and timely and efficient regulatory systems.

Strengthening the innovation environment is not an easy task. It entails introducing changes in areas that appear to be problematic and that are sometimes difficult to transform. The benefits of transforming the health innovation environment, and of making it more attractive and supportive for developing new technologies, will be felt not only in our health systems, but well beyond. Improvements will bring economic growth, boost Canada’s competitiveness, and contribute to improved global health and well-being.
2. GIVEN THE HIGH PROPORTION OF HEALTH RESEARCH PERFORMED IN UNIVERSITIES, IT IS ESSENTIAL TO PROMOTE MORE COLLABORATION BETWEEN UNIVERSITIES AND THE BUSINESS SECTOR IN ORDER TO BOOST THE COMMERCIALIZATION OF KNOWLEDGE.

In terms of innovation, fundamental differences exist between Canada and the other OECD countries examined in this report. First, the distribution of where health research is conducted is very different: far more takes place in Canadian universities than in the private sector or in government. In Canada, 60 per cent of health research is performed in higher-education institutions, compared with just 28 per cent in the comparator countries. Furthermore, Canadian universities fund more health research than do universities abroad. Both factors could lead to less focus on market potential and needs.

Certainly, Canadian universities do not compare well with their American and European counterparts in their ability to disseminate and protect their knowledge assets and transform them into innovations. Canadian universities produce a highly skilled workforce and advance scientific knowledge by publishing hundreds of scientific articles in peer-reviewed journals, but they have significantly fewer invention disclosures, patent applications, patents granted, and licences executed.

Opportunities also abound for enhanced organizational reputation; funding for research interests; greater employment; and access to education, training, and technologies.

Little collaboration occurs between universities and business enterprises in Canada. Ontario’s universities had the greatest amount of health R&D funded by business enterprises in 2003, which represented only about 10 per cent of their total funding. Given that the private sector plays an important role in the dissemination and transformation of new products (e.g., surgical equipment, medical devices, new biological products), it makes sense that stronger links between Canada’s universities (including its teaching hospitals) and industry might result in greater commercialization. Most certainly, Conference Board of Canada research in the business sector has proven that there is a direct correlation between collaboration and innovation. But increased collaboration is not easy to achieve due to intellectual property issues that arise in revenue-generating opportunities. It would benefit both sides to overcome this problem. Not only does the approximately $27-billion domestic health-care market represent considerable opportunities for commercialization, but opportunities also abound for enhanced organizational reputation; funding for research interests; greater employment; and access to education, training, and technologies. Some university–business collaborations are thriving, such as that between the University of British Columbia’s Burt Lab and Angiotech, indicating that success in this area is indeed possible and very rewarding for both sides.

To move ahead, academic researchers must be encouraged—possibly through economic incentives—to see the link between their work and its market and commercial potential. More interaction between academic researchers and the business sector would facilitate this.

3. WE CANNOT LOSE SIGHT OF THE FACT THAT THE TRANSFORMATION OF KNOWLEDGE INTO INTEGRATED HEALTH INFORMATION SYSTEMS IS AN ESSENTIAL STEP IN THE INNOVATION PROCESS AND IS KEY TO IMPROVED PATIENT CARE. AS SUCH, THESE SYSTEMS MUST BE FUNDED, ADOPTED, AND CONSISTENTLY USED.

The transformation of knowledge into integrated health information systems is an essential step in the innovation process for two reasons: these systems, in and of themselves, bring social and economic value (e.g., supporting more effective and safer patient care management), and they also enable appropriate planning, introduction, and management of other health innovations.

Although Canada has made some improvements in this area, we are far behind other industrialized countries.

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1 In Making Health Innovation More Effective (2005), Global Advantage Consulting (for The Change Foundation) estimated that our health-care market, defined as the goods and services consumed in Canada (excluding labour) can be broken down as follows: $18.4 billion in drugs, $4.8 billion in medical devices, and $3.9 billion in health services and software and informatics.
A strong, clear message from this report is that more effort must be directed toward improving the adoption and use of integrated information systems in health care. Canada invests much less than other systems or countries in health information technology (IT) and interoperable EHRs. The marked investment gap makes it near impossible to build effective and sustainable IT solutions. Although a strong initial investment has been made in Infoway ($1.2 billion plus more recent budget commitments of an additional $400 million), it still does not seem to be enough to reach the target of electronically compatible health records for half of Canadians by 2009.

This deficiency poses a serious concern, as these technologies have the ability to transform and bring substantial benefits to our health-care system, our society, and the economy at large. The return on investment from a pan-Canadian EHR is estimated to have gross benefits exceeding investment dollars by an 8:1 margin, and to generate net savings of $39.8 billion. Some of the savings forecast in the health-care system are as follows:²

- reduction of duplicate and unnecessary lab tests (estimated savings of $10.4 billion over 20 years);
- reduction of duplicate and unnecessary radiological tests (estimated savings of $3.6 billion over 20 years); and
- reduction in adverse drug events (about 29 million events over 20 years, estimated savings of $48.3 billion).

On top of the financial savings, EHRs benefit the health-care system in many other ways, such as:

- strengthening productivity, efficiency and health-care coordination;
- facilitating the modernization of health programs (e.g., home care and chronic disease management programs);
- supporting health-care reform agendas targeting the long-term sustainability and improved performance of the health-care system (e.g., primary health-care reform, wait times strategy); and
- supporting increased quality and safety of care practices.

In addition to these benefits, the implementation of the EHR would also make waves in the labour market. Richard Alvarez, President and Chief Executive Officer of Infoway, recently referred to a Conference Board study that estimated the effects of EHR activity to be the creation of 37,000 jobs by 2010—8,000 in Ontario. This translates into $2 billion in new labour income for Canadians. The study also estimates that these investments will have generated $1 billion in corporate pre-tax profits— and every dollar invested by Infoway and the provinces adds $1.34, on average, to Canada’s GDP.³ The benefits are so immense that it is difficult to fathom why Canada is taking so long to implement these systems.

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² Booz Allen Hamilton, Pan-Canadian Electronic Health Record, Canada Health Infoway’s Strategy.

³ The Conference Board of Canada, The Economic Contribution of Capital Investment Spending by Canada Health Infoway and Regional Sponsors.
health system, but if implemented in a faulty manner or not managed properly, they will drain valuable resources and discourage stakeholders in their innovation efforts. The Conference Board of Canada’s Innovation Framework provides a good structure to effectively study innovation health systems, but strong data are lacking on performance, utilization, and outcome in all areas. The development of innovation indicators and appropriate data collection infrastructure will ensure that innovation health systems are suitably understood, supported, measured, and managed.

Focusing on these four key areas would do much to bolster technological innovation in the Canadian health system.

**FIRST THINGS FIRST: CREATE A VISION**

Despite the importance of innovation for our society’s health, well-being, and economic prosperity, we seem to lack a vision to provide direction. So before work can begin on the four focus areas described above, it is essential that a vision be created to define the role of innovation in Canada’s health systems. This vision should be created by leaders and supported by grassroots professionals, and should foster the successful alignment between national targets and regional priorities. Strategic alignment between innovation stakeholders—including governments, academic centres and research institutions, health-care organizations, and other social institutions—would facilitate a concerted effort in the pursuit, attainment, and management of innovation.

**A CALL TO ACTION**

The Centre for Health Care and Innovation, created and managed by The Conference Board of Canada, is showing leadership by supporting this research. But we are only at the beginning of the journey. This report advances the discussions that will lead to increased and steady innovation in our health systems. It underscores the fact that more research is needed to better understand the intricacies of innovation policies and their effects on health systems—and is a call to action to engage in such research.
Identifying High Performers in Health

BENCHMARKING METHODOLOGY

The research for this report was undertaken over a 12-month period. It is important to note that the benchmarking methodology used in the analysis of data for this report and presented in this appendix reflects the one used in Conference Board reports prior to 2007. (The Conference Board of Canada’s benchmarking methodology has changed somewhat recently.)

Indicators are divided into three categories: health status, health outcomes, and health-care utilization and performance. Table 1 shows the specific health indicators in each category.

Where appropriate, these 19 indicators were divided by gender, which led to 30 specific indicators. Canada’s national average was compared with that of other OECD countries, since they are leading industrialized countries and thus serve as a relevant peer group. Indicator scores for the countries were standardized and used to calculate an overall mean score for every country, which was then ranked from highest to lowest.

Standardized scores for each indicator were calculated using the following formula:

\[
\text{Standard score} = \frac{(\text{actual value} - \text{mean})}{\text{standard deviation}} + 100
\]

Where a lower number was desirable for an indicator, the inverse of the above formula was applied:

\[
\text{Standard score} = \frac{(\text{mean} - \text{actual value})}{\text{standard deviation}} + 100
\]

GOLD–SILVER–BRONZE RANKING

Once data were obtained for the countries, performance was ranked for each indicator by assigning a gold-, silver- or bronze-level grade, based on scores. For each indicator, the difference between two scores (those of the top and bottom performers) was calculated and then split into thirds. A country achieved a gold-level performance if its indicator score was in the top third of all scores, a silver level if its score was in the middle third, and a bronze level if its score fell within the bottom third.

Subsequently, the performances for each of the three categories (health status, health outcomes, and health system utilization and performance) were counted. A gold-level performance was weighted as two points, while a silver-level performance was weighted as one point. Bronze-level performers did not receive any points, by virtue of finishing in the bottom group. Ranking the performances this way is important, as it places emphasis on indicator scores, rather than on a simple ordinal ranking.

To illustrate, Country A may rank second in mortality rate for stroke but be far behind the first-ranked country,
Country B. Referring to Country A as number two in mortality rate for stroke would therefore overlook the more important issue—that there is a huge performance gap between the first- and second-ranked countries.

The final ranking of the countries studied is presented in Table 2.

**LIMITATIONS OF THE METHODOLOGY**

The Conference Board of Canada acknowledges that there are limitations in its methodology, but despite these challenges, it considers this approach to be groundbreaking and very relevant to understand relative performance. One of the main challenges for this benchmarking exercise was obtaining comparable data across all countries. Initially, 70 indicators were chosen, but only 19 were found across at least 80 per cent of the countries (the threshold selected to include in this benchmarking). It was recognized that more data in the health-care utilization and performance areas were desirable, so efforts were made to find information on patient satisfaction, hospitalization rate for ambulatory care–sensitive conditions, wait times, proportion of female population aged 18 to 69 with at least one Pap test in the past three years, home care clients per 100,000 population, and patient-perceived quality with overall health-care services.

Another important limitation results from the use of provincial averages as national indicators. Averages can mask disparities within jurisdictions, such as differences

### Table 1
**Selected Health Indicators**

<table>
<thead>
<tr>
<th>Health Status</th>
<th>Health-Care Outcomes</th>
<th>Health-Care Utilization and Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life expectancy</td>
<td>Mortality rate for stroke</td>
<td>Immunization for influenza, aged 65 and over (“flu shot”)</td>
</tr>
<tr>
<td>• for overall population</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• by income</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infant mortality</td>
<td>Mortality rate for acute myocardial infarction (AMI)</td>
<td></td>
</tr>
<tr>
<td>Low birth weight</td>
<td>Mortality rate for prostate cancer</td>
<td></td>
</tr>
<tr>
<td>Incidence rate for lung cancer</td>
<td>Mortality rate for lung cancer</td>
<td></td>
</tr>
<tr>
<td>Incidence rate for prostate cancer</td>
<td>Mortality rate for breast cancer</td>
<td></td>
</tr>
<tr>
<td>Incidence rate for breast cancer</td>
<td>Mortality rate for colorectal cancer</td>
<td></td>
</tr>
<tr>
<td>Incidence rate for colorectal cancer</td>
<td>Potential years of life lost (PYLL) due to suicide</td>
<td></td>
</tr>
<tr>
<td>Self-reported health</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body mass index</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIDS incidence per million population</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: The Conference Board of Canada.
between urban and rural populations. While the mean of two jurisdictions may be similar, there could in fact be a very wide distribution of health conditions at play in one jurisdiction and little variance in another. Thus, a major disadvantage of the mean is that it is sensitive to outlying points.

Despite the difficulties, there is value in benchmarking. These comparisons offer potential to consider alternative options, an opportunity for mutual learning, reconsideration of policies, cross-fertilization, or even policy transfer where appropriate.  

1 Nolte et al., *Investing in Health: Benchmarking Health Systems.*

---

**Table 2**

International Health Performance

<table>
<thead>
<tr>
<th>Overall Ranking</th>
<th>Gold</th>
<th>Silver</th>
<th>Bronze</th>
<th>n.a.*</th>
<th>Weighted Count</th>
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<td>45</td>
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<td>4</td>
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<tr>
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*n.a.= data unavailable

Source: The Conference Board of Canada.
APPENDIX B

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APPENDIX C

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