



## Measuring the Level and Determinants of Health System Efficiency in Canada

Factors Influencing Health



Canadian Institute  
for Health Information

Institut canadien  
d'information sur la santé



## Our Vision

Better data. Better decisions.  
Healthier Canadians.

## Our Mandate

To lead the development and maintenance of comprehensive and integrated health information that enables sound policy and effective health system management that improve health and health care.

## Our Values

Respect, Integrity, Collaboration,  
Excellence, Innovation

# Table of Contents

Acknowledgements.....	iii
Summary.....	v
Introduction .....	1
Description of Methods .....	3
Estimating Efficiency Through DEA .....	3
Description of Data .....	6
The Unit of Analysis: Health Regions.....	6
Health System Output: Reduction of PYLL From Treatable Causes of Death.....	7
Health System Inputs: Five Major Components of Spending.....	8
Health System Inputs: Environmental Adjustors .....	12
Summary of Input and Output Data .....	12
Factors That May Affect Health System Efficiency .....	13
Results .....	14
Discussion.....	17
Limitations and Future Research .....	19
Conclusion .....	20
Appendix A: Measuring the Dollar Value of Patient Flow for Hospital Care .....	23
Appendix B: Estimating Physician Spending in the Health Regions .....	25
Estimating Alternative Payments .....	25
Estimating Patient Flow.....	25
Appendix C: Description of the Variables Included in the Second Stage of Analysis .....	27
Appendix D: Measuring the Robustness of the DEA Estimates Across Different Model Specifications .....	29
Appendix E: A Description of the CMDDB's Coverage .....	31
References.....	33



# Acknowledgements

The Canadian Population Health Initiative (CPHI), part of the Canadian Institute for Health Information (CIHI), wishes to acknowledge the many individuals who were involved in developing this report. The core project team was made up of Sara Allin, Diana Ridgeway, Li Wang, Erin Graves, Jean Harvey and Jeremy Veillard, in ongoing consultation with **Michel Grignon**, Director, Centre for Health Economics and Policy Analysis, and Associate Professor, McMaster University.

We would like to acknowledge and thank the peer reviewers who provided valuable feedback to improve the content of the report:

**Peter Smith**, Professor of Health Policy, Imperial College Business School and Centre for Health Policy, London, England

**Isabelle Joumard**, Senior Economist, Public Economics Division, Economics Department, Organisation for Economic Co-operation and Development

**Audrey Laporte**, Associate Professor of Health Economics, Institute of Health Policy, Management & Evaluation, University of Toronto

**Claudia Sanmartin**, Chief and Senior Researcher, Health Analysis Division, Statistics Canada

We also benefited from feedback from and discussion with teams of economists and analysts at the provincial ministries of health led by **Martha Burd**, B.C. Ministry of Health; **Justin Peffer**, Ontario Ministry of Health and Long-Term Care; **Mike Joyce**, Nova Scotia Department of Health and Wellness; **Kathleen Peterson**, Saskatchewan Ministry of Health; and **Andy Bhamra**, Alberta Health. Also we are grateful to the Institute for Clinical Evaluative Sciences, in particular to **Rick Glazier**, **Peter Gozdyra** and **Sue Schultz** for sharing their insights and some aggregate data with us.

We would like to acknowledge and thank other CIHI staff members who provided strategic and data support: Anyk Glussich, Kate Millar, Emily Wilkins, Adam Rondeau, Walter Feeney, Katerina Gapanenko, Keith Denny, Christopher Kuchciak, Ruolz Ariste, Claude Lemay, Jordan Hunt, Kathy Lee, Sam Herold, Sunita Karmakar-Hore, Pierre Léveillé, Greg Zinck, David Paton and Kira Leeb. In addition, for quality assurance coordination and support, we wish to acknowledge Annie Sebold, Karen Weir, Nicole Slunder and Allison Lesk.

Finally, we are grateful to John Wright, CIHI's Board of Directors, the CIHI Advisory Council on Population Health and the NHEX Expert Advisory Group for their guidance in helping to shape the direction of this report.



# Summary

In recent years, public discourse on the performance of the Canadian health system has shifted from increasing the available resources to making better use of those resources. The goal of this study is to measure health system efficiency in Canada and to examine the factors that help explain variations in estimates of efficiency across the health regions. Here, the term “health system” refers to all activities under the jurisdiction of provincial and territorial ministries of health.

This study uses data envelopment analysis (DEA) to estimate efficiency at the regional level and then undertakes exploratory statistical analysis to examine the factors related to variations in health system efficiency. To determine the health system’s objective against which efficiency is measured, a scoping review of official statements of health system objectives, a series of stakeholder consultations and a dialogue among health system leaders were carried out. The health system’s objective is for Canadians to have access to timely and effective health care when they are sick or need care. In the current study, this objective was measured as the reduction in potential years of life lost (PYLL) from treatable causes of death. The health system resources used to achieve this objective were measured as the five major components of health spending: hospitals, physician services, pharmaceuticals, residential care facilities and community care.

In addition, to ensure that only those health systems operating in similar environments were compared, three key environmental factors were included as inputs in the analysis. These factors included a population measure of education, the proportion of the population who immigrated to Canada within the last 10 years and the proportion of the population who did not identify as Aboriginal persons.

There are possible efficiency gains for all regions in Canada as their efficiency is estimated to be, on average, between 0.65 and 0.82. This means that if all regions were perfectly efficient, between 12,600 and 24,500 premature deaths could possibly be prevented in Canada.

Results from the multivariate analysis of the efficiency estimates at the regional level suggest that gains in efficiency could potentially come from targeted improvements to modifiable risk factors and their causes, and from improved health care services management and organizational practice.

Specifically, the main factors that had statistically significant associations with efficiency included the following:

- Indicators of potentially missed prevention opportunities (prevalence of smoking, obesity, physical inactivity and chronic conditions);
- Hospital readmission rates; and
- Operational factors, including investment in primary care and the length of stay among patients designated as alternate level of care.

The results also suggest that some contextual factors are important: equitable access to physician care is positively associated with efficiency, while a higher average income of the population is negatively associated with efficiency.

In total, the included factors explain almost 50% of the variation in efficiency estimates. The unexplained 50% variation could be driven in part by clinical practice variations and in part by population or patient characteristics that could not be measured.

Overall findings from the analysis of regional variations in the level of efficiency suggest that there is room for improvement for all regions. The findings also suggest that system inefficiencies cannot be addressed solely by targeting management and organizational practices. Moreover, there may be some value in expanding the horizons of the efficiency agenda to include greater attention to the modifiable risk factors: smoking, physical inactivity and the other important causes of chronic diseases.

In addition, findings from the measurement of efficiency (the DEA) have implications for the design of provincial and regional funding formulas. Regional variations in the amount of resources needed to achieve their objectives can result from environmental and population characteristics.



# Introduction

There is great interest in Canada and other countries in ensuring that health system resources are used effectively. Improving health system efficiency is seen as one way to ensure its sustainability.<sup>1</sup> Efficiency reflects the extent to which health system objectives are met, given the resources invested in the system.<sup>2</sup> In the wake of the recent economic downturn, efforts to ensure that resources are used so they achieve the best possible performance are especially timely, given the tight budget constraints faced by health system managers. In this study, the health system includes all activities under the jurisdiction of provincial and territorial ministries of health.

Measuring health system efficiency has been the focus of several high-profile international studies. In 2000, the World Health Organization (WHO) conducted a comprehensive analysis of health system efficiency across all 191 member states.<sup>3</sup> This analysis stimulated a flurry of dialogue around health system performance measurement, including its methodological and conceptual challenges.<sup>4</sup> The WHO analysis looked at the efficiency with which the health system achieved the aggregate of five performance objectives: average level of health status, inequalities in health status, responsiveness, inequalities in responsiveness and fairness of financial contribution.<sup>3</sup> Canada ranked 30 out of the 191 countries in this study. Canada was also part of an Organisation for Economic Co-operation and Development (OECD) study that compared different approaches to measuring efficiency using one common approach in the literature, data envelopment analysis (DEA). Canada ranked 14 out of 30 OECD countries, a ranking that suggests life expectancy could be increased by nearly two years and amenable mortality could be reduced by about 20% if the health system was performing optimally.<sup>5</sup>

International studies provide insight into the potential gains to be realized with improvements in efficiency. However, given the provincial and, increasingly, regional responsibilities for health system delivery and administration in Canada, it is important to examine efficiency at the regional level within Canada.<sup>6</sup> Therefore, in 2012, the Canadian Institute for Health Information (CIHI) developed a model for measuring health system efficiency.<sup>6</sup> CIHI undertook a scoping review of official statements of health system objectives and conducted in-depth interviews with senior health ministry officials to understand their views regarding inputs to and objectives of the health system.<sup>7</sup> Another set of health sector decision-makers and stakeholders took part in a facilitated dialogue on health system objectives, boundaries and methods for studying efficiency.<sup>8</sup> Incorporating decision-maker perspectives when developing a model for measuring efficiency helped to ensure that the resulting analyses of efficiency would be relevant and applicable in the Canadian context.

The aim of this project is to build on the qualitative work that CIHI undertook and to develop a made-in-Canada model for measuring health system efficiency by bringing together information on the resources that go into, and the objective achieved by, regional health systems in Canada. The aim of this work is to understand the factors associated with health system efficiency. This study focuses on “technical efficiency,” which tells us the extent to which health systems are achieving their objectives. In the economics literature, these objectives are referred to as “outputs” and resources as “inputs.” Put simply, an analysis of technical efficiency allows us to empirically assess the effectiveness with which inputs are converted into outputs. The questions of whether we are investing the right amount of resources into the health sector and whether the objective that is measured is the most valued by Canadians are not addressed in this study.

Efficiency is a value-neutral concept. Efficiency is not only about managers and professionals working hard and effectively; it also depends on factors beyond their control, those relating to the context in which they work. Many factors can be expected to affect health system efficiency. For instance, the Commission on the Reform of Ontario's Public Services examined characteristics of government service delivery and developed a comprehensive set of recommendations, many of which focused on improving health system efficiency.<sup>9</sup> An Institute of Medicine report on improving the effectiveness and efficiency of the American health system also summarized the main sources of excess costs in the health system.<sup>10</sup>

Broadly speaking, factors that can be expected to affect efficiency may be grouped into two categories: clinical and operational.<sup>11, 12</sup> Clinical factors refer to health care provided that is ineffective, inappropriate or harmful.<sup>12</sup> This category also includes missed opportunities for primary, secondary and tertiary prevention,<sup>10, 13</sup> which relate to the notion that health gains could be achieved with lower-cost interventions.<sup>11</sup> Operational factors indicate effective yet high-cost care that relates, for example, to services that could be provided as effectively by lower-cost providers or in settings that are less capital-intensive.<sup>11, 12</sup> These two categories of inefficiency provided some direction when selecting indicators to be included in an empirical analysis of the determinants of efficiency. (See the section Description of Data below for more details on the indicators selected for this study.)

Empirical studies that have analyzed health system efficiency have limited comparability, as they use different input measures, output measures and methods.<sup>14</sup> However, some general patterns can be observed, such as the finding that population risk factors that may in part reflect missed prevention opportunities—such as the prevalence of obesity, smoking, poor diet and alcohol consumption—are negatively associated with efficiency.<sup>15, 16</sup> There is also some evidence that provider payment models, patient cost-sharing and spending on administrative activities affect efficiency.<sup>17, 18</sup>

The empirical literature has also found associations between socio-economic conditions and efficiency both across and within countries' health systems.<sup>15–17</sup> In other words, while efficiency is influenced by the choices and effectiveness of relevant system managers, there may also be factors beyond their control in the external environment where a health system is located and that may facilitate or hinder the successful use of resources.<sup>2</sup> Therefore, to be consistent with other studies,<sup>3, 5, 19, 20</sup> the efficiency estimates produced here were adjusted for some of these environmental constraints that vary across regions and that may affect health systems' ability to achieve their objectives.

Building on that literature, this study measures the average efficiency of health systems in Canada's health regions and examines the factors that can help explain variations in estimates of efficiency.<sup>i</sup> The report is organized as follows. The next section describes the methods and data that were used. This is followed by the Results section and, finally, the Discussion and Conclusion sections in which the implications and limitations of this study and options for future research are presented.

---

i. There are 101 health regions in Canada (Prince Edward Island is considered one region), but this study includes only 89 regions in the 10 provinces due to data availability. Because of lack of data, this study excludes the three territories and three regions in Quebec: regions 2410 (Région sociosanitaire du Nord-du-Québec), 2417 (Région sociosanitaire du Nunavik) and 2418 (Région sociosanitaire des Terres-Cries-de-la-Baie-James). In addition, for some small regions, Statistics Canada releases indicators for only a larger region that combines smaller regions. More information is provided in the sections Description of Data and Results. The complete list of health regions is available on [Statistics Canada's website](#).

## Description of Methods

A DEA approach was used to calculate robust estimates of efficiency at the regional level.<sup>21</sup> DEA is a non-parametric method that relies on linear programming to calculate the maximum achievable system output for every level of input (as depicted by the curved line in Figure 1, the “frontier”). These estimates were then used to identify the factors that help explain variations in efficiency. The software package Frontier Efficiency Analysis with R (FEAR 1.0) was used to carry out the DEA estimations;<sup>22</sup> Stata 11.0 was used for the second-stage regression.

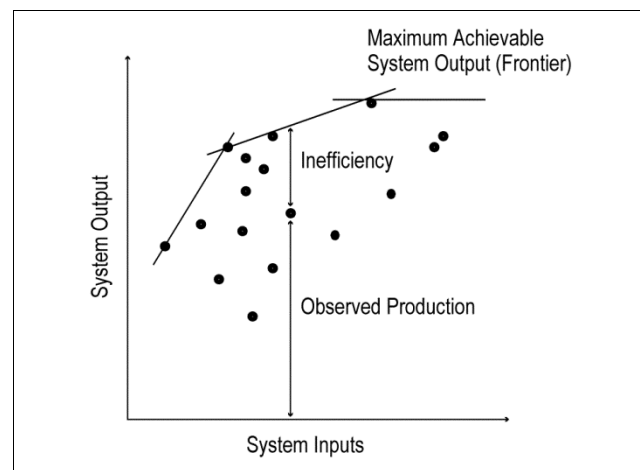
### Estimating Efficiency Through DEA

DEA is one of the most common approaches to measuring efficiency in the health sector.<sup>14, 23</sup> It is considered a flexible approach because, unlike parametric approaches, it does not require the estimation of a functional relationship between the inputs and outputs, nor any of the model testing needed with statistical techniques. This descriptive approach is based on the following notion: if one health region can produce more output than another when both have the same level of inputs, the latter is not efficient. More specifically, a region is inefficient to some extent if a linear combination of two other regions that would use the same level of inputs can produce more output.<sup>2</sup>

A number of different decisions need to be made in a DEA.<sup>2</sup> The first is whether to assume constant or variable returns to scale. Constant returns to scale means that each unit of input produces the same (constant) number of units of output. Graphically, the frontier is a straight line. Diminishing returns to scale means that each additional input unit is less productive than the previous one. The assumption of variable returns to scale (VRS) is considered appropriate for analysis in the health sector, in part because there are evident diminishing marginal returns (adding more resources increases output by less) when one examines the relationship between spending on aggregate and health outcomes.<sup>24</sup> In addition, a constrained VRS frontier must be used when ratio data (such as spending per capita) is included in the model.<sup>25</sup>

The second decision is whether the interest is in maximizing outputs or minimizing inputs (containing costs). Maximizing outputs means producing the maximum amount of output from a given amount of input. Minimizing inputs aims to produce a given output with the minimum amount of input.<sup>14</sup> In this study, we are concerned with maximizing output based on the assumption that ministries of health want to get closer to achieving their objectives, given a fixed budget.

Figure 1: DEA Approach to Measuring Efficiency



**Source**

Adapted from Canadian Institute for Health Information. *Developing a Model for Measuring the Efficiency of the Health System in Canada*. Ottawa, ON: CIHI; 2012.

A third decision relates to the set of outputs and inputs, including how to control for factors beyond the control of health system managers that affect their ability to achieve their objectives. With respect to the treatment of these environmental factors, there is no generally accepted methodology.<sup>26</sup> We included three environmental factors (education, proportion of recent immigrants in the population and proportion of non-Aboriginal persons in the population) as inputs in the DEA estimation, consistent with previous studies,<sup>3, 19, 20</sup> and then incorporated the remaining contextual variables in a second-stage analysis (see Description of Data). Including some key environmental variables in the calculation of efficiency estimates means that health systems, when their efficiency was being assessed, were not held responsible for the level of these variables. Health systems were compared only with other health systems operating in similar or more challenging environments.<sup>26</sup>

## Increasing the Robustness of DEA

DEA presents some important methodological challenges that need to be considered.<sup>2</sup> The two main ones are that DEA is sensitive to high-performing outliers<sup>27</sup> and that it attributes the entire gap between the frontier and observed achievement to inefficiency; there is no allowance for random error.<sup>28</sup> Smith and Street note further that additional challenges arise due to the lack of tests to identify whether the DEA model is specified correctly. We address the last item to some extent through sensitivity analyses.<sup>27</sup>

To address the first challenge relating to possible bias arising from the presence of outliers, we applied a statistical outlier detection method.<sup>29</sup> This approach essentially drops one observation from the sample at a time; if the results are robust to its exclusion, this observation is not considered an outlier.

To address the second challenge, we introduced a random component into the analysis with a type of re-sampling method<sup>ii</sup> designed specifically for DEA. The assumption underlying this approach is that the distance between a region and the efficiency boundary (frontier) can indicate both noise (random error or bias) as well as inefficiency. Noise is due to the fact that the observed data on inputs and/or outputs is itself measured with error. In addition, random events (for example, the cost of a major hospital renovation in a given area) can affect some specific health systems at the time of measurement.<sup>28</sup> We used the smoothed bootstrap method,<sup>30</sup> a technique that corrects the estimates of efficiency for random noise and that has been applied in other studies of health system efficiency.<sup>20</sup> This approach allows the calculation of bias-corrected estimates of efficiency (hereafter referred to as robust estimates) and the calculation of confidence intervals around those estimates. Smith notes that a well-specified DEA model will overestimate efficiency;<sup>31</sup> therefore, robust estimates are consistently lower than point estimates.

---

ii. This method is described in the DEA literature as “bootstrapping,” which is somewhat of a misnomer. Typically, bootstrapped estimators will generate a confidence interval around an estimator. Here, the goal is to modify the estimator itself. The method applies the idea of re-sampling to bootstrapping, hence the name.

Further assurance of the robustness of results obtained from the DEA analysis can be gained through a series of separate sensitivity analyses. To test the sensitivity of the results to alternative specifications, the mean robust estimates and standard deviations were compared. In addition, correlations across analyses were calculated between the (robust) efficiency estimates of health regions and their rankings in terms of the (robust) efficiency estimates.<sup>2</sup> Details of the specific sensitivity analyses are provided in the Results section.

## Analysis of Factors Affecting the Robust Estimates of Efficiency

Once the robust estimates of efficiency were generated for each region, we then conducted a multivariate analysis to examine the relationship between efficiency and the factors that were expected to be associated with efficiency, based on the literature. There is no generally accepted methodology for incorporating environmental factors into analyses of efficiency.<sup>26</sup> In this study, we incorporated three key environmental factors as inputs in the DEA model to ensure that only health systems operating in similar environments were compared.

This type of two-stage analysis is widely used.<sup>32</sup> However, it has been criticized on the grounds that the efficiency estimates entered as the dependent variables in the second stage are “serially correlated” and thus violate conventional regression assumptions.<sup>32, iii</sup> Hence this approach can be considered exploratory rather than conclusive,<sup>2</sup> as there is a risk that the tests of statistical significance may not be accurate.

A backward step-wise regression was used to select variables to be included in the second stage, since there are more variables of interest than would be permitted with the sample size in this study. The logarithm of the robust efficiency estimates was the dependent variable. Results were also compared with a forward step-wise regression, and results were largely unchanged. The final regression model included only those variables with statistically significant associations with efficiency estimates using a criterion of a p-value less than 0.2, which is within the range recommended for studies with a relatively small sample.<sup>33</sup> Finally, conventional tests for any possible violations of the regression assumptions were undertaken. These included scatter plots of residuals (to detect the magnitude of serial correlation), tests for homoscedasticity (as a special case of serial correlation where the random term correlates with the dependent variables) and variance inflation tests for multicollinearity among the independent variables (the factors entered in the regression are too closely related to each other, making the estimated coefficients unreliable).

---

iii. Among the set of assumptions necessary for a linear regression to be valid is the requirement that the dependent variable (in our case, efficiency scores calculated in the first stage) be the result of a deterministic relationship with the explanatory factors (this relationship is the estimated linear model) and a random component drawn independently from the same probability distribution. The key word here is “independently”; because the efficiency scores generated in the first stage are not independent across regions (the score of Region A depends on all other regions), it is likely that the random component is not independent across regions. This is called “serial correlation” and the consequence is that the regression cannot provide reliable estimates of the variance of estimated coefficients. As a result, tests of statistical significance (whether a coefficient is different from 0) are not reliable.

## Description of Data

This section describes the data that was used in this analysis of health system efficiency. Specifically, it describes the components of CIHI’s proposed model of efficiency:<sup>6</sup>

- The unit of analysis;
- The objective that health systems aim to achieve;
- The inputs that health systems possess in order to achieve that objective; and
- The factors that may affect the ability of health systems to turn resources into valued outputs.

To summarize, the unit of analysis is the health region and the output of interest is the reduction of potential years of life lost (PYLL) from treatable causes of death. The inputs include the major components of health spending—hospitals, physician services, pharmaceuticals, residential care facilities and community care—measured in dollars, as well as some key environmental adjusters.<sup>iv</sup> To adjust for possible random fluctuations in spending over time, a three-year average of data was considered, where possible. Also, spending on a per capita basis was measured by dividing the spending data by regional population size.

Where possible, provincial spending (meaning public, even though it is spent at the health region level) was separated from other public and private sources of spending in order to measure the spending over which the provincial ministries of health have most discretion. One exception is with prescription drug spending, of which nearly 40% on average was from provincial and territorial funds in Canada in 2012.<sup>34</sup> The provincial ministries of health have a range of programs that provide public coverage for prescription drugs for some population groups that are defined, for example, by income or age.<sup>35</sup> This analysis considered total spending, both public and private, on prescription drugs. The analysis recognized that health system managers do not control the volume of drugs prescribed or dispensed but that these are important inputs into health systems’ ability to achieve their objective.

### The Unit of Analysis: Health Regions

Health regions are administrative bodies legislated by provincial ministries of health.<sup>36</sup> They tend to be defined by geographical areas and are generally responsible for maintaining the health of their respective populations and for providing health services to residents. The legislated roles of health regions and their relationship with local hospitals and other providers vary from province to province.<sup>36</sup> Decision-making is often shared between provinces and regions. However, for the purpose of this study, the health system was defined at the sub-provincial level for two reasons: first, the number of provinces is too few for meaningful empirical analysis; and second, there are variations across regions in terms of the populations they serve, the range of resources that are available and the innovative practices they adopt to coordinate and plan services for their populations.<sup>36–38</sup>

---

iv. These decisions were informed by interviews and deliberation with senior federal, provincial and territorial health system stakeholders and were described in detail in a previous CIHI report.<sup>6</sup>

## Health System Output: Reduction of PYLL From Treatable Causes of Death

The results of interviews with senior decision-makers and a facilitated stakeholder dialogue suggested a good deal of agreement across provinces regarding the objective of the health system against which we should measure efficiency: ensuring that Canadians have access to effective care when they are sick or need care.<sup>6-8</sup> Stakeholders acknowledged that the health system in Canada also aims to improve overall population health but that this objective is influenced by many factors beyond the direct responsibility of the health system.

In this study, the objective of ensuring access to care for Canadians when they need it was measured by the reduction of PYLL from treatable causes of death (henceforth referred to as treatable PYLL). Underlying this choice of output measure is the assumption that Canadians should not die prematurely from causes of death considered treatable by the health system when they have access to effective care when they are sick or need care.<sup>39</sup> Some examples of treatable causes of death include sepsis, pneumonia, colorectal cancer, breast cancer in women, hypertensive diseases, asthma and most other respiratory diseases, renal failure, pregnancy and childbirth.<sup>40</sup>

Treatable PYLL measures the additional years a person would have lived if he or she had not died before a specified age (80 years, in this case) from a cause of death considered treatable by the health system. In practice, this means that a person who died at age 25 from a treatable cause of death would have lost 55 potential years of life. These values of the difference between the actual age of death and age 80 are then summed over the population and divided by the population count. The earlier the age at which death occurs, the larger the PYLL value and the greater the loss of years of life.<sup>39</sup> In Canada, premature deaths are currently reported based on deaths occurring before age 75. We tested the sensitivity of the results to different age cut-offs (ages 75 and 85), and the results remained relatively unchanged. (For more details, see Results and Appendix D.)

Rates of PYLL per 100,000 population from 2007 to 2009 were age-standardized.<sup>41</sup> They were also transformed by taking the inverse of PYLL ( $1 / \text{PYLL} \times 100,000$ ) to ensure that, all other things being equal, increased inputs should reduce efficiency and increased outputs should increase efficiency.<sup>2</sup> The sensitivity of this particular transformation was tested against another option, subtracting the observed value by a large number.

An alternative measure for treatable PYLL is the age-standardized mortality rate (ASMR) from treatable causes of death. The main difference between these measures is that, while PYLL places greater weight on deaths among younger people than among older people, the ASMR gives exactly the same weight to each death. A sensitivity analysis tested the robustness of the results to the choice of PYLL or ASMR, which would not be expected to have a meaningful impact on the results, given that they are highly correlated with a correlation coefficient of 0.88 across the study's sample of health regions.

## Health System Inputs: Five Major Components of Spending

Health system inputs include the major components of health spending (hospitals, physician services, pharmaceuticals, residential care facilities and community care), measured in dollars.<sup>v</sup> Spending data was assigned to regions using the May 2011 version of the Postal Code Conversion File (PCCF) produced by Statistics Canada.<sup>42</sup>

Table 1 provides a summary of the data sources, the time period for which the data was available, and some key exceptions and limitations. Contributions of this work have been to

- Gather quantitative evidence from a wide variety of sources (federal, provincial, private, administrative and survey-based) on health spending at the regional level;
- Compare sources of evidence on the basis of their accuracy and ability to provide reliable estimates at the regional level; and
- Determine gaps in our empirical knowledge that would help us gain a better understanding of the health system in Canada and its performance.

This work will therefore assist analysts in carrying out regional comparisons or studies of the health system in Canada.

**Table 1: Summary of the Spending Input Data Sources and Limitations**

Input Category	Data Source	Year	Exceptions/Limitations
<b>Hospitals</b>	Canadian MIS Database (CMDDB)	2007–2008 to 2009–2010	Quebec regional expenditures are estimated using a Quebec-specific methodology, as hospital and non-hospital expenditures are not disaggregated in the expenditure data that CIHI receives.
<b>Physicians</b>	National Physician Database (NPDB) and Scott’s Medical Database (SMDB)	2007–2008 to 2009–2010	Physician distributions from the SMDB are used to allocate alternative payments to regions for all provinces except Ontario and to allocate fee-for-service payments to regions in Saskatchewan.
<b>Residential Care Facilities</b>	Statistics Canada’s Residential Care Facilities Survey	2008	Data from 2007 and 2009 had a relatively high proportion of missing geographic identifiers.  To ensure comparability across jurisdictions, we include facilities providing all levels of care, including those that provide no medical or nursing supervision.
<b>Community Care</b>	Statistics Canada Census	2006	Earnings of nurses are used to approximate community care spending.
<b>Prescription Drugs</b>	IMS Brogan Canada	2010	Data prior to 2010 was not available.

**Source**

Canadian Institute for Health Information.

v. In total, the data constitutes 80% of the NHEX total provincial spending on average.<sup>52</sup>



This study measures technical efficiency in the production of reduced treatable PYLL but, because inputs are measured in monetary terms, this could be interpreted as a type of cost-efficiency analysis. The difference between cost functions and production functions is that the cost function uses a single measure of inputs (for example, total or average cost) and then models cost as a function of the multiple outputs produced; a production function models a single output as a function of the mix of inputs (as in the case of this study). A production function defines inefficiency as output that falls short of that predicted by the production function. A cost function defines inefficiency as the extent to which an organization's costs exceed those predicted by the cost function.

## Hospitals

Total hospital expenditures were measured at the organization level (for example, a hospital or group of hospitals under a parent organization) using CIHI's Canadian MIS Database (CMDB). In the CMDB, a hospital is broadly defined as "an institution where patients are accommodated on the basis of medical need and are provided with continuing medical care and supporting diagnostic and therapeutic services and which is licensed or approved as a hospital by a provincial government or is operated by the government of Canada."<sup>44</sup> All provincially administered health service organizations are included in the CMDB; institutions such as federal and military hospitals do not report to the CMDB.

The variables and concepts associated with the CMDB are based on the *Standards for Management Information Systems in Canadian Health Service Organizations* (MIS Standards).<sup>44</sup> Hospital expenditures were grouped by region and then adjusted by deducting research expenses to better isolate provincial spending on operating expenses.

It is also possible to isolate annualized hospital capital expenses, including equipment and building expenses. However, there are some limitations to the measurement of capital expenses in the CMDB, including differences in capitalization thresholds and inconsistencies in adhering to the MIS Standards across regions (for example, differences in how facilities divide spending between capital and operating expenses). Therefore, no adjustments were made for capital expenses.

Hospital expenditures net of research expenditures were then adjusted by the estimated dollar value of patient flow across regions using a modified version of CIHI's indicator of patient flow, the inflow–outflow ratio.<sup>40</sup> The existing indicator was modified to take into account the Resource Intensity Weight (RIW) of each separation as well as the average cost per RIW in the health region where care was delivered. In summary, health regions with inflow–outflow ratios greater than 1 had their per capita spending estimates adjusted downward to account for the fact that these regions had a net inflow of patients (see Appendix A).

## Physicians

Physician spending includes total clinical payments to general practitioners (GPs) and specialists from CIHI's National Physician Database (NPDB). Payments include both fee-for-service (FFS) payments and alternative (non-FFS) payments. Alternative payments represented approximately one-quarter of total payments in 2009–2010, and the share varied across Canada (from 14% in Alberta to 45% in Nova Scotia).<sup>45</sup> Although it is not as straightforward to allocate alternative payments to health regions as it is for FFS payments, not including alternative payments as inputs would bias the estimates of efficiency across regions.

FFS payments are available at the physician practice level and were allocated to health regions based on geographic identifiers. For all but three provinces (Quebec, Alberta and Saskatchewan), a six-digit postal code was available.<sup>vi</sup> Some of the payments for Quebec and Alberta were assigned to health regions based on the forward sortation area (FSA) in Quebec and census metropolitan area or census agglomeration (CMA/CA) in Alberta. Where a CMA/CA or FSA mapped to more than one health region, the payments were not assigned to a health region.<sup>vii</sup> The remaining payments without sufficient geographical information were allocated to regions proportionally, based on the supply of GPs and specialists in the region. Counts of GPs and specialists by region and year were taken from Scott's Medical Database (SMDB).<sup>46</sup> Payments made by one province for services that occurred in a different province were excluded.

Total alternative payments are available at the provincial level only. Alternative payments include salaried payments, capitation and block funding.<sup>45</sup> Total provincial alternative payments<sup>45</sup> were allocated to regions proportionally, based on the physician supply in that region using data from the SMDB.<sup>46</sup> For the two provinces where alternative payments are not separated by physician specialty (Alberta and Nova Scotia), the average distribution of payments to GPs and specialists in the other eight provinces<sup>viii</sup> was used to impute provincial spending on GPs and specialists.

Finally, the total regional specialist spending (combined FFS and alternative payments) was adjusted by patient flow using the inflow–outflow ratio, weighted by the intensity of the acute case (see Appendix A). This was based on the assumption that specialists work in hospitals and therefore experience the same net patient flow as hospitals. Without information on the flow of patients for primary care, adjustments could not be made to GP payments for cross-region flow. (See Appendix B for a discussion of some of the methodological issues with estimating physician spending.)

---

vi. In provinces with complete geographical information (B.C., Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario and P.E.I.), the proportion of payments that we were not able to map to a health region ranged from 0.02% to 1.99% for GPs and from 0.03% to 4.11% for specialists.

vii. Of physician payments, 8% could not be mapped to health regions in Quebec, 84% in Alberta and 100% in Saskatchewan.

viii. On average, alternative payments to GPs represented 60% of total alternative payments to physicians.<sup>45</sup>

## Residential Care Facilities

Using Statistics Canada's Residential Care Facilities Survey, total spending on residential care facilities by provincial health insurance plans was estimated. These facilities include the following:<sup>47</sup>

- Homes for the aged, including nursing homes and other facilities that provide services and care for the aged (but excluding homes where care was not provided);
- Facilities for persons with mental disorders such as developmental delays, psychiatric disabilities, and alcohol or drug problems; and
- Other residential care facilities, including for persons with physical disabilities.

For each facility, the proportion of total income for accommodations that came from the provincial insurance plan was calculated. The proportion was then multiplied by the facility's total expenditures. This method was used to estimate expenditures for operating and maintaining the facility, excluding capital costs.

## Community Care

The earnings of nurses working in the community were used as a proxy for regional spending on community care. The Labour Market Activities and Income modules of the 2006 Census were used to measure total earnings of individuals who selected "registered nurses" as their occupation, based on the job at which they had worked the most hours. Those working in offices of dentists, hospitals, and nursing and residential care facilities were excluded. For each region, we calculated total spending on nurses on the basis of income reported on the long-form census or from income tax files (for those respondents who gave permission for their income tax files to be accessed).

This approximation of community care spending is imprecise and, therefore, there are some limitations worth noting. Without information on the geographical location of nurses' employment, earnings were allocated to health regions on the basis of the nurses' postal code of residence. One limitation with this approach is that it does not account for the possibility that nurses' places of employment may be located outside their region of residence. Another limitation with this data is that the income estimates from the census might have included wages, salaries and self-employment income for non-health-service-related work.

## Prescription Drugs

Regional estimates of total spending on prescription drugs outside hospitals are from IMS Brogan Canada. IMS Brogan assigned expenditures to health regions based on community pharmacy postal codes using the May 2011 PCCF. These estimates were projected, based on data from approximately 82% of the total dispensed prescriptions nationally (the coverage ranges from 60% in Newfoundland and Labrador to 94% in Quebec). IMS Brogan receives data from a panel of more than 5,800 retail pharmacies and uses a geospatial methodology to estimate the data for non-panel pharmacies. The methodology is supplemented by public and private claims data that IMS Brogan collects. The estimation of prescription drug spending at the regional level is based on the location of pharmacies, not patients.

## Health System Inputs: Environmental Adjustors

There are significant variations in socio-economic and population characteristics across Canada's health regions.<sup>36, 37</sup> It has been documented in the literature that these factors are important in explaining variations in efficiency.<sup>15-17</sup> While there is no accepted method of accounting for these environmental characteristics in efficiency analyses, a set of environmental adjustors was included as inputs in the first stage of the analysis—the calculation of efficiency estimates with DEA. These adjustors were selected, based on a review of the literature and a regression analysis with the output (treatable PYLL) as the dependent variable.

The environmental adjustors were included in the calculation of DEA estimates on the basis that, although they can be considered outside the responsibility of health systems, they significantly reduce treatable PYLL. The adjustors included the proportion of the population age 25 to 29 who have a secondary school graduation certificate or equivalent, the proportion of the population who immigrated to Canada within the past 10 years<sup>48</sup> and the proportion of the population who were not Aboriginal persons.<sup>49</sup> In other words, regions with a better-educated population, a greater concentration of recent immigrants and a smaller concentration of individuals identifying as Aboriginal persons have, on average, lower rates of treatable mortality, which is consistent with the literature. These three measures were based on self-reporting in the 2006 Census.<sup>50</sup>

Given the relatively small sample size for this analysis, we needed to limit the number of input variables included in the model to ensure reliable efficiency estimates. Since there is no way to know which is the best model, sensitivity analyses including one, two and three of the environmental adjustors were conducted and results obtained from these alternate models. Since not all characteristics of the environment that the literature suggests may be associated with efficiency could be included as inputs in a DEA, a set of contextual factors was included in a second stage of the analysis. (Appendix C lists all variables included in the second stage of analysis.)

## Summary of Input and Output Data

Table 2 describes the input and output variables used in DEA, based on the sample of 84 regions. Five outliers were dropped, based on the statistical outlier testing: Region 5, New Brunswick (1305); Burntwood/Churchill, Manitoba (4685); Heartland, Saskatchewan (4707); Mamawetan/Keewatin/Athabasca, Saskatchewan (4714); and Richmond, British Columbia (5931). These outliers were consistent across all seven model specifications. Four of the statistical outliers had very small populations (fewer than 50,000 residents); therefore, there may be imprecision in the input and output estimates for these regions. In the fifth region, Richmond, B.C., there were nearly 200,000 residents in the time period of the study, so the input and output measures are likely to be measured precisely; however, this region instead appears to be a high-performing outlier with both low spending and low treatable PYLL.

There is considerable variation in treatable PYLL per 100,000 across the provinces, as shown in the range and standard deviation around the mean. Hospitals represent the largest component of spending in the data set, which is consistent with national estimates.<sup>51</sup> Here again, spending per capita varies across regions.

**Table 2: Description of the Health System Input and Output Variables Used in DEA, Including Environmental Adjustors, 84 Regions**

Inputs: Spending per Capita, \$	Mean	Standard Deviation	Range	
			Minimum	Maximum
<b>Hospitals</b>	1,718.93	520.40	951.32	3,826.39
<b>Prescription Drugs</b>	545.60	123.50	288.53	884.25
<b>Physicians</b>	471.15	122.42	177.01	816.72
<b>Residential Care Facilities</b>	336.42	164.00	74.20	901.83
<b>Community Nurses</b>	54.49	18.51	19.59	98.68
<b>Inputs: Environmental Adjustors</b>				
<b>Education (High School or More) (%)</b>	82.33	6.85	63.30	94.00
<b>Recent Immigrants (%)</b>	3.16	4.21	0.10	16.70
<b>Non-Aboriginal Persons (%)</b>	92.74	9.21	49.50	99.60
<b>Output</b>				
<b>PYLL From Treatable Causes (Before Age 80), per 100,000 Population, Age-Standardized</b>	1,666.34	317.92	1,066.6	2,452.6

**Notes**

Since DEA estimates can be sensitive to the choice of inputs and outputs, analyses were conducted to test the sensitivity to the choice of environmental adjustors included as inputs. The models included one environmental adjustor (education), two environmental adjustors (education and recent immigrants) and the baseline model (all three variables). Analyses were also conducted to test the sensitivity of the DEA estimates to the measurement of system output, including changing the age cut-off for defining premature deaths to age 75 and age 85; calculating the reduction of PYLL by subtracting the observed estimate by a large number (800 million) versus by inverting PYLL as 1/PYLL; and measuring the ASMR from treatable causes of death versus PYLL.

**Sources**

Canadian Institute for Health Information; 2006 Census, Statistics Canada; and Statistics Canada custom calculations.

## Factors That May Affect Health System Efficiency

As summarized in the Introduction, two broad categories of factors affect efficiency: the clinical and the operational.<sup>11, 12</sup> In addition, the empirical literature consistently demonstrates the importance of contextual factors in explaining variations in system efficiency. Table C1 in Appendix C summarizes the clinical and operational factors in this study in the second stage of the analysis, as well as a set of contextual factors that were included in the second stage of the analysis: the distribution of age and gender within the population; physical and geographical characteristics (for example, population density and the presence of a teaching hospital in the region); and socio-economic conditions (for example, income inequality and average income). These contextual factors were not found to be correlated with treatable PYLL in this study, but they have been identified in the literature as correlating with health system efficiency.<sup>6</sup>

Equitable access to care was also included in the second stage of the analysis, as equity is often considered an important objective<sup>6</sup> and one that might affect efficiency. For instance, equity could be achieved to the detriment of efficiency (if too much is devoted to treating vulnerable populations, even though their health may not improve as much as that of the rest of the population), as in the well-known equity–efficiency trade-off. However, it can also be argued that more effective health systems provide more equitable access and, as a result, treat the most

vulnerable who are also those who can benefit the most from interventions. Equity was raised by stakeholders as an important, although not primary, goal of the health system<sup>6</sup> and has also been recognized as a key dimension of health system performance.<sup>52</sup> In this study, we measured the income-related inequity in the likelihood of visiting a physician in the past year, using self-reported income and utilization information from the Canadian Community Health Survey and methods of calculating indices of horizontal inequity.<sup>53</sup> This method yields an index of inequity taking positive values when the higher-income groups use more health care than the lower-income groups for the same level of need. Ensuring equitable access to care could relate to both operational and clinical choices and to characteristics of the environment. In this study, we included this measure of equity among the set of contextual factors that may affect efficiency.

The possible clinical and operational factors are numerous. Based on the examples provided in the theoretical papers,<sup>11, 12</sup> recommendations of the Commission on the Reform of Ontario's Public Services<sup>9</sup> and data availability, a set of indicators was selected to represent these two broad categories.

Clinical factors include rates of hospitalizations for ambulatory care sensitive conditions (ACSCs) and readmissions to hospitals; repeat hospitalizations for mental illness; and rates of Caesarean sections and vaginal births after C-section (VBAC). They also include measures of population health that to some extent reflect missed opportunities for primary and secondary prevention, specifically the current prevalence of smoking, overweight, obesity, physical inactivity and multiple (defined as three or more) chronic conditions.

Finally, operational factors include the investment in primary care (measured in this study as the number of GPs as a percentage of the total number of physicians working in a region) and a series of indicators based on hospital data, including cost per weighted case (CPWC), spending on administration as a percentage of total spending, typical length of hospital stay, alternate level of care (ALC) days as a proportion of total bed days and the length of stay among ALC patients, nursing hours worked per weighted case, and occupancy rates.

## Results

DEA and the smoothed-bootstrapping method generated robust point estimates of efficiency that could then be analyzed to understand the factors that relate to variations in efficiency. Seven different DEA models were run to calculate efficiency estimates, testing the sensitivity of the results to changes in the input and output measures. The robust estimates of efficiency ranged from 0.65 to 0.82 on average across the sample of health regions using these different specifications; the baseline model yielded a robust estimate that averaged 0.73. In practical terms, this means that if all regions were perfectly efficient, between 12,600 and 24,500 premature deaths could be prevented in Canada.

It is important to note that the value of an approach such as DEA is less the extraction of precise estimates of efficiency—which one should report cautiously—than its use as an exploratory analytical tool for further analysis.<sup>2</sup> That said, the robust estimates of efficiency did not appear to be sensitive to changes in model specification. Correlations were high (0.70 to 0.99) among the efficiency estimates produced by the seven models that varied the input and

output variables. Correlation coefficients for the estimates and rankings produced by the seven different models are presented in Appendix D. It is also worth noting that the average efficiency score of 0.73 in health regions in Canada is not far from the 0.80 estimated efficiency found for Canada by the OECD, based on a comparison across countries.<sup>5, ix</sup>

The remainder of this section focuses on understanding the variations in the estimates of efficiency by exploring the clinical and operational factors that are expected to influence efficiency, as well as the contextual factors that may also be associated with efficiency. Many of the clinical and operational factors identified in the literature—such as medical errors, clinical appropriateness, care coordination and expanding scopes of practice (for example, for pharmacists and nurses)—are difficult to measure. However, CIHI calculates several indicators that relate to these two categories.<sup>40, 54–56</sup>

Table 3 reports the results of the multivariate regression of contextual, clinical and operational factors on the robust efficiency estimates produced from the baseline model. Eight variables were selected, based on statistically significant associations with efficiency from the backward step-wise regression. Results from statistical testing and observations of residual scatterplots suggest no violations of the conventional regression assumptions. Appendix C lists all the variables that were considered in this second-stage analysis, as well as the correlation coefficients between each variable and the robust efficiency estimate.

Among the contextual factors, a higher average income of residents in a region was negatively related with efficiency: a 10% increase in average income was associated with a 3% reduction in efficiency. This implies that, in richer regions, there may be more spending on health services that does not necessarily translate into reductions in treatable deaths, after controlling for variations in education, immigrant and concentration of Aboriginal persons (as these were included as environmental adjustors in the calculation of DEA estimates).

There was also a negative association between inequitable access to physician services and efficiency: regions with greater inequity in favour of higher-income groups were less likely to be efficient than regions with a more equitable distribution of physician services. In other words, if lower-income groups are less likely to have visited a physician in the past year than higher-income groups that have comparable levels of health, there may be negative implications for health system efficiency. An increase in pro-rich inequity by 0.1 was associated with a decrease in efficiency of 16%. Health system managers therefore do not need to trade off equity for efficiency; these results suggest that they can improve performance by improving access to care for people with lower income.

Three of the four clinical factors that appeared to be associated with efficiency were those that reflect potentially missed prevention opportunities: the prevalence of key risk factors and multiple health conditions. The results from the regression suggested that an increase in the prevalence of smoking by 10 percentage points would decrease efficiency by 10%; an increase of 10 percentage points in the proportion of the population physically inactive would decrease efficiency by 7%; an increase by 10 percentage points in the proportion of the population with

---

ix. This OECD study used DEA to estimate efficiency, using the avoidable mortality rate as the output and health care spending per capita and a composite indicator of the socio-economic environment and lifestyle factors as inputs. The potential gains in avoidable mortality for Canada were estimated to be 20%, indicating an efficiency estimate of 0.8.

multiple chronic conditions would decrease efficiency by 12%. The overall rate of unplanned readmissions to hospital within 30 days was also inversely related to efficiency: an increase of 10 percentage points in the rate of 30-day readmissions per 100 patients was associated with a reduction in efficiency of 19%.

Operational factors associated with efficiency included the relative density of GPs in a region compared with specialist physicians (an increase by 10 percentage points in that relative density would improve efficiency by 5%), as well as the average length of stay among patients designated as ALC (an increase of 10 days in the ALC length of stay decreased efficiency by 2%).

By entering the different categories of variables sequentially in separate regression models, it was possible to test the relative contribution of each category to the total variation in efficiency that these variables can collectively explain. However, the order in which these categories are entered will affect the amount of variation explained. We therefore present a range of variations, explained by entering the three categories in all possible orders (see Table 3). These results suggest that contextual factors included here explained between 7% and 14% of total variation in efficiency, clinical variables explained between 14% and 26%, and operational variables explained between 12% and 22% of variation in efficiency. Altogether, these variables accounted for almost 50% of variation in efficiency estimates across regions; the remaining 50% was unexplained with the available data.

**Table 3: Regression Results With Contextual, Clinical and Operational Factors as Predictors of the Log of Robust Efficiency Estimate**

Variables	Coefficient	Standard Error	P> t	Range of R <sup>2</sup> Explained
<b>Contextual Factors</b>				<b>7% to 14%</b>
Average Income (Logarithm)	-0.304*	0.098	0.003	
Inequity in the Likelihood of Visiting a Physician in Past 12 Months	-1.737 <sup>†</sup>	0.862	0.047	
<b>Clinical Factors</b>				<b>14% to 26%</b>
Daily Smoking (%)	-0.010 <sup>†</sup>	0.004	0.015	
Physical Inactivity (%)	-0.007*	0.002	0.004	
Multiple (Three or More) Chronic Conditions (%)	-0.013*	0.004	0.001	
30-Day Overall Readmission (Rate per 100)	-0.021 <sup>†</sup>	0.009	0.028	
<b>Operational Factors</b>				<b>12% to 22%</b>
GPs (% of All Physicians)	0.005*	0.001	0.000	
ALC Length of Stay (Days)	-0.002*	0.001	0.003	

**Notes**

\* Indicates statistical significance at p<0.001 level.

† Indicates p<0.05 level.

**Source**

Canadian Institute for Health Information calculations.



The six other model specifications produced results similar to those reported in Table 3. However, there were some additional variables that appeared to be statistically significantly associated with efficiency using these alternate specifications. These variables included the following: the prevalence of obesity (negatively associated with efficiency); the average CPWC among hospitals in the region (also negatively associated with efficiency); and the total number of nursing inpatient services hours worked per weighted case (found to be positively associated with efficiency in the multivariate model).

## Discussion

The results of this study suggest that there are possible efficiency gains for all regions in Canada; the level of efficiency in Canada lies on average between 0.65 and 0.82. Results of the second-stage analysis suggest that gains in efficiency could potentially arise not only from improved management and organizational practice but also from targeted improvements to modifiable risk factors and their causes. Together, these improvements could potentially prevent between 12,600 and 24,500 premature deaths.

The two-stage approach to measuring and explaining efficiency used in this study allowed us to identify a set of variables that are likely to be important in understanding efficiency. Clinical factors were found to be significantly associated with efficiency, specifically the indicators of successful prevention efforts, including efforts regarding the prevalence of smoking, physical inactivity, obesity, multiple chronic conditions and hospital readmissions. A study of OECD countries also showed that tobacco consumption and obesity were associated with lower efficiency.<sup>16</sup> A case could therefore be made for investing in prevention efforts and better management of chronic diseases on the grounds of the possible improvements in health system efficiency that could result; this is consistent with other recommendations.<sup>9–11</sup>

Furthermore, continued efforts to reduce hospital readmissions, the topic of a recent national conference,<sup>57</sup> could have the effect of increasing the ability of regional managers to improve health, given their fixed budgets. Studies show that readmissions relate in part to characteristics and management practices of hospitals.<sup>58, 59, 60</sup> Readmissions are also affected by coordination efforts and partnerships between hospitals and community care,<sup>61</sup> and by timely and effective follow-up care with a physician.<sup>62</sup>

Some operational factors included in the analysis were also significantly associated with health system efficiency. These included the level of investment in primary care, as well as some of the hospital-based indicators. The number of GPs as a percentage of total physicians in the region is an imperfect indicator of primary care investment, in part because the number of specialists is affected by the presence of hospitals in the region. However, strong primary care is widely recognized as an important determinant of health system performance<sup>63, 64</sup> and is consistent with the policy agenda in many jurisdictions aimed at reforming and increasing investment in primary care that was seen throughout the 2000s.<sup>65</sup>

Among the hospital-based indicators related to efficiency were the ALC length of stay, as well as the CPWC and the number of nursing hours worked per weighted case. This suggests that the continued efforts across jurisdictions to facilitate the discharge of ALC patients (mostly seniors<sup>66</sup>) from hospital to a more appropriate care setting may contribute to efficiency gains at a system level. It is not surprising to see a relationship between higher average costs in hospital and health system efficiency, given that hospitals represent the largest component of health system spending. The finding that more nursing hours per inpatient was positively associated with efficiency suggests that efforts to increase nursing supply in hospitals could have the effect of improving efficiency at a system level.

The results of the study also suggest that there may be efficiency gains associated with more equitable access to physician care. Ensuring equitable access to care is an important element of health system performance,<sup>52</sup> and efforts under way in most jurisdictions to improve accessibility of primary care could go some way toward improving equity as well.

Overall, this study identified some of the key factors associated with health system efficiency; together, the variables included in the analysis explained nearly 50% of the variation in efficiency. In other words, we were not able to explain half of the variation in efficiency that was observed across Canada's health regions. These variations could be driven in part by patient or population characteristics that are not measured, and in part by missing operational and clinical indicators, such as those that could reflect efforts to improve quality and patient safety.

A recent study showed that controlling for socio-economic differences across jurisdictions reduces the potential role for clinical variations in explaining regional variations in health system spending.<sup>67</sup> However, clinical practice variations are still a strong candidate for helping to explain the remaining variations in health system efficiency in this study. Some indicators of clinical variations were included in the analysis, such as regional rates of C-section and VBAC, but these were not significantly associated with efficiency.

The literature suggests that the use of various health care services, such as surgical procedures and diagnostic imaging, varies widely both within and across countries.<sup>68</sup> For example, Canadian studies have reported that regions within a province differed substantially in the rate of surgical procedures such as percutaneous coronary intervention (PCI) for heart attack patients and joint surgery for arthritis and related conditions.<sup>68, 69</sup> Corallo and colleagues, in a systematic review of medical practice variation studies, noted a number of causes of variation that have been suggested in the literature. Some of these were related to "supply-sensitive care"; others were related to patient characteristics such as preferences and participation in decision-making.<sup>68</sup> While it is not possible to empirically test this hypothesis with the available data, it could be a fruitful subject for future research. Additional factors that the Council of the Federation's Health Care Innovation Working Group suggest might help us understand variations in efficiency include the uptake of clinical practice guidelines, such as for cardiovascular disease and diabetes, the use of team-based models of care and the implementation of Lean (continuous improvement).<sup>70</sup>

## Limitations and Future Research

As noted in the Description of Methods section, there are some important limitations with DEA; these were addressed to some extent through sensitivity analyses, DEA-bootstrapping and outlier detection methods. However, there is no approach available to identify whether the DEA model is correctly specified; therefore, results should be interpreted cautiously and are suggestive rather than conclusive.<sup>27</sup> Furthermore, there are some methodological challenges with the two-stage approach of this study that may limit the ability to draw firm conclusions from the results of the regression. However, these approaches are widely used and provide useful information that can help guide future research efforts.

Future studies would benefit from improvements in the availability and comparability of data on spending and health system characteristics. A number of important data limitations make it difficult to measure spending at the regional level. The first relates to the ability to attribute spending in one region to the patients who received those services. In other words, patient- or record-level data is needed to account for patient flow across regions. In the case of hospital care, by linking patient postal code information in the Discharge Abstract Database (DAD) with spending data in the CMDB, we can account for patient flow across regions to some extent (see Appendix A). However, for other sectors, such as physicians, there is information available on the practice location but not on the location where the service was provided. In this study, patient flow for specialist care was estimated using the measure of patient flow for hospitals as a proxy.

The second data limitation relates to the ability to measure spending on non-hospital and non-physician care, such as institutional care, community care and public health. The estimate of community care spending is limited to the earnings of nurses. However, a significant amount of community care is provided by other health professionals, such as personal support workers, and it is likely that the use of nurses relative to personal support workers varies across health regions. In future, CIHI's CMDB will become an accurate and comparable source of spending data in these non-hospital sectors. At present, however, there is limited comparability across provinces for these sectors (see Appendix E).

There are some additional gaps in the data that are important to consider in analyses of health system efficiency. The first relates to the estimates of alternative (non-FFS) payments to physicians, which make up an increasing proportion of total physician payments in Canada.<sup>45</sup> Currently, it is not possible to measure these payments at a regional level, although, in some provinces, there is available data to do these estimations. (See Appendix B for more information.) The timing of data availability also affects analyses of efficiency. This study refers to the 2007 to 2009 time period, as this is the most recent period for which vital statistics data is available. Further research could bring together multiple years of data to examine changes over time in efficiency. Finally, there are likely some areas of spending that are missing from the analysis and that affect health systems' abilities to achieve their objective. For example, the costs of transporting patients from remote regions to urban centres are covered provincially, but there is no available information on the region of residence of the patients who received these services.

Challenges also arise in measuring the objective of the health system. A common critique with mortality-based measures of health is that they do not consider quality of life or morbidity. Measuring the health system objective—to ensure that Canadians have access to timely and effective health care when they are sick or need care—requires information both on the deaths of those with conditions considered treatable by the health system and on the health of those living with treatable conditions. Future work should therefore aim to incorporate a new output measure that combines treatable PYLL with a measure of morbidity related to treatable conditions, using the health utilities index.<sup>71</sup>

There are also limitations in our ability to measure many of the clinical and operational characteristics of health systems that are expected to influence efficiency. While the results of this study are suggestive of some of the key factors affecting efficiency, further research could consider qualitative analysis, such as with the use of case studies, to disentangle some of the processes and factors that can help us gain a better understanding of efficiency. Furthermore, some examples of such factors that are missing from this analysis but are likely to be uncovered through further research include

- The effective processes by which integration and coordination of care across sectors is achieved, for instance, with the use of information technology such as electronic health records to reduce duplication and improve care processes;
- Quality improvement processes such as those to reduce harmful incidents; and
- Expanded scopes of practice (for example, for pharmacists and nurses) to provide care that is more cost-effective.

## Conclusion

The ability of regional health systems to achieve their objective (reducing years of life lost from treatable causes of death) varies with their given level of resources. This variation was observed even though comparisons were made only among health systems operating in similar environments in terms of the level of educational attainment in the region, the concentration of recent immigrants and the number of individuals identifying as non-Aboriginal persons. The results suggest that, if all regions were perfectly efficient, between 12,600 and 24,500 premature deaths could possibly be prevented without incurring additional costs.

Both operational and clinical factors were significantly associated with efficiency in this study. Specifically, the important clinical factors included indicators of missed prevention opportunities and hospital readmission rates, while the operational factors related to investment in primary care and the appropriate use of hospitals. This study also found that equitable access to physician care was positively associated with efficiency, suggesting that the benefits of reducing inequities may extend beyond the experiences of those facing barriers to accessing additional health system gains in terms of improved value for money.

Overall, these findings suggest that system inefficiencies cannot be addressed solely by targeting management and organizational practices. Moreover, there may be some value in expanding the horizons of the efficiency agenda to focus greater attention on the modifiable risk

factors: smoking, physical inactivity and the other important causes of chronic diseases. Finally, these findings have implications for the design of regional and provincial funding formulas, given that regional variations in the amount of resources required to achieve the objective of reducing treatable causes of death are the result of environmental and population characteristics that were adjusted for when estimating efficiency.



## Appendix A: Measuring the Dollar Value of Patient Flow for Hospital Care

For this study, a modified version of CIHI's inflow–outflow ratio indicator<sup>40</sup> was used to adjust regional spending on hospitals for patient flow and the varying cost of delivering care across regions. The modification was done to account for the RIW of each separation and the average cost per RIW at the regional level. Thus hospitalizations that required more resources were weighted more highly when they moved between regions than hospitalizations requiring fewer resources. This methodology also took into account the higher cost of delivering care in some regions using the CPWC.

The ratio is the number of separations (discharges or deaths) from acute care facilities within a given region, multiplied by their CIHI-calculated RIW for each hospitalization and by the average CPWC for the health region where the care was delivered, and then divided by the number of acute care separations generated by the residents of that region, multiplied by their hospitalization-specific RIW and the average CPWC for that region. A ratio greater than 1 indicates that care provided by the region exceeded the average cost for residents of that region.<sup>40</sup> Health regions with inflow–outflow ratios greater than 1 had their per capita estimates adjusted downward to account for the fact that more was spent on treating patients than was accounted for by the dollars spent to treat the geographically defined population.

$$\text{Per capita expenditure} = \frac{\text{Hospital expenditure}}{\text{Region population} \times \text{RIW- and CPWC-adjusted inflow–outflow ratio}}$$

One limitation with this approach to measuring patient flow is that the ratio takes into account the average cost of a hospitalization for a given region instead of the actual cost.





## Appendix B: Estimating Physician Spending in the Health Regions

Two methodological challenges arise when estimating physician spending at the regional level: estimating alternative (non-FFS) clinical payments to physicians at the regional level and measuring patient flow in the absence of record-level data that includes each patient's place of residence.

### Estimating Alternative Payments

In the case of Ontario, it is possible to estimate the distribution of alternative payments to GPs in the regions, which are called local health integration networks (LHINs). Data on the counts of primary care doctors in each primary care model in each LHIN was provided by the Institute for Clinical Evaluative Sciences (ICES). This information was combined with publicly available payment data.<sup>72</sup> The analysis showed that alternative payments to GPs are not proportionally distributed across LHINs; alternative payments are slightly lower than expected, based on the supply of GPs, in the more densely populated LHINs (such as Toronto Central LHIN) and slightly higher than expected, based on the supply of GPs, in the more rural LHINs. Therefore this distribution, instead of the proportional distribution based on the supply of GPs, was used to calculate alternative payments in the Ontario LHINs when estimating per capita physician spending for the efficiency analysis. For all other provinces, however, the proportional distribution method was used.

Data from Ontario also suggests that the proportion of total payments to specialists through alternate payment plans differs according to specialty.<sup>72</sup> However, among the six specialties for which alternative payments constituted more than 25% of total payments (emergency medicine, geriatric medicine, hematology, medical oncology, pediatrics and neurosurgery),<sup>72</sup> their distribution across LHINs was nearly identical to the distribution of all specialists combined.<sup>73</sup> Therefore, the assumption of a proportional allocation of alternative payments to the LHINs based on supply of specialists is reasonable.

### Estimating Patient Flow

Without information in the NPDB on where patients live, it is not possible to estimate patient flow for physicians. In this study, we assumed that the patient flow for specialists is equal to the patient flow for hospital services and therefore adjusted specialist spending by the RIW-adjusted inflow–outflow ratio. However, for primary care physicians, this study assumed no net patient flow. Research at ICES was done to identify informal multispecialty physician networks using health administrative data,<sup>74</sup> which included data on patient flow for primary care across LHIN boundaries that was shared with CIHI. Based on our calculations using this data, it appears that, in three LHINs, between 8% and 10% of patients are coming from another LHIN to access comprehensive primary care from a GP; in one LHIN (3505), it is 17%.



## Appendix C: Description of the Variables Included in the Second Stage of Analysis

**Table C1: Description of Variables That May Affect Efficiency and That Are Included in Second Stage of Analysis, and Correlations With Efficiency Estimates (n = 84)**

Contextual Factors	Year(s)	Mean	SD	Min	Max	Correlation
Men	2006 <sup>a</sup>	0.5	0.01	0.48	0.52	0.11
Population Age 65 and Older	2006 <sup>a</sup>	0.14	0.03	0.08	0.22	0.03
Population Density	2006 <sup>a</sup>	249.08	896.03	0.13	5,679.0	-0.05
Long-Term Unemployment	2006 <sup>a</sup>	4.10	2.85	1.3	16	-0.19
Average Income (\$)	2006 <sup>a</sup>	32,164.27	5,287.72	23,611	50,111	-0.02
Income-Related Inequality in Likelihood of a Physician Visit	2007 and 2008 <sup>b</sup>	0.02	0.01	-0.02	0.05	-0.29*
Income Inequality (Gini Index)	2007 and 2008 <sup>b</sup>	0.26	0.14	0.04	0.65	0.16
No Teaching Hospitals in the Region	FY 2008–2009 <sup>c</sup>	0.80	0.4	0	1	0.26*
Clinical Factors						
Daily Smoking (% of Population Age 12 and Older)	2007 and 2008 <sup>b</sup>	18.78	3.59	10.3	26.6	-0.27*
Obese (% of Population Age 18 and Older)	2007 and 2008 <sup>b</sup>	19.91	5.06	6.3	30.8	-0.31*
Overweight (% of Population Age 18 and Older)	2007 and 2008 <sup>b</sup>	35.65	3.31	23.7	43.7	-0.19
Three or More Chronic Conditions (% of Population Age 12 and Older)	2007 and 2008 <sup>b</sup>	24.34	3.70	16.5	32.2	-0.24*
Physically Inactive (% of Population Age 12 and Older)	2007 and 2008 <sup>b</sup>	49.16	5.85	29.4	61.3	-0.24*
ACSC Admissions per 100,000 Population	FY 2007–2008 to 2009–2010 <sup>d</sup>	415.66	151.74	185.67	880.33	-0.20
Repeat Hospitalizations for Mental Illness (% of Patients With at Least One Hospitalization for Mental Illness)	FY 2007–2008 to 2009–2010 <sup>d</sup>	10.93	2.68	4.1	18.1	0.10
C-Sections (% of Total Births)	FY 2007–2008 to 2009–2010 <sup>e</sup>	23.58	7.04	0	37.36	-0.03

(cont'd on next page)

**Table C1: Description of Variables That May Affect Efficiency and That Are Included in Second Stage of Analysis, and Correlations With Efficiency Estimates (n = 84) (cont'd)**

Clinical Factors	Year(s)	Mean	SD	Min	Max	Correlation
<b>VBAC Rate (per 100 Births)</b>	FY 2007–2008 to 2009–2010 <sup>e</sup>	15.64	7.39	2.97	34.71	-0.01
<b>Overall 30-Day Readmission Rate (% of All Hospital Discharges)</b>	FY 2009–2010 <sup>e</sup>	9.33	1.84	6.24	15.96	-0.02
<b>30-Day Readmissions (Surgical)</b>	FY 2009–2010 <sup>e</sup>	6.72	1.57	1.2	14.12	-0.01
<b>30-Day Readmissions (Pediatric)</b>	FY 2009–2010 <sup>e</sup>	5.54	1.46	1.56	9.44	-0.22*
<b>30-Day Readmissions (Medical)</b>	FY 2009–2010 <sup>e</sup>	13.64	1.64	10.38	18.53	0.06
Indicators Factors						
<b>GPs (% of Total Physicians)</b>	2007 to 2009 <sup>f</sup>	63.75	14.37	34.53	98.93	0.19
<b>Nursing Inpatient Services Total Worked Hours per Inpatient Case</b>	FY 2007–2008 to 2009–2010 <sup>g</sup>	50.99	7.43	39.63	72.74	-0.11
<b>Average Typical Length of Stay in Acute Hospital (Days)</b>	FY 2007–2008 to 2009–2010 <sup>c</sup>	4.77	1.61	2.55	11.68	0.07
<b>Average ALC Length of Stay in Acute Hospital (Days)</b>	FY 2007–2008 to 2009–2010 <sup>c</sup>	9.28	8.73	3.84	68.67	0.01
<b>ALC Cases (% Total Inpatient Cases)</b>	FY 2007–2008 to 2009–2010 <sup>c</sup>	4.86	5.52	0.45	33.40	0.002
<b>Average Occupancy Rate in Acute Hospitals</b>	FY 2007–2008 to 2009–2010 <sup>g</sup>	81.10	12.89	22.40	96.71	-0.04
<b>Average Spending on Administration as % of Total Hospital Spending</b>	FY 2007–2008 to 2009–2010 <sup>g</sup>	5.32	1.23	3.20	8.90	-0.23*
<b>Average CPWC (\$), Acute Hospitals</b>	FY 2009–2010 <sup>g</sup>	5,123.27	711.34	3,555.22	7,197.14	-0.12

**Notes**

\* Statistically significant at  $p < 0.05$ .

FY: Fiscal year. Otherwise, years are calendar years.

ACSC: Ambulatory care sensitive condition.

VBAC: Vaginal birth after Caesarean section.

GP: General practitioner.

ALC: Alternate level of care.

CPWC: Cost per weighted case.

**Sources**

- Census, Statistics Canada.
- Canadian Community Health Survey, Statistics Canada.
- Canadian Hospital Reporting Project Hospital Profiles, Canadian Institute for Health Information.
- Health Indicators, Canadian Institute for Health Information.
- Canadian Hospital Reporting Project Clinical Indicators, Canadian Institute for Health Information.
- Scott's Medical Database, Canadian Institute for Health Information.
- Canadian MIS Database, Canadian Institute for Health Information.

## Appendix D: Measuring the Robustness of the DEA Estimates Across Different Model Specifications

**Table D1: Correlations Between Robust Efficiency Estimates From Seven Model Specifications**

	Correlation Coefficients of Efficiency Scores						
	Model 1	Model 2	Model 3 (Baseline)	Model 4	Model 5	Model 6	Model 7
<b>Model 1: Spending Inputs + Recent Immigrants</b>	1						
<b>Model 2: Spending Inputs + Recent Immigrants + Non-Aboriginal</b>	0.94*	1					
<b>Model 3: Spending Inputs + Recent Immigrants + Non-Aboriginal + Education</b>	0.92*	0.97*	1				
<b>Model 4: Baseline Modified to Use 1/PYLL at Age 85</b>	0.91*	0.96*	0.99*	1			
<b>Model 5: Baseline Modified to Use 1/PYLL at Age 75</b>	0.78*	0.81*	0.83*	0.82*	1		
<b>Model 6: Baseline Modified to Use Survival Rate Based on PYLL at Age 80</b>	0.92*	0.97*	1.0*	0.99*	0.83*	1	
<b>Model 7: Baseline Modified to Use ASMR at Age 80</b>	0.76*	0.81*	0.84*	0.90*	0.71*	0.84*	1
	Spearman Rank Correlation Coefficients of Region Rankings						
	Model 1	Model 2	Model 3 (Baseline)	Model 4	Model 5	Model 6	Model 7
<b>Model 1: Spending Inputs + Recent Immigrants</b>	1						
<b>Model 2: Spending Inputs + Recent Immigrants + Non-Aboriginal</b>	0.94*	1					
<b>Model 3: Spending Inputs + Recent Immigrants+ Non-Aboriginal + Education</b>	0.89*	0.93*	1				
<b>Model 4: Baseline Modified to Use 1/PYLL at Age 85</b>	0.89*	0.93*	0.98*	1			
<b>Model 5: Baseline Modified to Use 1/PYLL at Age 75</b>	0.82*	0.86*	0.88*	0.87*	1		
<b>Model 6: Baseline Modified to Use Survival Rate Based on PYLL at Age 80</b>	0.89*	0.94*	0.97*	0.96*	0.86*	1	
<b>Model 7: Baseline Modified to Use ASMR at Age 80</b>	0.75*	0.79*	0.82*	0.86*	0.77*	0.81*	1

### Notes

\* Statistically significant at  $p < 0.05$ .

PYLL: Potential years of life lost.

ASMR: Age-standardized mortality rate.

### Sources

Canadian Institute for Health Information calculations.



## Appendix E: A Description of the CMDB's Coverage

CMDB submissions are intended to cover all services delivered by the regional health authorities (RHAs) in a given jurisdiction.<sup>x</sup> There are three subtleties to this statement:

1. Services that are **not** delivered by an RHA will not be reported in the CMDB submission. One example is public health. Public health services are a responsibility of the jurisdictional ministries of health. They are usually the responsibility of a department within the ministry of health that is separate from the department responsible for direct care delivery through RHAs. As such, most provinces have no, or limited, public health services that are the responsibility of the RHAs. For example, the chief medical officer of health rarely reports to an RHA. However, some jurisdictions have devolved certain aspects of public health (such as vaccinations or well-baby clinics) to the RHAs. Similarly, in some jurisdictions (for example, Ontario and Manitoba), the laboratory component of public health is a separate entity that does not report to the CMDB. In other jurisdictions (for example, New Brunswick and Nova Scotia), this work is included as part of the work conducted in hospital laboratories. As a result, the CMDB provides a limited and incomplete picture of public health expenditures across the jurisdictions.
2. Services delivered by private health service organizations are typically absent from the CMDB submission. An example applicable to most jurisdictions is residential care facilities that are operated privately. One exception to this example is Ontario, as it has recently made inroads in reporting limited data for the province's privately operated residential care facilities.
3. A type of service may be delivered in one jurisdiction by RHAs but not in another.
4. So what services are common across all CMDB submissions and what are the exceptions?

**Hospital services** are the best-understood component of the CMDB data. There is 100% coverage of provincially administered hospitals across all CMDB submissions, indicating that provincially administered hospitals are the responsibility of RHAs across all jurisdictions. There are a small number of hospitals in Canada that do not report to the CMDB; these hospitals are federally administered and include military hospitals, hospitals on reserves and hospitals in correctional facilities.

**Non-hospital services** are less understood. We do know that publicly administered residential care services are not always delivered by the RHAs of some jurisdictions, including New Brunswick and Nova Scotia. (In New Brunswick, residential care is a function of the Ministry of Social Development.) Consequently, the data for these organizations is not included in the CMDB submission of these jurisdictions.

---

x. In Ontario (which has not adopted the regional health authority structure), the CMDB submissions consist of health service organizations funded by the Ontario Ministry of Health and Long-Term Care (MOHLTC). These organizations provide services that are not directly provided by the MOHLTC. (An example of a service provided by the MOHLTC is payment for FFS physicians.)

There are other services whose inclusion in provincial/territorial CMDB submissions varies. These include but are not limited to the following:

- Ambulance services (not included in the Ontario CMDB submissions, as they are expenses of the counties; included in B.C. CMDB submissions);
- Public health (in New Brunswick, services related to epidemiology, the medical health officer and central planning are not included; Public Health Ontario is a Crown Corporation that does not report to the CMDB); and
- Home care (included in Ontario's CMDB submission; home care services provided by private operators are not reported in New Brunswick).

Defining the non-hospital frame of the CMDB and improving the understanding of it will be an area of focus for the MIS and Costing department moving forward. An initial project to compare CMDB and Continuing Care Reporting System (CCRS) reporting populations commenced in 2013.

In the context of the CMDB, the term “services” is often synonymous with “organizations.” However, within organizational submissions to the CMDB, there is also variation in the **breadth and depth** of data that is provided. Consider that there are two main kinds of data in the CMDB: financial and statistical. All submitting organizations provide financial data (that is, expenses and revenues) to the CMDB, but there is substantial variation in the reporting of statistical data, such as service activity statistical volumes (the number of medical imaging exams, pharmacy attendance days, etc.) and workload.



## References

1. Health Canada. Minister Ambrose addresses the 146th Canadian Medical Association Meeting - Working Together for Real Outcomes. [http://www.hc-sc.gc.ca/ahc-asc/media/nr-cp/\\_2013/2013-114-eng.php](http://www.hc-sc.gc.ca/ahc-asc/media/nr-cp/_2013/2013-114-eng.php). Updated August 19, 2013. Accessed September 23, 2013.
2. Jacobs R, Smith PC, Street A. *Measuring Efficiency in Health Care: Analytic Techniques and Health Policy*. Cambridge, U.K.: Cambridge University Press; 2006.
3. World Health Organization. *The World Health Report 2000: Health Systems: Improving Performance*. Geneva: WHO; 2000.
4. Anand S, Ammar W, Evans T, et al. Report of the Scientific Peer Review Group on Health Systems Performance Assessment. In: Murray CJ, Evans DB, eds. *Health Systems Performance Assessment*. Geneva: World Health Organization; 2002;837-927.
5. Joumard I, Hoeller P, André C, and Nicq C. *Health Care Systems: Efficiency and Policy Settings*. Paris, France: OECD Publishing; 2010.
6. Canadian Institute for Health Information. *Developing a Model for Measuring the Efficiency of the Health System in Canada*. Ottawa, ON: CIHI; 2012.
7. Abelson J and Pasic D. *Health System Efficiency Project: A Qualitative Study of Provincial and Territorial Health Ministry Perspectives*. Ottawa, ON: CIHI; 2011. [http://chepa.org/docs/documents/CIHI\\_HSEP\\_Qual\\_Study\\_FinalRep.pdf](http://chepa.org/docs/documents/CIHI_HSEP_Qual_Study_FinalRep.pdf). Accessed September 24, 2013.
8. Lavis JN. *Dialogue Summary: Measuring Health System Efficiency in Canada*. Hamilton, ON: McMaster Health Forum; 2011. [http://www.mcmasterhealthforum.org/images/docs/measuring%20health%20system%20efficiency%20in%20canada\\_dialogue-summary\\_2011-11-07.pdf](http://www.mcmasterhealthforum.org/images/docs/measuring%20health%20system%20efficiency%20in%20canada_dialogue-summary_2011-11-07.pdf). Accessed September 4, 2013.
9. Ontario Ministry of Finance Commission on the Reform of Ontario's Public Services. *Public Services for Ontarians: A Path to Sustainability and Excellence*. Toronto, ON: Queen's Printer for Ontario; 2012. <http://www.fin.gov.on.ca/en/reformcommission/>. Accessed September 3, 2013.
10. Smith M, Saunders R, Stuckhardt L, and McGinnis JME. *Best Care at Lowest Cost: The Path to Continuously Learning Health Care in America*. Washington, D.C.: National Academies Press; 2012. <http://www.iom.edu/Reports/2012/Best-Care-at-Lower-Cost-The-Path-to-Continuously-Learning-Health-Care-in-America.aspx>. Accessed October 8, 2013.
11. Lavis JN, Stoddart GL. Can we have too much health care? *Daedalus*. 1994;123(4):43-60.
12. Bentley T, Effros R, Palar K, Keeler EB. Waste in the U.S. Health Care System: A Conceptual Framework. *The Milbank Quarterly*. 2008;86(4):629-659.
13. McGlynn EA, Asch SM, Adams J, et al. The quality of health care delivered to adults in the United States. *New England Journal of Medicine*. 2003;348(26):2635-2645.
14. Hollingsworth B. The measurement of efficiency and productivity of health care delivery. *Health Economics*. 2008;17(10):1107-1128.
15. Liu C. *Three Essays on Health Economics*. Guelph, ON: University of Guelph; 2008.

16. Afonso A and St. Aubyn, M. *Relative Efficiency of Health Provision: A DEA Approach With Non-Discretionary Inputs*. 2006. <http://www.iseg.utl.pt/departamentos/economia/wp/wp332006deuece.pdf>. Accessed September 19, 2013.
17. Wranik D. Healthcare policy tools as determinants of health-system efficiency: Evidence from the OECD. *Health Economics, Policy and Law*. 2012;7:197-226.
18. Bhat VN. Institutional arrangements and efficiency of health care delivery systems. *European Journal of Health Economics*. 2005;50:215-222.
19. Puig-Junoy J. Measuring health production performance in the OECD. *Applied Economics Letters*. 1998;5(4):255-259.
20. Joumard I, André C, Nicq C, and Chatal O. *Health Status Determinants: Lifestyle, Environment, Health Care Resources and Efficiency*. Paris, France: OECD Publishing; 2008.
21. Charnes A, Cooper W, Rhodes E. Measuring the efficiency of decision-making units. *European Journal of Operational Research*. 1978;2:429-444.
22. Wilson PW. FEAR: A software package for frontier efficiency analysis with R. *Socio-Economic Planning Sciences*. 2008;42(4):247-254.
23. Hollingsworth B. Non-parametric and Parametric Applications Measuring Efficiency in Health Care. *Health Care Management Science*. 2003;6(4):203-218.
24. Organisation for Economic Cooperation and Development. Health at a Glance 2011: OECD Indicators. Updated 2011. Accessed September 24, 2013.
25. Hollingsworth B, Smith P. The use of ratios in Data Envelopment Analysis. *Applied Economics Letters*. 2003;10(11):733-735.
26. Smith P, Street A. Measuring the efficiency of public services: the limits of analysis. *Journal of the Royal Statistical Society*. 2005;168(2):401-417.
27. Smith P and A. Street. *Analysis of Secondary School Efficiency: Final Report*. Nottingham, U.K.: Department for Education and Skills; 2006.
28. Liu C, Laporte A, Ferguson B. The quantile regression approach to efficiency measurement: Insights from Monte Carlo simulations. *Health Economics*. 2008;17:1073-1087.
29. Wilson PW. Detecting outliers in deterministic nonparametric frontier models with multiple outputs. *Journal of Business and Economic Statistics*. 1993;11(3):319-323.
30. Simar L, Wilson PW. Sensitivity analysis of efficiency scores: how to bootstrap in nonparametric frontier models. *Management Science*. 1998;44(1):49-61.
31. Smith P. Model misspecification in Data Envelopment Analysis. *Annals of Operations Research*. 1997;73:233-252.
32. Simar L, Wilson PW. Estimation and inference in two-stage, semi-parametric models of production processes. *Journal of Econometrics*. 2007;136:31-64.
33. Steyerberg EW, M.J.C. Eijkemans, F.E Harrell, J.D.F Habbema. Prognostic modelling with logistic regression analysis: a comparison of selection and estimation methods in small data sets. *Statistics in Medicine*. 2000;19:1059-1079.

34. Canadian Institute for Health Information. *Drug Expenditure in Canada, 1985 to 2012*. Ottawa, ON: CIHI; 2013. [https://secure.cihi.ca/free\\_products/Drug\\_Expenditure\\_2013\\_EN.pdf](https://secure.cihi.ca/free_products/Drug_Expenditure_2013_EN.pdf). Accessed August 26, 2013.
35. Canadian Institute for Health Information. *National Prescription Drug Utilization Information System Database - Plan Information Document*. Ottawa, ON: CIHI; 2013. [https://secure.cihi.ca/free\\_products/NPDUIS\\_PlanInformation\\_1307\\_e1.pdf](https://secure.cihi.ca/free_products/NPDUIS_PlanInformation_1307_e1.pdf). Accessed August 26, 2013.
36. Canadian Institute for Health Information. *Health Indicators 2013*. Ottawa, ON: CIHI; 2013. <https://secure.cihi.ca/estore/productFamily.htm?locale=en&pf=PFC2195&lang=en>. Accessed September 4, 2013.
37. Statistics Canada. Health Profile, January 2013. <http://www12.statcan.gc.ca/health-sante/82-228/>. Updated January 18, 2013. Accessed August 30, 2013.
38. Health Council of Canada. Health Innovation Portal. <http://innovation.healthcouncilcanada.ca/>. Updated 2013. Accessed August 30, 2013.
39. Canadian Institute for Health Information. *Health Indicators 2012*. Ottawa, ON: CIHI; 2012.
40. Canadian Institute for Health Information. *Health Indicators 2013: Definitions, Data Sources and Rationale, May 2013*. Ottawa, ON: CIHI; 2013. Accessed September 11, 2013.
41. Statistics Canada. Health status indicators based on vital statistics. <http://www.statcan.gc.ca/pub/82-221-x/2012002/quality-qualite/qua2-eng.htm#a222>. Updated May 13, 2013. Accessed November 5, 2013.
42. Statistics Canada. *Postal Code Conversion File (PCCF), Reference Guide, May 2011*. Ottawa, ON: Statistics Canada; 2011. <http://www5.statcan.gc.ca/bsolc/olc-cel/olc-cel?catno=92-153-G&lang=eng>. Accessed March 20, 2013.
43. Canadian Institute for Health Information. *Cautions for Comparing Financial Data Compiled in Accordance With the Standards of the Quebec Manuel De Gestion Financière and Those of the 2009-2010 CIHI Management Information System*. Ottawa, ON: CIHI; 2013.
44. Canadian Institute for Health Information. *Canadian MIS Database--Hospital Financial Performance Indicators, 1999-2000 to 2009-2010, Methodological Notes, Revised August 2011*. Ottawa, ON: CIHI; 2011.
45. Canadian Institute for Health Information. National Physician Database, 2010-2011 Data Release. <https://secure.cihi.ca/estore/productFamily.htm?locale=en&pf=PFC2032&lang=en&media=0>. Updated 2013.
46. Canadian Institute for Health Information. Scott's Medical Database. [http://www.cihi.ca/cihi-ext-portal/internet/en/document/spending+and+health+workforce/workforce/physicians/hhrdata\\_smdb](http://www.cihi.ca/cihi-ext-portal/internet/en/document/spending+and+health+workforce/workforce/physicians/hhrdata_smdb). Updated 2013. Accessed September 4, 2013.
47. Statistics Canada. *Residential Care Facilities--2008/2009*. Ottawa, ON: Statistics Canada; 2011.
48. Ng E. The healthy immigrant effect and mortality rates. *Health Reports*. 2011;22(4):1-5.
49. Tjepkema M, Wilkins R, Senécal S, Guimond E, Penney C. Mortality of Métis and Registered Indian adults in Canada: an 11-year follow-up study. *Health Reports*. 2009;20(4):1-21.

50. Statistics Canada. Table 109-0300, Census indicator profile, Canada, provinces, territories, health regions (2001 boundaries) and peer groups. Updated 2011. Accessed November 21, 2013.
51. Canadian Institute for Health Information. *National Health Expenditure Trends, 1975 to 2012*. Ottawa, ON: CIHI; 2012. <https://secure.cihi.ca/estore/productSeries.htm?pc=PCC52>. Accessed September 17, 2013.
52. Canadian Institute for Health Information. *A Performance Measurement Framework for the Canadian Health System*. Ottawa, ON: CIHI; 2013. [https://secure.cihi.ca/free\\_products/HSP\\_Framework\\_Technical\\_Report\\_EN.pdf](https://secure.cihi.ca/free_products/HSP_Framework_Technical_Report_EN.pdf). Accessed November 19, 2013.
53. van Doorslaer E and Masseria C. *Income-Related Inequality in the Use of Medical Care in 21 OECD Countries*. Paris, France: OECD; 2004.
54. Canadian Institute for Health Information. *Canadian Hospital Reporting Project Technical Notes - Clinical Indicators*. Ottawa, ON: CIHI; 2013. <http://www.cihi.ca/cihi-ext-portal/internet/en/tabbedcontent/health+system+performance/indicators/performance/cihi010657#toolkit>. Accessed September 11, 2013.
55. Canadian Institute for Health Information. *Canadian Hospital Reporting Project Technical Notes - Financial Indicators*. Ottawa, ON: CIHI; 2013. <http://www.cihi.ca/cihi-ext-portal/internet/en/tabbedcontent/health+system+performance/indicators/performance/cihi010657#toolkit>. Accessed March 20, 2013.
56. Canadian Institute for Health Information. *Canadian Hospital Reporting Project Hospital Profile Data Dictionary*. Ottawa, ON: CIHI; 2012.
57. Reducing Hospital Readmissions & Discharge Planning Conference: Identify, Predict & Prevent Unplanned Readmissions. Vancouver: Oct. 28, 2013.
58. Canadian Institute for Health Information. *All-Cause Readmission to Acute Care and Return to the Emergency Department*. Ottawa, ON: CIHI; 2012. <https://secure.cihi.ca/estore/productFamily.htm?locale=en&pf=PFC1823>. Accessed October 8, 2013.
59. Joynt KE, Jha AK. Who has higher readmission rates for heart failure, and why?: Implications for efforts to improve care using financial incentives. *Circulation: Cardiovascular Quality and Outcomes*. 2011;4:53-59.
60. Stukel T, Fisher ES, Alter DA, et al. Association of hospital spending intensity with mortality and readmission rates in Ontario hospitals. *Journal of the American Medical Association*. 2012;307(10):1037-1.
61. Boutwell AE, M.Bihrl Johnson, P.Rutherford, et al. An early look at a four-state initiative to reduce avoidable hospital readmissions. *Health Affairs*. 2013;30(7):1272-1280.
62. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. *New England Journal of Medicine*. 2009;360(14):1418-1428.
63. Starfield B, Shi L, Macinko J. Contribution of primary care to health systems and health. *Milbank Quarterly*. 2005;83(3):457-502.

64. Macinko J, Starfield B, Shi L. The Contribution of Primary Care Systems to Health Outcomes within Organization for Economic Cooperation and Development (OECD) Countries, 1970-1998. *Health Services Research*. 2003;38(3):831-865.
65. Hutchison B, Levesque J, Strumpf E, Coyle N. Primary health care in Canada: Health systems in motion. *Milbank Quarterly*. 2011;89(2):256-288.
66. Canadian Institute for Health Information. *Seniors and Alternate Level of Care: Building on Our Knowledge*. Ottawa, ON: CIHI; 2012.
67. Sheiner L. *Why the Geographic Variation in Health Care Spending Can't Tell Us Much About the Efficiency or Quality of Our Health Care System*. Washington, D.C.: Board of Governors of the Federal Reserve System (U.S.); 2013.
68. Corallo AN, Croxford R, Goodman DC, Bryan EL, Srivastava D, Stukel T. A systematic review of medical practice variation in OECD countries. *Health Policy*. 2014; 114(1): 5-14.
69. Williams, J., Shipton D, Badley EM, et al. *Arthritis and Related Conditions in Ontario: ICES Research Atlas, Chapter 6: Surgical Services*. Toronto, ON: Institute for Clinical Evaluative Sciences; 2004.
70. The Council of the Federation. *From Innovation to Action: The First Report of the Health Care Innovation Working Group*. Ottawa, ON: The Council of the Federation; 2012. [http://www.councilofthefederation.ca/phocadownload/publications/health\\_innovation\\_report-e-web.pdf](http://www.councilofthefederation.ca/phocadownload/publications/health_innovation_report-e-web.pdf).
71. Allin S, Graves E, Grignon M, Ridgeway D, Wang L. Health-adjusted Potential Years of Life Lost: a health-sector relevant measure of population health. *Health Reports*. 2013; submitted for publication.
72. Institute of Clinical Evaluative Sciences. *Payments to Ontario Physicians From Ministry of Health and Long-Term Care Sources 1992/3 to 2009/10*. Toronto, ON: Institute for Clinical Evaluative Sciences; 2012.
73. Ontario Physician Human Resources Data Centre. *Physicians in Ontario 2009*. Hamilton, ON: Ontario Physician Human Resources Data Centre; 2009. <https://www.ophrdc.org/Public/Report.aspx?owner=pio>.
74. Stukel T, Glazier RH, Schultz S, et al. Multispecialty physician networks in Ontario. *Open Medicine*. 2013;7(2) <http://www.openmedicine.ca/article/view/577/501>. Accessed November 12, 2013.

Production of this report is made possible by financial contributions from Health Canada and provincial and territorial governments. The views expressed herein do not necessarily represent the views of Health Canada or any provincial or territorial government.

All rights reserved.

The contents of this publication may be reproduced unaltered, in whole or in part and by any means, solely for non-commercial purposes, provided that the Canadian Institute for Health Information is properly and fully acknowledged as the copyright owner. Any reproduction or use of this publication or its contents for any commercial purpose requires the prior written authorization of the Canadian Institute for Health Information. Reproduction or use that suggests endorsement by, or affiliation with, the Canadian Institute for Health Information is prohibited.

For permission or information, please contact CIHI:

Canadian Institute for Health Information  
495 Richmond Road, Suite 600  
Ottawa, Ontario K2A 4H6

Phone: 613-241-7860

Fax: 613-241-8120

[www.cihi.ca](http://www.cihi.ca)

[copyright@cihi.ca](mailto:copyright@cihi.ca)

ISBN 978-1-77109-268-5 (PDF)

© 2014 Canadian Institute for Health Information

How to cite this document:

Canadian Institute for Health Information. *Measuring the Level and Determinants of Health System Efficiency in Canada*. Ottawa, ON: CIHI; 2014.

Cette publication est aussi disponible en français sous le titre *Mesurer l'efficacité du système de santé canadien et ses déterminants*.

ISBN 978-1-77109-269-2 (PDF)

## Talk to Us

### **CIHI Ottawa**

495 Richmond Road, Suite 600  
Ottawa, Ontario K2A 4H6  
Phone: 613-241-7860

### **CIHI Toronto**

4110 Yonge Street, Suite 300  
Toronto, Ontario M2P 2B7  
Phone: 416-481-2002

### **CIHI Victoria**

880 Douglas Street, Suite 600  
Victoria, British Columbia V8W 2B7  
Phone: 250-220-4100

### **CIHI Montréal**

1010 Sherbrooke Street West, Suite 300  
Montréal, Quebec H3A 2R7  
Phone: 514-842-2226

### **CIHI St. John's**

140 Water Street, Suite 701  
St. John's, Newfoundland and Labrador A1C 6H6  
Phone: 709-576-7006



[www.cihi.ca](http://www.cihi.ca)  
**At the heart of data**



Canadian Institute  
for Health Information

Institut canadien  
d'information sur la santé