


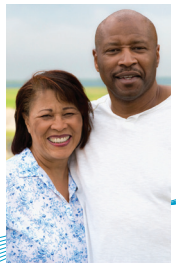


Developing a Model for Measuring the Efficiency of the Health System in Canada

Updated October 2012

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

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Abbreviations

AMI	acute myocardial infarction
CI	Concentration Index
CIHI	Canadian Institute for Health Information
CT	computed tomography
DALE	disability-adjusted life expectancy
DEA	data envelopment analysis
DMU	decision-making unit
HALE	health-adjusted life expectancy
HI	Horizontal Inequity Index
HUI	Health Utility Index
LTC	long-term care
MRI	magnetic resonance imaging
OECD	Organisation for Economic Co-operation and Development
PYLL	potential years of life lost
SFA	stochastic frontier analysis
SES	socio-economic status
WHO	World Health Organization

Key Points

- Health system policy- and decision-makers have a responsibility to ensure that scarce health system resources are used wisely to provide the best possible health services to the public while containing current and future costs. Measuring variations in health system efficiency and learning from them could be a helpful approach for policy- and decision-makers in this regard as it could inform policies and interventions maximizing health outcomes from scarce public resources.
- The goal of this project is to develop an approach for measuring the technical efficiency of the health system in a manner that is relevant to federal, provincial, territorial and regional policy- and decision-makers.
- Consultations with health system stakeholders at federal, provincial and territorial levels were the most significant contributions in defining this approach. A review of health system data available in Canada at the provincial, territorial and regional levels helped assess the feasibility of the health system efficiency measurement model proposed.
- The report provides an overview of the methods used to develop the approach, describes the main decision points and concludes with a presentation of an approach to health system efficiency measurement at the provincial and regional levels.
- The next steps in the project are as follows: test the model, using available data to produce preliminary results of the health system efficiency measure; engage with policy-makers and health system managers at the regional level to explore possible factors leading to inefficiencies; and identify successful policies that can serve as a learning opportunity for Canadian jurisdictions.

Executive Summary

Health system policy- and decision-makers have a responsibility to ensure that scarce health system resources are used judiciously and wisely to provide the best possible health services to Canadians. Part of this responsibility involves a key policy challenge about how to improve public services while containing current and future costs. Doing so requires measuring health system efficiency (an assessment of how well health system resources are combined to produce health services) and identifying and sharing various activities contributing to high performance.

Previously, Canada has been part of a number of international studies on health system efficiency. These studies tend to consider the Canadian health system as a single entity, although there are 14 health systems in Canada provided by provincial, territorial and federal governments, most of which are further divided into health regions and/or health authorities that deliver health services to Canadians. Therefore, international comparisons of the Canadian health system to other countries provide little information for Canadian policy- and decision-makers about variation of efficiency that may exist across provinces, territories and health regions in Canada.

Canada's two leading organizations for statistical data—Statistics Canada and the Canadian Institute for Health Information (CIHI)—collect and report comparable statistical information at the national, provincial, territorial and health region levels. The data collected by these institutions will be more useful for measuring efficiency within Canada. Also, the use of more complete data than is available for comparison at the international level will make it easier to assess the system efficiency.

Previous health system efficiency work often targeted researchers and did not consider how policy- and decision-makers could use the information, nor did it translate empirical findings into policy tools. To achieve a higher level of usefulness, future analysis should be designed and carried out hand-in-hand with policy- and decision-makers, and should align with their information needs. This level of engagement with information users does not appear in any of the studies reviewed for this project.

CIHI is undertaking a large-scale project on health system efficiency measurement in Canada. The goal of this project is to develop a Canadian framework for measuring health system efficiency that considers maximizing results given the resources utilized. The project aims to identify the ways that policy-relevant characteristics contribute to efficiency in a manner that is relevant to federal, provincial, territorial and regional policy- and decision-makers. The framework will serve as a learning opportunity to share successful interventions across Canadian jurisdictions. The target audience for this project is policy-makers and health system managers at regional, provincial, territorial and federal levels.

The project involves three steps: 1) defining a model to measure efficiency and to evaluate the availability of data; 2) testing this model using available data, with the intent to benchmark Canadian jurisdictions and identify best practices to enhance health system performance; and 3) providing these results to policy- and decision-makers to help in the identification of system improvements. The following report is the product of the first step in the project. It explains the process for developing the measurement framework or model and outlines our proposed approach to measuring health system efficiency for Canadian jurisdictions.

While recognizing the benefits of disease-based and sub-sector approaches, this report focuses on a system-level approach, which is more appropriate for system policy- and decision-makers. The proposed approach includes calculating efficiency scores for health system decision-making units, followed by regression analyses supporting an identification of potential options for efficiency improvements. Calculating efficiency scores requires making choices and decisions about the objectives of the health system (what it is meant to achieve), the boundaries of the health system (what do they include), a health system decision-making unit (what is it) and which econometric methods to use.

The most significant contribution in making these choices and decisions resulted from a consultation process with health system stakeholders, which included a review of federal, provincial and territorial documentation, semi-structured interviews and a policy dialogue with leaders from various health system groups in Canada. To supplement this information, CIHI also conducted a range of literature review activities to collect information on the current state of efficiency measurement in health care and other industries. Finally, CIHI conducted a review of data at the provincial, territorial and regional levels to assess the feasibility of the proposed efficiency model.

Health system policy- and decision-makers who were consulted placed considerable emphasis on providing access to timely and effective health care when individuals get sick, although they agreed that the health system should, in the meantime, focus on improving overall health within the population. The group of health system policy-makers and system managers consulted agreed that measures such as premature mortality indicators were an appropriate way to measure the outcomes portion of the health system efficiency model. As an input to the system, they suggested that health system expenditures on hospitals and other institutions, doctors, nurses and other health system professionals, prescription medications and public health were the most appropriate measure.

As suggested by the consulted stakeholders and recommended by the literature, two of the most common types of economic analysis—data envelopment analysis (DEA) and stochastic frontier analysis (SFA)—will be used to measure health system efficiency. Due to characteristics of the Canadian health system and sampling considerations, the analysis will be conducted at the regional level, therefore using health regions, or the equivalent, as the decision-making units of the system.

Overall, as a base model, each method of analysis (DEA and SFA) will include a range of health system expenditures as the main input and a single outcome related to one of four mortality measures: premature mortality, avoidable mortality, preventable mortality or treatable mortality. To minimize the external differences between regions, environmental factors will be included in

the model (in the case of the SFA) or the health regions will be grouped by these factors and efficiency assessment will be carried out individually for each group (in the case of the DEA). Based on the stakeholders' feedback and the literature recommendations, the following environmental factors will be accounted for in the efficiency model: population density, unemployment rate, average income, proportion of people age 65 and older, proportion of Aboriginal population, proportion of immigrants and income inequality (as a GINI coefficient).

The second step in the process of measuring health system efficiency includes a regression analysis using throughputs, health inequality indicators and system performance indicators to identify potential options for efficiency improvements. Sensitivity analysis will identify the most influential inputs, environmental factors and indicators used in the regression analysis. The data was collected for 2006, 2007 and 2008, the most recent years for which mortality data was available.

The immediate next step for this project will be to apply the available data to the efficiency model and produce preliminary results. CIHI will continue its engagement with provincial, territorial and regional governments to explore possible factors leading to inefficiency and successful policies that can support a more efficient health system. Further model refinement and subsequent iterations of the analysis will take place in 2012–2013.

The report consists of nine chapters:

- Chapter 1: Introduces the background and rationale for this project and for health system efficiency measurement more generally;
- Chapter 2: Summarizes the approach taken by CIHI and outlines the methods employed to develop the efficiency model;
- Chapter 3: Presents different approaches to measuring efficiency and describes common elements of any efficiency model—system objectives, boundaries, decision-making units and methods;
- Chapter 4: Elaborates on the choice of health system objectives and the measures used to capture these objectives, including a summary of a range of stakeholder consultations with senior policy- and decision-makers on the topic;
- Chapter 5: Discusses options for defining health system boundaries and suggests definitions for health system inputs, throughputs and environmental factors;
- Chapter 6: Explains the approach for selecting decision-making units (DMU), a health system unit used to measure efficiency;
- Chapter 7: Summarizes advantages and disadvantages of two well-known econometric methods for measuring efficiency and inefficiency—data envelopment analysis (DEA) and stochastic frontier analysis (SFA);
- Chapter 8: Covers the proposed efficiency model; and
- Chapter 9: Points out challenges encountered in the course of this project study, limitations based on available data, and next steps for the larger project.

In Canada, total health expenditure has steadily climbed since 1975 (with a short plateau from 1991 to 1996) and was estimated to reach $200.5 billion in 2011.[6] Public-sector expenditures account for 70% of this spending.[6]

As with any type of publicly financed service, policy- and decision-makers must assess whether health expenditures and health system resources are being used efficiently to improve health outcomes[7] and whether such expenditures are in line with citizens' preferences.[2] Canadian research suggests that increasing health spending will not suffice to address the challenges the health system is facing; using available resources more efficiently could be an important part of the answer.[8] A recent public opinion survey confirms this idea: more Canadians perceive inefficient management as a bigger issue for the health system than amount of funding.[9]

Service providers and users of Canada's publicly financed health system often note the importance of measuring and reporting performance in the delivery of health services. For example, large-scale consultations, such as those conducted by the Romanow Commission, indicate that citizens consistently report a desire to understand the value of health services provided in relation to the amount of money spent, as well as how various jurisdictions across Canada compare with one another and over time.[10] Similarly, a recent dialogue initiated by the Canadian Medical Association indicates that Canadians value timely, efficient and compassionate care.[11] Efficiency of the health system is also a shared value among federal, provincial and territorial governments across Canada.[12]

Health system policy- and decision-makers have a responsibility to ensure that scarce health system resources are used judiciously and wisely to provide the best possible public services. Part of this responsibility involves a key policy challenge: improving public services while containing current and future costs.[13] Doing so requires measuring efficiency and identifying and sharing various activities that contribute to high performance.[14]

Health system efficiency involves an assessment of how well health system resources (for example, labour and capital) are combined to produce health services[4] (see Box 1 for a description of the key concepts involved in efficiency assessment). Efficiency can be presented as the ratio between actual system results (that is, health system outputs or outcomes) and the maximum achievable results possible, given the system resources or inputs used. The difference between actual results and maximum achievable results can be attributed to inefficiency within the system (and, in some cases, may include inefficiency from factors external to the system). The concepts of productivity and efficiency are closely related and often used interchangeably; however, their meanings are not precisely the same. Productivity involves the ratio of actual system results (that is, outputs or outcomes) to actual inputs or resources put in, whereas efficiency would involve an assessment of whether the system is achieving the highest productivity level possible from each input (Box 2 explains the key concepts related to health system technical efficiency).

Box 1: Key Concepts

Health system objectives consist of health system priorities outlined by various jurisdictions (including national, provincial/territorial and regional). Examples include achieving the highest health status for the overall population, reducing mortality and reducing inequalities in health status between certain groups in society.[1]

Health system outputs are immediate results of activities undertaken by the health system. It is the generic term for completed processes that can be quantified (for example, the number of completed episodes of care, or the number of patients treated).

Health system outcomes are health gains attributable to actions of the health system (such as improvements in length and quality of life) and qualitative characteristics valued by patients (such as experiences associated with care).[2]

Health system inputs are resources the health system employs to produce outputs or outcomes. The most common inputs include health human resources (for example, doctors and nurses), capital resources (for example, hospitals and equipment) and consumables (for example, medications and assistive devices). Inputs can also include specific initiatives, information or funding provided for the system to obtain desired outputs or outcomes.

Environmental constraints are influences on performance that lie outside the control of the health system. In particular, characteristics of the patient population (such as various demographics) are often considered to be outside influences that determine the context within which the health system operates.[2]

Decision-making unit (DMU) refers to an entity that designs and controls *the process* that converts inputs into outputs and outcomes (for example, a hospital) or one that designs and controls *the rules* to which system stakeholders must adhere (for example, a government department or ministry responsible for health).[3]

Efficiency commonly refers to the best use of resources in the production of a given product or service.[4] Typically, there are two types of efficiency: **technical efficiency** and **allocative efficiency**.

Technical efficiency refers to making the most of outputs and/or outcomes for a given level and mix of inputs, or minimizing input use for a given level of outputs and/or outcomes.[4] It is measured as the ratio between what is actually produced and the maximum achievable output, by DMU, taking into consideration the resources available within a given context. Inefficiency would be the result of resources left idle or not producing outcomes in the best possible way.

$$\text{Technical Efficiency} = \frac{\text{Actual Output}}{\text{Maximum Achievable Output}}$$

Technical efficiency may be considered from an **input-oriented** or **output-oriented** perspective. Input-oriented technical efficiency involves minimizing the amount of resources spent to reach a given level of outputs and/or outcomes. Output-oriented efficiency would focus on maximizing the result (output) for a given amount of resources.

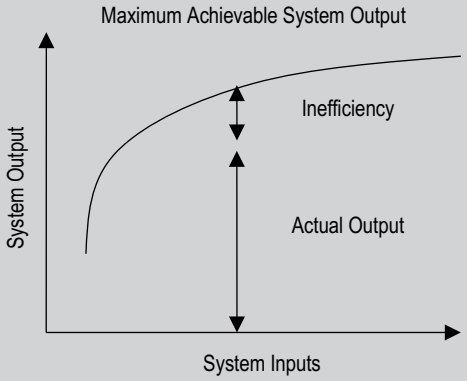
Allocative efficiency involves an assessment of how different resources are combined to produce various and competing system outcomes.[5] This type of efficiency supposes that each outcome is technically efficiently produced and supposes a decision at the societal level to evaluate how much of each outcome is demanded, leading to an optimal allocation of resources.

Box 2: Key Concepts

Health system technical efficiency measures the extent to which the resources used by the health system achieve maximum possible output given available resources and current technology (output oriented).

$$\text{Efficiency} = \frac{\text{(Actual Output)}}{\text{(Maximum Achievable Output)}}$$

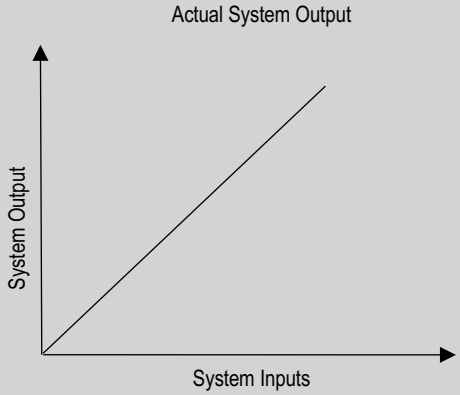
The difference between actual output and maximum achievable output can be attributed to inefficiency (in some cases including random error).



Productivity is the ratio of actual output to actual input, or how much output is produced per unit of input.

$$\text{Productivity} = \frac{\text{Output}}{\text{Inputs}}$$

The concepts of productivity and efficiency are closely related to each other; however, productivity is the comparison of two components (inputs and outputs), whereas the highest productivity level from each input is recognized as efficiency.[22]



Economic theory mainly distinguishes between technical, allocative and cost efficiency. Technical efficiency involves minimizing input for a certain level of output (labelled as *input-oriented technical efficiency*) or maximizing results (that is, outputs or outcomes) for a given level of input (labelled *output-oriented technical efficiency*).[15] Allocative efficiency involves optimizing how resources are allocated to produce maximum results, and cost efficiency focuses on minimizing the costs associated with achieving various results. The textboxes describe the key concepts related to efficiency measurement.

Internationally, Canada has been part of a number of high-profile studies on health system efficiency. For instance, Canada was ranked 30th among 191 countries based on an assessment of overall health system performance conducted by World Health Organization (WHO) in 2000.[16] Canada was also part of a report produced by the Organisation for Economic Co-operation and Development (OECD) that identified institutional characteristics that may affect system performance. In the report, Canada was grouped with three other countries (Australia, Belgium and France) based on basic public insurance coverage, reliance on market mechanisms at the provider level and similar gate-keeping arrangements. The average efficiency for this group was above the OECD average.[13] Another OECD report ranked 30 countries by such measures of health status as potential years of life lost (PYLL) and health-adjusted life expectancy (HALE); Canada ranked 9th and 8th, respectively, on these two measures.[17] Lastly, a recent study on policy-relevant health system characteristics that contribute to efficiency ranked Canada 12th among 21 OECD countries.[18]

International studies tend to consider the Canadian health system as a single entity. However, there are many health systems in Canada: one for each of the 10 provinces, 3 territories and the federal government (which has jurisdiction over military personnel, the Royal Canadian Mounted Police and inmates of federal prisons, and which also delivers a range of health services and programs to eligible First Nations and Inuit). All administer and deliver the range of Canada's health services. Services under provincial and territorial jurisdiction are funded with the assistance of federal cash and tax transfers.[19] Subsequently, all provincial and territorial health insurance plans are expected to meet pan-Canadian principles set out under the *Canada Health Act*.[19] Each provincial and territorial health insurance plan fully covers medically necessary services. However, the *Canada Health Act* does not define medically necessary services,[20] and it is up to the provinces and territories to determine which medically necessary services are covered.[19] Furthermore, most of the provinces and territories are differentially divided into health regions and/or health authorities, which oversee health service delivery to Canadians (for example, hospital care, long-term care, home care and public health services), although some services (for example, health system legislation or fee-negotiation responsibilities) remain at the provincial and territorial levels.[19]

Therefore, the Canadian health system is a composition of 14 health systems differing in policy, administration, planning, implementation and negotiation practices. Although there is a preliminary picture of how Canada ranks in terms of efficiency, compared with other countries, there is little work outlining variations in system efficiency that may exist across provinces, territories and health regions in Canada. This poses several challenges for Canadian policy- and decision-makers.

Approaches used in previous international studies appear to be driven by data availability and comparability across countries, which can be a challenge when data collection methods and availability differs significantly from country to country. Canada's two leading organizations for statistical data—Statistics Canada and the Canadian Institute for Health Information (CIHI)—collect and report comparable statistical information at the national, provincial, territorial and health region levels. The data collected by these institutions will be useful for measuring efficiency within Canada. Also, the use of more complete data than is available for comparison at the international level will make it easier to assess the country's efficiency. Despite this potential, results may not be fully comparable with jurisdictions outside of Canada due to differences in coding practices or methods.

There are a few examples from other countries where policy-makers have used efficiency studies to inform decision-making processes. For instance, Australia incorporates efficiency measurement in hospital performance indicator suites, Norway uses efficiency measurement to guide resource allocation at the regional level[4] and New Zealand has been using efficiency measurement to review health expenditures.[21]

Previous health system efficiency work often targets researchers and does not consider how the information could be utilized by policy- and decision-makers, nor does it translate empirical findings into policy tools.[4] To be useful for policy- and decision-makers, future health system efficiency work should be more comprehensive, not merely providing efficiency scores, but also identifying the nature and form of inefficiency and providing insights into what can be done to

improve health system efficiency.[4] To achieve a higher level of usefulness, future analysis should be designed and carried out hand-in-hand with policy- and decision-makers, and must align with their information needs. This level of engagement does not appear in any of the studies reviewed for this project.

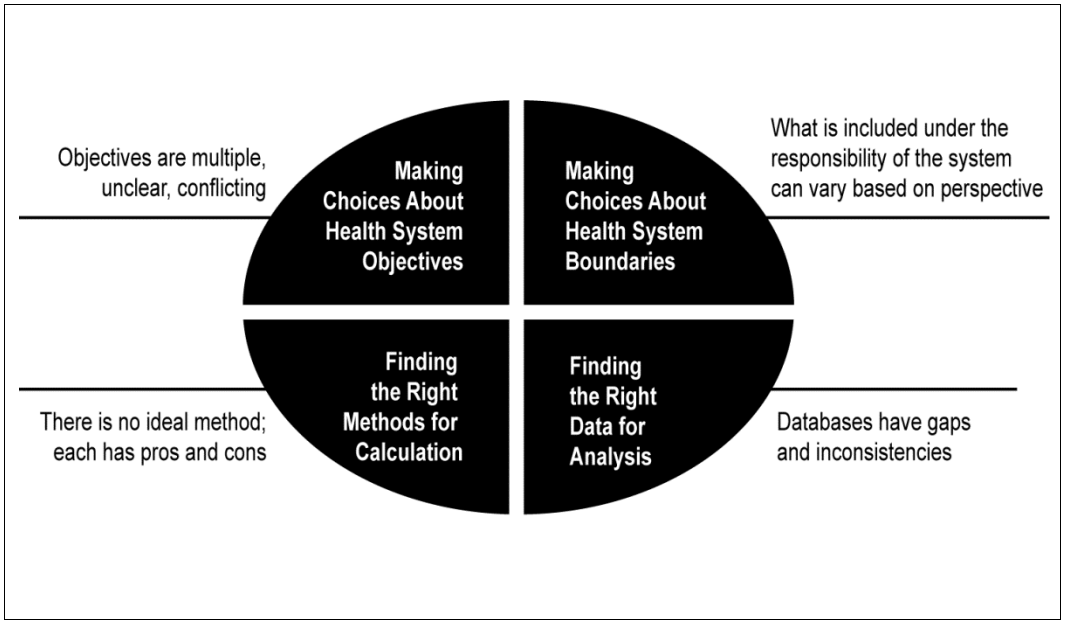
CIHI is undertaking a large-scale project on health system efficiency in Canada. The goal of this project is to develop a Canadian framework for measuring efficiency that focuses on so-called *output-oriented efficiency* (maximizing results given the resources available). The project aims to identify the ways that policy-relevant characteristics contribute to efficiency in a manner that is relevant to federal, provincial, territorial and regional policy- and decision-makers. The framework will serve as a learning opportunity to share successful policies across Canadian jurisdictions. The target audience for this project is policy-makers and health system managers at regional, provincial, territorial and federal levels.

The project involves several steps. The first is to define a model to measure efficiency and to evaluate the availability of data. The second is to test this model using available data with the intent to benchmark Canadian jurisdictions and identify best practices to enhance health system performance. The third step is to provide these results to policy- and decision-makers to help in the identification of system improvements. This report is the product of the first step in the project. It explains the process for developing the measurement framework or model and outlines our proposed approach to measuring health system efficiency.

Chapter 2: Study Approach and Methods

Assessing efficiency is not a straightforward task. It requires making choices involving multiple, sometimes unclear and possibly conflicting objectives about what the health system is meant to achieve. It also requires defining and making some difficult decisions about what is included in the boundaries of the health system. In addition, effective assessment must overcome gaps and inconsistencies in data, as well as technical challenges of various methods for calculating efficiency. See Figure 1 for an illustration of these many challenges and decision points.

Figure 1: Challenges, Decisions and Choices in Defining Health System Objectives and Measuring Health System Efficiency



The primary challenge in defining a model of health system efficiency is to agree on system objectives and the best measures to capture these objectives. A background literature review conducted for the purposes of this report indicates that a major shortcoming in the existing literature is that choices around objectives (and the assumptions that underlie these choices) are often made without consulting the stakeholders who are in a position to make use of the evidence and bring about performance improvement.

A health system has a number of stakeholders, including citizens, practitioners, scholars, policy-makers, decision-makers and elected officials. Each of these groups might have its own view on what the health system should be trying to achieve, indicating the importance of soliciting a range of input to define health system objectives. Given that policy- and decision-makers, and elected officials in particular, are "the central building blocks of an effective health system,"[23]

Box 3: Stakeholders' Contribution to Defining System Objectives

Smith and Street suggest that "someone on behalf of society has to decide what objectives ought to be pursued. That is rarely a role for analysts or researchers—rather, it is the legitimate role of politicians. In developing a performance model, an important requirement is to seek out a clear political statement on what is valued from legitimate stakeholders."[3]

tapping into their interests, knowledge, experience and expectations was a central part of this project. By soliciting their input using a range of different methodologies, CIHI is better able to understand what various ministries are trying to produce and what they expect of the health system.

Using a range of methods, this report summarizes the main findings from our work to address the challenges associated with measuring health system efficiency, including making decisions about objectives, boundaries, measurement techniques and data availability.

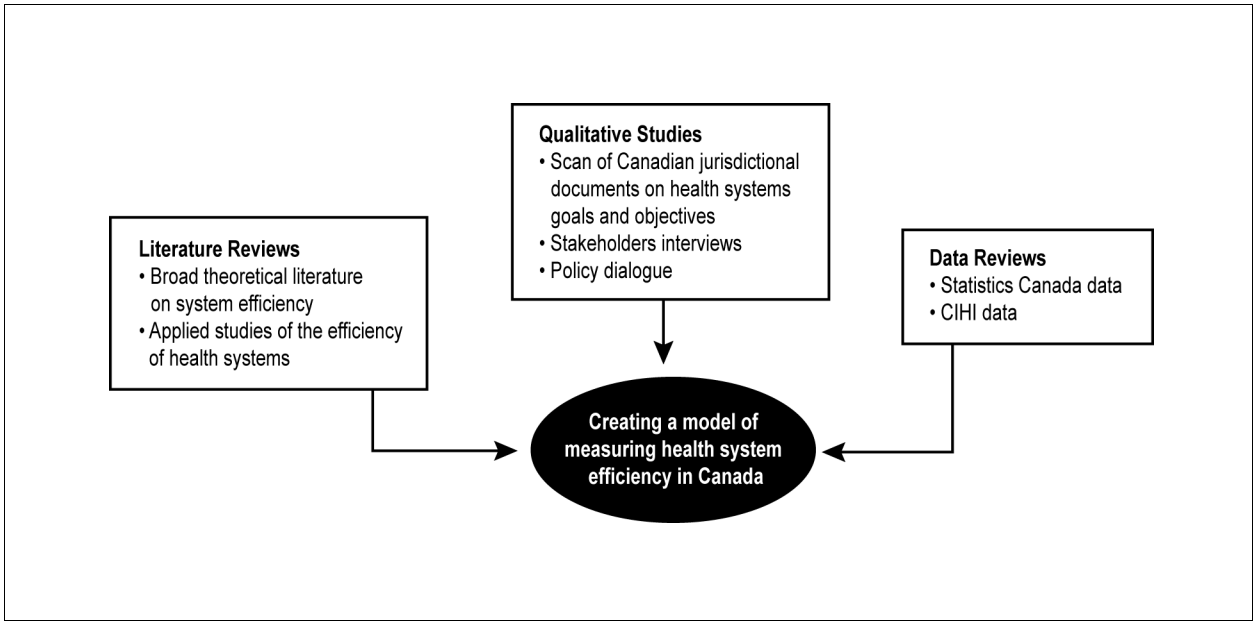
Methods

This report synthesizes information gathered from multiple sources, including

- Theoretical literature on efficiency (including health system efficiency and efficiency measurement from other sectors);
- Applied studies of efficiency within health systems;
- Publicly available documents produced by Canadian federal, provincial and territorial governments;
- Qualitative interviews and a stakeholder dialogue with senior health system decision-makers; and
- Data collected by CIHI and Statistics Canada.

Figure 2 illustrates major input components to the report.

Figure 2: Major Input Components to the Report



Literature Reviews

There were several literature review components to this report, from theoretical studies concerned with different approaches to measuring technical efficiency of public and private entities (not limited to health systems), to empirical (applied) studies concerned with measuring efficiency of health systems at various jurisdictional levels. Fifty-six studies conducted at the national, sub-national and local levels were reviewed to analyze choices of health system measures and methods used, including the rationale that underlies those choices. Facility-level studies (such as those conducted among hospitals only) and drug, treatment and intervention-specific studies were excluded from the review. See the appendix for a more detailed explanation of the methodology used for the literature review components of this project.

Qualitative Studies to Collect Stakeholders Opinion

In contrast to previous studies, CIHI collected information on stakeholder views regarding health system objectives and boundaries to determine what should be included in and excluded from the final efficiency model. CIHI used a broad range of consultation methods for this exploration, including

- A policy review and synthesis of government documents available in the public domain;
- Semi-structured interviews with senior civil servants serving in Canada's provincial and territorial governments; and
- A facilitated stakeholder dialogue with senior health system decision-makers.

CIHI is attempting to create a model of health system efficiency measurement that can provide suggestions and insight for action to those who are responsible for allocating scarce health system resources across competing needs and a range of settings. The choice of stakeholders for these consultations thus included federal, provincial and territorial policy-makers who are responsible for health system governance in Canada. Further details are presented in Table 1.

1. **A review of publicly available documents produced by Canadian federal, provincial and territorial governments.** CIHI reviewed and synthesized publicly available information at the provincial, territorial and federal levels, such as annual reports, legislation, parliamentary speeches and committee reports, and strategic planning documents and frameworks. To stay within a reasonable project scope, sources related to specific political parties such as speeches from the throne, political party platforms or transcripts from parliamentary debates were not included in the review. Analyses set out to identify objectives, visions and goals expressed for the health system in order to articulate roles and responsibilities and to identify any health system performance frameworks. The review process was iterative and was adjusted as required (for example, refining the key words, including multiple document types and incorporating various points in time) based on a preliminary search and review of the results. The team collaborated to build a preliminary list of domains, which guided the scanning of all sources and documents. Relevant information from these domains was then documented in a series of spreadsheets (provincial, territorial and federal), which were adapted as the team grew more familiar with the content. Analyses subsequently explored categories within stated objectives and outcomes of the health

system including overall population health; distribution and disparities; and system performance/priorities. Additional categories were created around accountability and balancing priorities as coding progressed. For more information on methods and findings, see the companion product *Developing a Model for Measuring Health System Efficiency in Canada—Policy Review Summary*.

2. **Semi-structured interviews with senior health ministry personnel.** Interviews with current and former senior health ministry officials across the majority of Canadian provinces and territories were conducted by external contractors. Included were those holding relevant deputy minister, assistant deputy minister, associate deputy minister, executive director and director positions for a minimum of two years and individuals who had recently departed from these positions (for example, moved to a different portfolio in the same ministry, moved to a different ministry or left the public service altogether). Key informants were selected using a combination of purposive and snowball sampling with positional criteria guiding the final decisions. These non-probability sampling techniques were best suited to the overall goal of this study. The goal of the sampling strategy was to identify individuals who, through their positions in government, were able to contribute most meaningfully to defining the range of health system inputs and outcomes that are most highly valued and why. The interview guide included questions that would elicit interviewee perspectives on the objectives and outcomes of their jurisdiction's health system and the health system inputs required to achieve them. Three interviews with former health ministry officials were used as a pilot to refine interview questions. All interviews were conducted by telephone and audio-recorded; later they were summarized to extract key themes and illustrative quotes from each interview question. Interview transcript data was also entered into a qualitative data management and analysis program to identify recurring themes across the interviews. For more information on methods and findings, see the stakeholder interviews companion product *A Qualitative Study of Provincial and Territorial Health Ministry Perspectives*.

3. **A stakeholder dialogue with senior health system decision-makers.** The stakeholder dialogue (also called a policy dialogue) undertaken for this project was convened on behalf of CIHI by the McMaster Health Forum to support a full discussion of relevant considerations about health system efficiency. See Box 4: Policy Dialogues for more information on the subject.

The dialogue included several key steps:

- Creating a pre-circulated issue brief that mobilized both global and local research evidence about the issue and key implementation considerations, elements of a model of health system efficiency and the challenges encountered in health system efficiency measurement;
- Ensuring fair representation among policy-makers, stakeholders and researchers through broad participation;
- Engaging a facilitator to assist with the deliberations;
- Conducting frank, off-the-record deliberations and not aiming for consensus; and
- Producing a summary report outlining the main decisions from the deliberations.

Participant views and experiences and the tacit knowledge they brought to the issues at hand were key inputs to the dialogue. The dialogue was designed to spark insights—insights that can come about when all of those who will be involved in or affected by future decisions about the issue can work through it together. The dialogue was also designed to generate action by those who participated in the dialogue and by those who review the dialogue summary in the future. For more information on methods and findings, see the Measuring Health System Efficiency event at the McMaster Health Forum.

Table 1 provides a summary of the goals of each qualitative portion of the study, their selection criteria and sample size.

Table 1: Qualitative Studies to Collect Stakeholders' Opinions

	Analysis of Government Documents	Elite Interviews	Facilitated Stakeholder Dialogue
Goal	To identify the stated objectives (that is, goals, mandates or visions) for the health system and their performance measures	To identify, explore and better understand health policy-makers' views regarding the desired inputs to and outcomes of the health system	To solicit stakeholders' views on health system objectives, boundaries and methods by giving stakeholders an opportunity to express their views in a frank, off-the-record facilitated deliberation
Selection Criteria	Publicly available documents produced by Canadian federal, provincial and territorial governments that address health system administration, functions and delivery (for example, annual reports, legislation and strategic documents)	Current or former senior health ministry officials of Canadian provincial and territorial governments (that is, deputy ministers, associate deputy ministers, assistant deputy ministers, executive directors and directors)	Current or former senior decision-makers from Canadian federal, provincial and territorial governments, health system consultants, and senior executives from technical-, administrator- and practitioner-oriented groups
Sample Size/Frame	A number of websites and publicly available resources from all provinces and territories, and select federal sources	17 interviewees from 9 provinces and 2 territories	16 participants from 6 provinces, 1 territory and the federal government
		There was no overlap between the participants in the 17 elite interviews and the 16 participants in the facilitated stakeholder dialogue	

As qualitative research usually does not quantify or enumerate,[26] both methods, interviews and stakeholder dialogue did not attempt to arrive at frequencies with which certain viewpoints were expressed by participants. All opinions expressed by stakeholders were valued equally in the transcript analyses. Although consensus was never sought, certain key themes and normative choices (represented by illustrative quotes in the companion products) dominating

Box 4: Policy Dialogues

Policy dialogues, or deliberative processes, are methods used to better support and engage in evidence-informed decision-making.[24] They draw on several forms of evidence to facilitate discussion about how and in what contexts evidence can be used to take action, and can be seen as useful evidence in their own right to complement other forms of scientific evidence.[24] Policy dialogues serve to engage various stakeholder groups in decision-making processes[25] and to integrate scientific evidence with stakeholder views.[24]

the discourse were captured by the involved researchers and are included in the following sections of this report. Researcher experience and skill served as a main instrument to judge prevailing opinions with respect to health system objectives, outcome measures, inputs and other relevant elements of the efficiency model.

Review of Data

As a final step of the study, a review of data (that is, indicators) availability and completeness at the provincial, territorial and health region levels was conducted using CIHI's and Statistics Canada's databases. The goal of the review was to identify appropriate indicators to be entered in the efficiency model, the level at which the data is collected (provincial or regional) and the year in which it was collected. In addition, CIHI assessed details on the quality of the data and on the quality of the collection process. The results of this review are summarized in the companion report *Developing a Model for Measuring Health System Efficiency in Canada—Data Availability*.

Chapter 3: Measuring Efficiency

There is no single way to measure health system efficiency. An OECD study identifies three common approaches to measure system efficiency: a sub-sector approach, a disease-based approach and a system-level approach.[14]

A **sub-sector approach** focuses on efficiency in a specific sector (such as inpatient care, outpatient care, pharmaceuticals, long-term care) and provides sector-specific policy recommendations. This approach is commonly used;[27] however, it does not take into account certain system challenges, such as coordination of care within the system, and can ignore inefficiencies in other sub-sectors. As a result, this approach might have little impact on the overall health status of the population.[13]

A **disease-based approach** focuses on health gains due to specific disease treatments[14] and does not cover the full range of the health system. Therefore, using this approach can lead to gaps in understanding efficiency within other areas that lie outside of these disease categories. However, a disease-based approach can be used to supplement the other two approaches because it focuses on health gains due to specific treatments and can produce disease-specific recommendations.[13] For example, a recent four-year research project in Europe called EuroHOPE was launched to evaluate the performance of European health care systems in terms of outcomes, quality, use of resources and costs for acute myocardial infarction, stroke, hip fracture, breast cancer and low-birth-weight infants.[28]

A **system-level approach**, employed by the WHO,[16] the OECD[13] and individual researchers,[29, 30] focuses on the broad objective of the health system, encompassing all health-related interventions for all individuals in the population. This approach explores the feasibility of measuring and comparing health systems across countries or within them. Using this approach, researchers must agree on the objectives of the health system as a whole, at a population level, and the best way to measure those objectives. This poses a challenge given that a range of factors that fully or partially lie beyond the control of the health system may influence whether and how these objectives are achieved.[14]

This report focuses on the system-level approach to measuring efficiency while recognizing that performance information at the sub-sector and disease levels could be useful complements to the analysis. Taking into consideration the potential limitations of this approach, this report aims to measure efficiency in a way that yields actionable results for policy-makers and system managers.

Components of the Efficiency Model

Based on CIHI's literature review, measurement of efficiency frequently consists of the following procedures:

- Calculate an efficiency score for each DMU in the system using one or several methods of the calculation. Given that some methods account for varying factors lying outside of health system control (for example, environmental factors), multiple methods are encouraged.
- Explore correlations between efficiency scores and various system performance measures (for example, access and quality) or factors that partially within the control of the health system (for example, smoking and obesity), and suggest ways to improve efficiency within the DMU.

While the calculation of efficiency scores is consistent across health system efficiency studies, there is great variation among the methods that account for environmental factors and health system performance characteristics. If environmental factors and health system performance characteristics are distinguished from inputs, they are either included alongside inputs as an uncontrollable parameter[31] or used as factors for efficiency scores in the second-stage regression analysis.[32]

To perform the procedures outlined above, four major components of the model must be identified:

1. Health system *objectives* (that is, what the system is meant to achieve), which will represent system outputs or outcomes in the final efficiency model;
2. Health system *boundaries* (that is, what is included in the system and what is not). This can include resources in the system (inputs), factors that lie outside of the health system but can be influenced by health system resources (throughput factors) and factors that lie outside of the control of the health system but can impact efficiency (environmental factors or constraints);
3. Health system *decision-making units* (DMUs) that convert resources (inputs) into outputs; and
4. The *methods* (estimation techniques) used to measure efficiency.

There is no single agreed-upon method for determining any of these components of efficiency.[5] However, the definition of these four components will directly affect the results of efficiency measurement. The process of defining these components requires making assumptions, and choices often depend on the values of system stakeholders.

In defining a tool to measure the efficiency of the Canadian health system, it is important to explore health system objectives and to make some decisions on what the system is meant to achieve (see Box 1: Key Concepts in Chapter 1).

Based on CIHI's literature review, there appears to be a lack of consensus both on the objectives of the health system and on concrete measures of these objectives. Moreover, there is frequently no clear rationale for choosing one type of objective over another, although some studies select objectives based on data availability.[13] This project aims to develop a tool that is methodologically sound and useful to policy-makers; therefore, seeking stakeholder input on defining health system objectives and proper measures of outputs and outcomes was integral to this project.

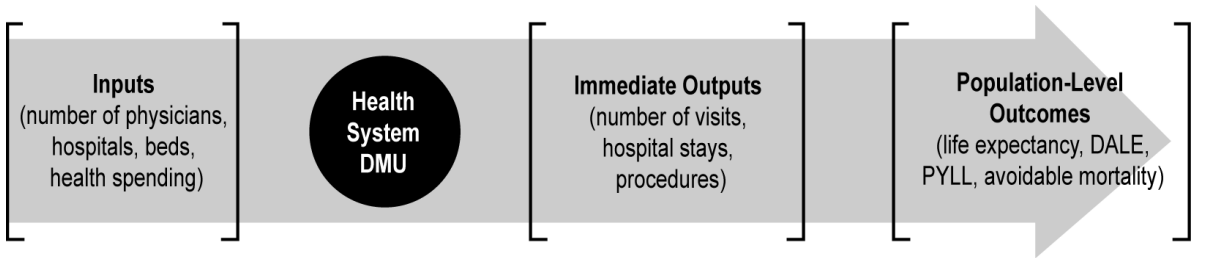
Choosing Between Health System Outputs and Outcomes

There are two major options for measuring health system objectives at the system-level (see Figure 3):

1. Measuring intermediate outputs (that is, health system activities such as the number of visits, hospital stays or procedures); and
2. Measuring population-level outcomes, such as life expectancy, disability-adjusted life expectancy (DALE), potential years of life lost (PYLL) and avoidable mortality.

Activity-based measures (outputs) are commonly used in hospital efficiency measurement, while a system-level approach usually focuses on population health outcomes.[14] Indeed, the literature review that informed this project identified that the majority (approximately three-quarters) of system-level studies opted for some measure of population-level outcomes (for example, Joumard, 2010,[13] and WHO, 2000[33]). Less than one-quarter of studies measured efficiency using system outputs, including number of visits, hospital stays, procedures or other types of activity (for example, Luoma et al., 1995,[34] and Gerdtham, 1999[35]).

Figure 3: Simplified Health System Workflow Schema



The literature suggests that using outputs in efficiency measurement would encourage the system (DMUs) to focus energy on such things as providing more procedures, longer hospital stays or more frequent physician visits, which do not necessarily translate into improved health at the population level.[35] In fact, focusing on outputs in this way has been shown to worsen population health.[35] Moreover, minimizing certain outputs could be considered an indicator of successful preventive efforts. For instance, the OECD considers lower rates of indicators such as avoidable in-hospital admissions as an indication of improved system performance.[36] In contrast, health system outcomes can be defined as changes in the health of the population attributed to the health system and thus have the potential to be more appropriate for identifying health system efficiency.[13] Given that CIHI's focus is on efficiency of the health system as a whole, using system-level outcomes as opposed to activity-based outputs is more appropriate for the purposes of our work. This approach will encourage improvements in population health instead of an increase of certain activities. Table 2 presents the differences between health system outputs and outcomes with regard to measuring health system efficiency.

Table 2: Options for Choosing Health System Objectives: Outputs Versus Outcomes

	Option 1: System Outputs	Option 2: System Outcomes
Health System Objective	Providing more services	Overall improvements to population health
Focus	Process outcomes of the health system, certain services and/or procedures	The health system as a whole
Measure	Visits, hospital stays, number of procedures	Life expectancy, DALE, premature mortality, PYLL

Box 5: Key Concepts

Life expectancy at birth is the average number of years a newborn can expect to live given prevailing mortality rates.

Disability-adjusted life expectancy (DALE) is an indicator that adds the concept of quality of life to life expectancy.[39]

Health-adjusted life expectancy (HALE) is the number of years—in full health—that a person at a given age is expected to live. It reflects both morbidity and mortality statistics.

The **Health Utility Index (HUI)** is used to assign a higher weight to the number of years lived in good health compared with those lived in poor health.

Disability-free life expectancy (DFLE) is the number of years—free of any activity limitation—that a person at a given age is expected to live. The measure uses only those years lived free of any activity limitation.

Health System Outcomes

The literature review conducted for the purposes of this report indicates that life expectancy, infant mortality rate and disability-adjusted life expectancy were the most common measures of health system outcomes. These were followed by potential years of life lost and survival rates. In general, the studies provide no justification beyond data availability for the choice of outcome measures.

The literature review also indicates that the pool of experts who follow an outcome approach could be divided into two groups. The first group (such as authors of *The World Health Report 2000*[16]) suggests that the health system should generate the largest possible level of health for the entire population. This group tends to use some measure of quality-adjusted life expectancy (for example, DALE or HALE) that involves comparing one's health state to a state of absolute perfect health (see Box 5: Key Concepts). Because this group considers the health of the entire population as the main objective of the system, they also consider the need for allocating resources to prevention as well as to treatment. A number of methodological and ethical issues have been raised in association with quality- or disability-adjusted life expectancy measures.[37, 38]

The second group (such as Or, 2005,[40] and Wagstaff and Wang, 2011[30]) uses an avoidable mortality approach. They consider the main goals of the health system to be the delivery of quality treatment to the sick and provision of illness and injury prevention, and accordingly measure performance based on the ability of the system to contribute to survival rates or reductions in the number of potential years of life lost (PYLL) or avoidable mortality (see Box 6: Key Concepts). Instead of comparing one's health state to a state of absolute perfect health, these experts prefer to estimate the effect of treatment and prevention.The use of avoidable mortality as a measure of health system outcomes suggests that the health system is responsible mainly for providing access to timely and effective health system and preventive measures. One limitation of premature mortality and PYLL is that progress in care for people age 75 and older would not be captured by these indicators.

Box 6: Key Concepts

Premature mortality: The age-standardized rate of premature deaths per 100,000 population. Premature deaths include individuals who are younger than 75 years of age. It is an overall indicator of population health that reflects deaths at younger ages, and can be used to guide efforts on health promotion and disease prevention. It requires creating a list of causes of death attributable to untimely or ineffective health care service (that is, deaths that should not have occurred if health care had been timely and effective).

Potential years of life lost (PYLL): A calculation of all deaths occurring at each age before 75 years of age and multiplying this by the number of remaining years to live until age 75.

Potentially avoidable mortality: The age-standardized rate of premature deaths that could potentially have been avoided through all levels of prevention (primary, secondary, tertiary) per 100,000 population. Premature deaths are those of individuals who are younger than 75 years of age.

Mortality from preventable causes: The age-standardized rate of premature deaths that could potentially have been prevented through primary prevention efforts per 100,000 population. Mortality from preventable causes is a subset of potentially avoidable mortality. It focuses on premature deaths from conditions that could potentially be avoided through primary prevention efforts, such as lifestyle modifications or population-level interventions (for example, vaccinations or injury-prevention activities). This indicator is relevant for reducing the number of initial cases (that is, incidence reduction), as deaths are prevented by avoiding new cases altogether.

Mortality from treatable causes: The age-standardized rate of premature deaths that could potentially have been avoided through secondary or tertiary prevention per 100,000 population. Mortality from treatable causes is a subset of potentially avoidable mortality. It focuses on premature deaths that could potentially be avoided through secondary and tertiary prevention efforts, such as screening for and effective treatment of an existing disease. This indicator is relevant for reducing the number of people who die once they have the condition, or case-fatality reduction.

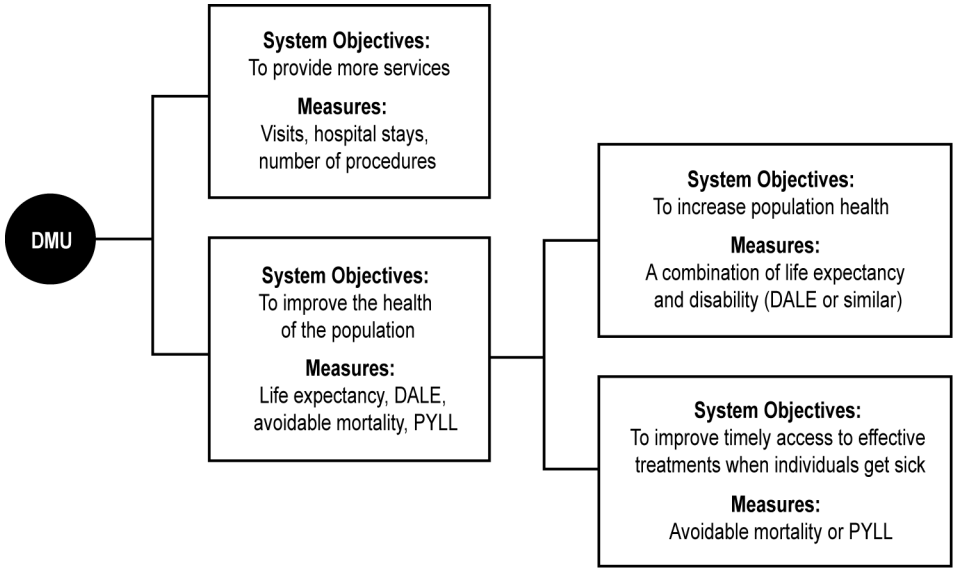
Table 3 presents the differences between these two groups and their approaches to health system outcomes.

Table 3: Options for Choosing Certain Health System's Outcomes

	Option 1: Improving Population Health	Option 2: Providing Access to Timely and Effective Health Services
Health System Objective	To generate the largest possible level of health within the population	To provide access to timely and effective health services
Outcome Measures	A combination of life expectancy and disability considerations (for example, DALE or a similar measure)	Survival rate, premature mortality or avoidable mortality (for example, PYLL or a similar measure)

In a recent study, the OECD reported a correlation between various measures of health system outcomes.[17] However, the reported correlation of -0.53 to -0.68 between DALE and PYLL indicates there is still the possibility of a DMU scoring high using DALE but low using PYLL when assessing health outcomes. Therefore, choosing outcome measures is an important decision in measuring efficiency. The decision tree depicted in Figure 4 represents the choices that need to be made in assessing system objectives and tools for measuring health system efficiency in Canada.

Figure 4: Decision Tree for Selecting System Objectives



Health Inequality Considerations

Achieving health equity has consistently been an important concept when discussing the objectives of the health system in Canada (see Box 7 for key concepts related to equity). Since the introduction of publicly financed health care for physician and hospital services (collectively referred to as medicare), the health system has followed the principles of universality and solidarity that sought a more equitable sharing of the burden of illness.[47] Equity considerations were featured prominently in such high-profile Canadian reports as Senator Kirby's *The Health of Canadians—The Federal Role*[48] and Commissioner Romanow's *Building on Values: The Future of Health Care in Canada*.[42]

An OECD report defines two groups of socio-economic–related health inequalities: inequalities in health status, measured by exploring difference in outcomes such as self-rated health or life expectancy, based on socio-economic status (SES); and inequalities in health care access and use, measured as differences in health services use or unmet medical need based on SES or income groups.[49] Another dimension of inequalities includes horizontal (equal treatment of equals) and vertical (appropriate unequal treatment of unequals) inequalities[1] (see textbox for definitions).

Socio-economic inequalities not associated with health (for example, income inequalities, measured as a GINI coefficient) are characteristics of the environment that health system DMUs must operate in. These will be discussed in a later chapter on health system boundaries.

Developing a model to measure efficiency requires making decisions as to whether the health system has an objective to reduce these health inequalities or not. If the decision is made that reducing inequality is an important function of the system, it would need to be included in the model as an additional health system outcome, along with other system objectives such as increased population health or reduced premature mortality. However, aggregating multiple objectives into efficiency measurement causes difficulties within the calculations due to requirements involving weighting certain objectives over others—an approach criticized in the literature.[51] Alternatively, health inequality measures (such as Concentration Index measures of health status) can be used in regression analyses to explain variations in health system efficiency across DMUs.

Box 7: Key Concepts

Health inequality is the term that signifies the existence of differences, variations and disparities in the health of individuals or groups.[41]

Health inequity refers to those inequalities in health that are perceived to be unfair.[41]

Equity means that citizens get the care they need, regardless of their social status or other personal characteristics such as age, gender, ethnicity or place of residence.[42]

Horizontal equity requires that patients who have the same needs be treated the same.[43]

Vertical equity in health care requires that patients with different needs be treated differently in an appropriate fashion that takes need and severity into consideration.[43]

GINI coefficient is a common measure of income distribution in a population that serves as a measure of income inequality. The GINI coefficient ranges from 0 to 1: 0 representing perfect equality and 1, total inequality.[44]

Concentration Index (CI) is another measure of inequalities similar to the GINI coefficient. It measures health care utilization differences associated with SES.[45]

The **Horizontal Inequity Index (HI)** measures health care utilization differences associated with SES after need standardization.[46]

Table 4 outlines two options for treating health inequality in an efficiency model.

Table 4: Options for Accounting for Equity Considerations

	Option 1: Health Inequality Is Not an Explicit System Objective	Option 2: Health Inequality Is an Explicit System Objective (in Addition to Other Health System Outcomes)
Health System Objective	To improve average access to effective treatment or average population health. As a result, health inequalities will be improved, as there is no trade-off between population outcomes and health inequalities.	To reduce health inequalities (to improve services to those who are in poorest health)
Target Group	The entire population who needs health services based on health status	Low SES group in poor health
Outcome Measure	Inequality is not included in the main efficiency analysis as a system outcome, but it could be included in additional analyses to explain inefficiencies	Concentration Index and/or Horizontal Inequity Index (capturing health status, health service access and health service use) should be added as an additional system outcome to the efficiency score calculation

Stakeholder Views on Health System Objectives

In contrast to previous studies, CIHI collected information on stakeholder views regarding health system objectives and boundaries (discussed later in the report) to determine what should be included in and excluded from the final efficiency model. CIHI used a broad range of consultation methods for this exploration to ultimately identify stakeholder views about the desired objectives of the health system, compare views across a range of decision-maker groups and identify how stakeholders prioritize different outcome measures that capture these larger objectives. This process allowed CIHI to incorporate more meaningful components and evidence into the final efficiency model and subsequent analysis. The following sections discuss the main findings from these consultations.

Government Documents

CIHI undertook a policy review and synthesis of government documents available in the public domain, exploring select documents from the federal, provincial and territorial levels. At the federal level, explicit goals for the system most often involved an articulation of the five *Canada Health Act* principles, with significant focus on ensuring timely access regardless of ability to pay and avoiding financial hardship as a result of paying for health care.[52, 53, 54] The most comprehensive set of goals for Canada was articulated in a federal/provincial/territorial effort entitled *Health Goals for Canada*. Although never formally endorsed, the goals draw on several themes related to prevention, promotion, health disparities and better population health,[55] and remain a valuable resource for understanding aspirations for health in Canada. Unlike at the provincial level, across all areas of inquiry the majority of federal sources tended to have statements that related to public accountability[52, 56] and sustainability. [52, 57]

Apart from these statements, there was a mix of statements related to overall population health and health disparities.[52, 56] Although goals for the health system involved overall population health, disparities, public accountability and sustainability, recommended areas for measurement and indicator monitoring focus more on the quality and accessibility of care delivery and general performance.

At the provincial and territorial levels, the most common statements or themes were optimal population health and well-being,[58–60] followed by quality of life when adapting to disability, illness or aging.[61] In addition, the documents mentioned health promotion[59, 62, 63] and disease prevention,[64] supporting the social determinants of health[65] and self-reliance.[66, 67] In referencing system performance and priorities, statements focused heavily on accessibility[58, 64, 68, 69] and quality or effectiveness of service.[61, 63, 64] The provincial and territorial sources included themes about continuity of care,[70] integration of services,[68] alternative forms of care,[65] patient-centred care,[71] and timely and appropriate care,[68, 72] followed by objectives such as cost effectiveness, efficiency[59] and innovation.[61]

In terms of equity statements, there was a mix between explicit statements about addressing disparity and other statements focused on identifying and meeting the needs of vulnerable populations. For instance, in some jurisdictions, there is reference to "reducing inequalities in health status"[59] and "ensuring equitable and quality services,"[58] or simply the mention of "equity" as a goal or vision for the health system.[68] In other jurisdictions there is reference to providing better care for specific populations,[71] including seniors, children, people at risk of abuse and those with disability or illness (mainly chronic conditions or mental illness/addictions).[58] Equity-related statements were present in all jurisdictions, although these statements were limited compared with the other categories.

Overall, in publicly available government documents, the two main stated objectives for the health system appear to be to improve average population health and to ensure timely access to care (without prioritization between the two). There was a limited focus on equity across the literature, although there were examples of explicit statements referring to the reduction of health disparities and inequalities, as well as specific reference to improving the health of vulnerable groups.

Elite Interviews

Semi-structured interviews were conducted with current and former senior health ministry officials across the majority of Canadian provinces and territories to further explore these findings. Stakeholder opinions collected through the interview process revealed that senior civil servants clustered key objectives for their provincial and territorial health systems around two main themes: improving health care delivery; and promoting and improving the health of individuals.

Almost all respondents listed at least one objective for the health system that focuses on health care delivery and just over half identified objectives related to improved population health. The most frequently cited objectives included access to diagnosis and treatment of disease, and providing accessible quality health care that is also adequate, appropriate, patient-oriented, effective and efficient. Additional objectives included creating a healthy workplace environment

with an appropriate mix of health human resources and ensuring high professional standards. Population-based objectives included such goals as improving the health of the population, health promotion and disease prevention, reduction of inequalities, and addressing determinants of health. Most stakeholders acknowledged that in an ideal world they would favour the improvement of population health over accessibility to treatment but public demand often forces an emphasis on access to services for those in need.

In terms of equity considerations, stakeholders emphasized that the most important objective of the health system in Canada is diagnosis and treatment of illness and disease, which includes ensuring health care is available where and when it is required. Focusing on disadvantaged socio-economic groups had lesser priority over accessible and quality care for everyone who requires it.

Overall, senior civil servants favoured accessible high-quality care over any other system objective or priority. They preferred health services to be available to all Canadians without a specific focus on disadvantaged socio-economic groups.

Stakeholder Dialogue

CIHI sponsored a policy dialogue with senior health system decision-makers to support a full discussion of relevant considerations about health system efficiency. Most dialogue participants agreed that enhancing the system's response to the health care needs of the population was the primary objective of the health system in Canada, and hence favoured the use of outcome measures such as premature mortality, potential years of life lost or other similar measures.

Participants emphasized the importance of focusing on diagnoses amenable to care and that, currently, Canadians often judge the health system based on the extent to which it provides access to timely and effective health care. Though premature mortality and other similar measures do not consider disability, these measures represent an important first step in the effort to measure health system efficiency, and participants felt that these suggested measures best captured expectations of the system.

Participants also recognized the value in having multiple health system efficiency measures and the value in maximizing average population health as an additional complementary objective of the health system. For these reasons, participants noted that incorporating measures that focus on overall population health, such as DALE, would be an important next step after CIHI makes progress in assessing health system efficiency using measures that capture access to timely and effective health care (for example, premature mortality).

Participants agreed that in addition to improving health system outcomes, there should also be some focus on reducing inequalities in health. They felt this could best be achieved through cross-ministry and cross-jurisdictional activities designed to address the determinants of health on a broader scale. However, some participants argued that enhancing health system performance should receive higher priority. Overall, dialogue participants favoured timely access to effective treatments when individuals get sick as the objective of the health system, and felt that health equity was a secondary system objective.

Summary of Stakeholder Views on Health System Objectives

There is agreement across the various forms of stakeholder consultation that the objective of Canada's health system should involve improving the overall health of the population as opposed to prioritizing specific sectors of the health system or specific diseases. Stakeholders agreed that objectives related to population health—including providing care to Canadians when they are sick—and focusing on both treatment and prevention are important priorities when assessing efficiency in the system.

Across all consultation methods, stakeholders emphasized the importance of reducing inequalities in health status and ensuring equitable and quality services. However, most evidence points to the importance of accessible and quality care for everyone who requires it, while limited evidence points to a needed focus on reducing inequalities among vulnerable groups in addition to improving overall health. This variation affects the decision of how CIHI chooses to incorporate inequality in the final efficiency model. Since most evidence points to the importance of providing access overall, inequalities in health status, as well as inequality in access and use of health services, would be more meaningfully incorporated as a variable in the regression analysis that further explores DMU efficiency scores, rather than as a variable used to calculate the efficiency score itself. Table 5 summarizes the results of the various forms of stakeholder consultation.

Table 5: Summary of Stakeholder Views on Health System Objectives

	Health System Objectives	Health Inequality Considerations
Review of Government Documents	To provide access to timely and effective health services (measured by avoidable mortality or similar measures)	Limited focus on reducing health inequalities as a system objective
Stakeholder Interviews	To provide access to timely and effective health services (measured by avoidable mortality or similar measures)	No explicit focus on reducing health inequalities as a system objective
Stakeholder (Policy) Dialogue	To provide access to timely and effective health services (measured by avoidable mortality or similar measures)	Explicit focus on health inequalities as an additional system objective

Available Indicators to Measure System Outcomes

CIHI and Statistics Canada provide an array of indicators to quantify health system outcomes. Table 6 includes some examples of indicators that could be used in the efficiency model. If not indicated otherwise, the listed indicators are available at CIHI and Statistics Canada at the provincial, territorial and health region levels. Additional information on these and other indicators, including their availability over time and across certain regions, can be found in the companion product *Developing a Model for Measuring Health System Efficiency—Data Availability*.

Table 6: Examples of Indicators for Measuring Health System Outcomes

Examples of Indicators	Short Description
Perceived Health	An indicator of overall health status reported by individuals age 12 and higher
Health Conditions	Information on selected health conditions, such as diabetes and high blood pressure
Birth-Related Indicators	Low birth weight and preterm birth
Life Expectancy	Life expectancy at birth and life expectancy at age 65
Premature Mortality	Age-standardized rate of deaths of individuals who are younger than age 75, per 100,000 population
Potential Years of Life Lost (PYLL)	All deaths occurring at each age before 75 and multiplying this by the number of remaining years to live until age 75
Potentially Avoidable Mortality	Age-standardized rate of premature deaths (before age of 75) that could potentially have been avoided through all levels of prevention (primary, secondary, tertiary), per 100,000 population
Mortality From Preventable Causes	Age-standardized rate of premature deaths that could potentially have been prevented through primary prevention efforts, per 100,000 population
Mortality From Treatable Causes	Age-standardized rate of premature deaths that could potentially have been avoided through secondary or tertiary prevention, per 100,000 population
Health Utility Index (HUI)	An index for measuring years lived in good health compared with years lived in poor health
Disability-Adjusted Life Expectancy (DALE)	A comprehensive index of mortality and health status
Wait-Time	Information on wait times for various procedures including such indicators as hip fracture surgery or diagnostic imaging (that is, MRI and CT scans)
In-Hospital Mortality	Information on selected conditions and interventions, including for instance 30-day in-hospital mortality for acute myocardial infarction (AMI) and stroke
Readmission	Information on readmission for selected conditions and interventions
Repeat Hospitalization for Mental Illness	A proxy measure for aspects of appropriateness of services

Health system inequalities evident across populations can be measured by stratifying premature mortality indicators (for example, potentially avoidable mortality) by income or other socio-economic characteristics. Income-related health inequalities can be measured by calculating a Concentration Index (CI) and/or Horizontal Inequity Index (HI) for a range of indicators. Table 7 provides more detail on indicators available from CIHI and Statistics Canada.

Table 7: Indicators to Measure Health Inequality and Calculate Concentration Index and/or Horizontal Inequity Index

Type of Inequality	Indicator
Income-Related Inequality in Health	• Perceived health status
Income-Related Inequalities in Health System Utilization	• Self-reported visits to general practitioners and specialists • Self-reported hospitalization • Self-reported access to family physicians
Income-Related Inequality in Health System Access	• Self-reported access to general practitioner

Proposed Health System Objectives for Health System Efficiency Model

The opinions of policy-makers and health system decision-makers were critical for making decisions on what health system objectives and related measures are to be included in the final efficiency model and related analyses. Although there was agreement that the health system should focus on taking care of those who are healthy (that is, including primary prevention efforts), there was considerably more emphasis placed on treating those who are sick (that is, ensuring access to good quality care). In addition, the stakeholder dialogue pointed to the importance of going beyond access or quality of health care services measures in the final efficiency model. Stakeholders felt that the final model should also take into account other population health outcomes over which ministries of health have influence.

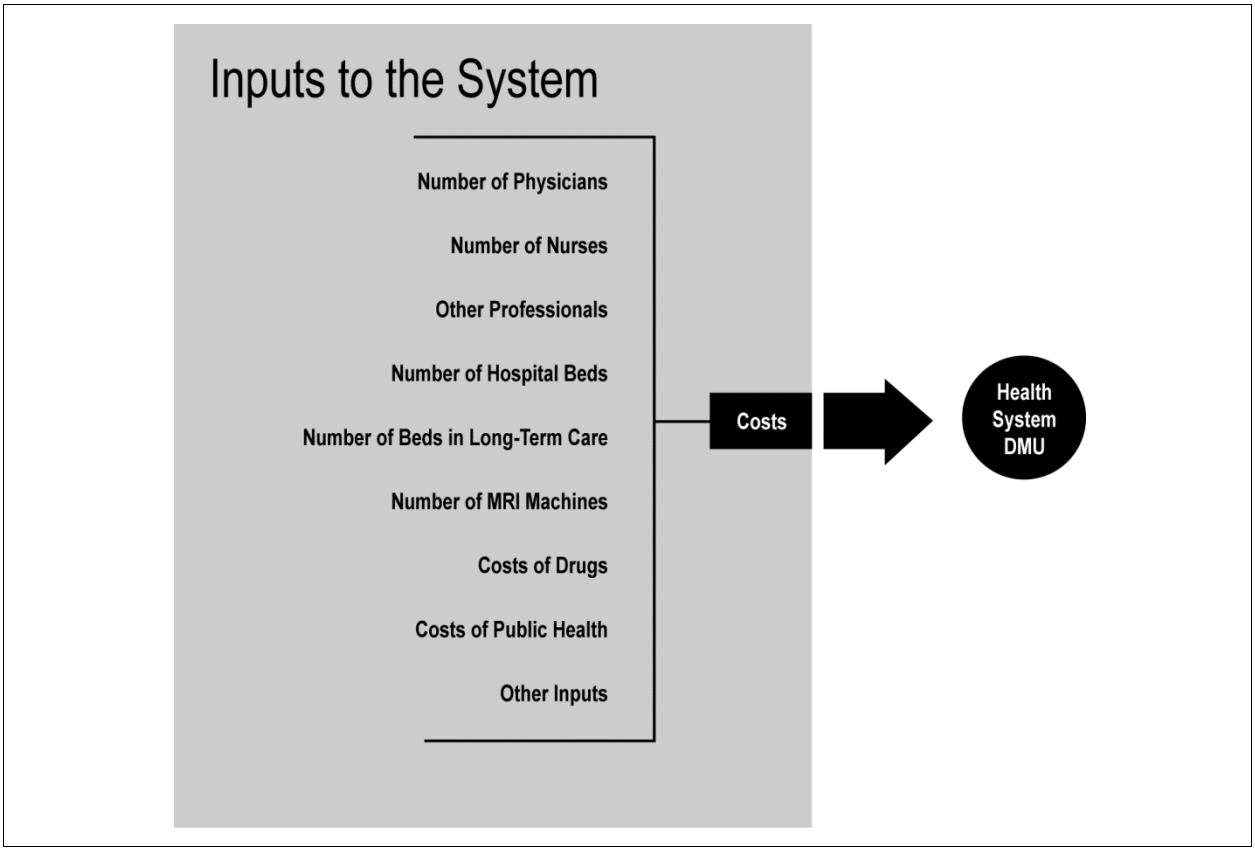
In terms of health inequalities (such as inequalities in health status and inequalities in health care access and use), most of the evidence indicates that stakeholders do not consider reducing health inequalities as a primary health system objective, although there was some agreement that this is a secondary priority of the system. Therefore, CIHI is proposing to avoid including measured health inequality in the health system efficiency score and instead include it in the model at the second stage of analysis, where a regression analysis will attempt to identify potential options for efficiency improvements. Other factors that may result in social inequalities (for example, income, gender or immigration status) will be considered as characteristics of the environment that the health system must operate in, and are considered further in the report discussion on health system boundaries. Further details of this proposed model are outlined later in this report.

Establishing the boundaries of the health system is a critical step in defining a model for measuring health system efficiency. The main decision points that need to be addressed to establish these boundaries involve reaching agreement on inputs (that is, system resources) and environmental factors (that is, factors that exist outside of the system or that act as system constraints). These two areas ultimately capture the features of the environment in which the defined DMUs operate.

Health System Inputs

System inputs are resources that the system uses to produce outputs and/or outcomes, and that are controlled by the system. In health systems, inputs can include such factors as the labour of health professionals, capital installed in hospitals or laboratories, and the utilization of drugs or devices used in treatments. Figure 5 provides additional examples of inputs.

Figure 5: Example of Health System Inputs



The literature review conducted for the purposes of this report found little consensus on how to define the inputs of the health system. The inputs most frequently chosen were physical resources (for example, the number of inpatient beds, physicians or nurses), followed by monetary units (for example, the dollar value of resources used in the system), or a combination of the two. In creating an efficiency model, once inputs have been decided on, they are directly entered into the production function to calculate the DMU's efficiency score. If the number of possible inputs is large, a sensitivity analysis can be run to identify the most important inputs for the model. Box 8 outlines additional considerations when choosing inputs for an efficiency model.

Box 8: Additional Considerations for Health System Inputs

Measuring units of input: An input to the health system can be measured by its dollar value, combining quantity and unit price, or by quantity only. For example, labour can be measured as expenditures on physician and nursing services, or as the density of these professions in the population. Choosing one method of calculation over another can affect efficiency results. For example, two jurisdictions may have the same number of doctors per 1,000 population, but the doctors in one jurisdiction may have different pay structures or levels of compensation. This jurisdiction could be considered more efficient than the other if labour input is measured in dollar value (assuming system outcomes are the same). However, if labour input is measured as number of doctors per 1,000 population, then efficiency would be considered the same.

Defining units of input: Depending on the input used in the efficiency model, the input can be defined in numerous ways. For example, "number of nurses" might include only practising nurses in the system or it might involve all individuals with a nursing degree who could potentially practise nursing in the area. The former approach assesses efficiency relative to what is spent, whereas the latter approach measures efficiency relative to what could be spent if all potential resources were put to use.

Time lags: One must also consider the gap in time between the use of resources and the effect these resources have on health, because most resources will have a delayed impact on the health of the population. For instance, adding more doctors to the health system today may lead to better care and potentially more illnesses diagnosed at an early stage, but the benefits for preventing serious problems and deaths would not be seen until future years.

Environmental Factors (Constraints) and Throughputs

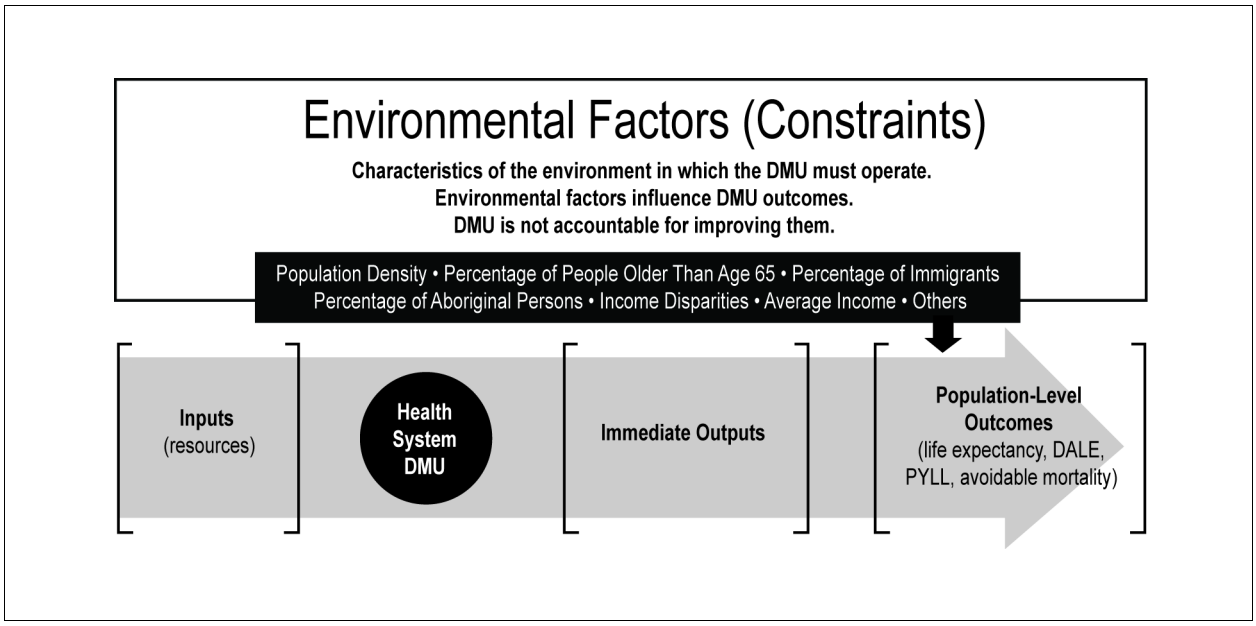
Factors that shape and form the environment in which a DMU operates or system constraints that exist outside the control of the health system are labelled as environmental factors. Building an efficiency model requires the identification of factors that influence health system outcomes and, therefore, efficiency within the DMU. One must then determine whether these factors are under the responsibility and control of the health system. For example, the proportion of the population age 65 years or older within the DMU area is an environmental factor that might affect how the DMU uses its resources, but the DMU cannot change the proportion of seniors in their geographic area, therefore making the factor a system constraint. Based on the literature, common environmental factors include

- Distribution of gender within the population;
- Physical and geographical characteristics;
- Socio-economic conditions (for example, income inequality or average income);

- Distribution of various demographic groups (for example, number of immigrants or number of people identifying as Aboriginal);
- Characteristics of sectors and related interventions existing outside of health including social service, justice or educational systems.[2]

Accounting for various environmental factors within an efficiency model allows researchers to compare DMU efficiency scores without the skewed effects that favourable or unfavourable factors across DMU environments might create. This approach provides increased focus on efficiency improvements under the control of the DMU and is better able to identify true performance leaders. Figure 6 illustrates environmental factors and their role within a health system efficiency model.

Figure 6: Environmental Factors That Influence the System Outcomes



Depending on the analysis methods used, there are several ways to account for environmental factors in an efficiency model. For example, when using stochastic frontier analysis (SFA), researchers are able to include environmental factors when defining the maximum possible outcomes (called an efficiency frontier). Conversely, when using data envelopment analysis (DEA), researchers are able to group DMUs by environmental characteristics and analyze efficiency of a DMU in comparison with other DMUs working under similar environmental conditions. Another common way to account for the influence of environmental factors on efficiency is to conduct a regression analysis using the efficiency scores and predetermined environmental factors, although this approach has raised some methodological concerns in the literature.[73] Further discussion on ways to account for environmental factors in the measurement of efficiency is provided later in this report.

The decision over which environmental factors are included in the final efficiency model is not straightforward, mainly due to the challenge of separating system inputs and environmental factors. For example, factors such as governance and organization of regional authorities, education of health professionals, or the presence and contributions of system actors such as private insurers or the pharmaceutical industry could all be considered inputs to the system or environmental constraints depending on one's perspective. The decision to label a factor as an input or an environmental constraint could in turn affect the results of efficiency measurement.

An additional challenge involves defining whether the health system can influence or take responsibility for improving the environmental factors in question. For example, the proportion of smokers or obese individuals within a DMU will influence that DMU's outcomes and efficiency score. If these factors are considered environmental constraints (that is, the health system is not responsible for these factors and would not spend resources on smoking- and obesity-related interventions), then the efficiency model would have to adjust the results to account for these factors. On the other hand, the health system could be held accountable for reducing smoking and obesity because these factors are well-known precursors to a wide range of chronic diseases that continue to be a significant burden on the health system. In this case, these factors would be viewed as intermediate results of system performance and would thus need to be considered in the efficiency model as *throughputs*.[i] Throughputs would not be included in calculating efficiency scores, but they would be included in a regression analysis that further explores efficiency scores to help identify the factors that contribute to an efficient health system. See Figure 7 for a visual representation of how throughputs fit into an efficiency model and Table 8 for more information on health system boundaries.

i. The literature regards throughputs as intermediate outcomes or processes that link inputs and outcomes.[74]

Other type of throughputs such as health system performance indicators for various access and quality measures as well as health system inequality indicators could also be used in search for inefficiency explanation (see Figure 7).

Figure 7: Examples of System Environmental Factors and Throughputs

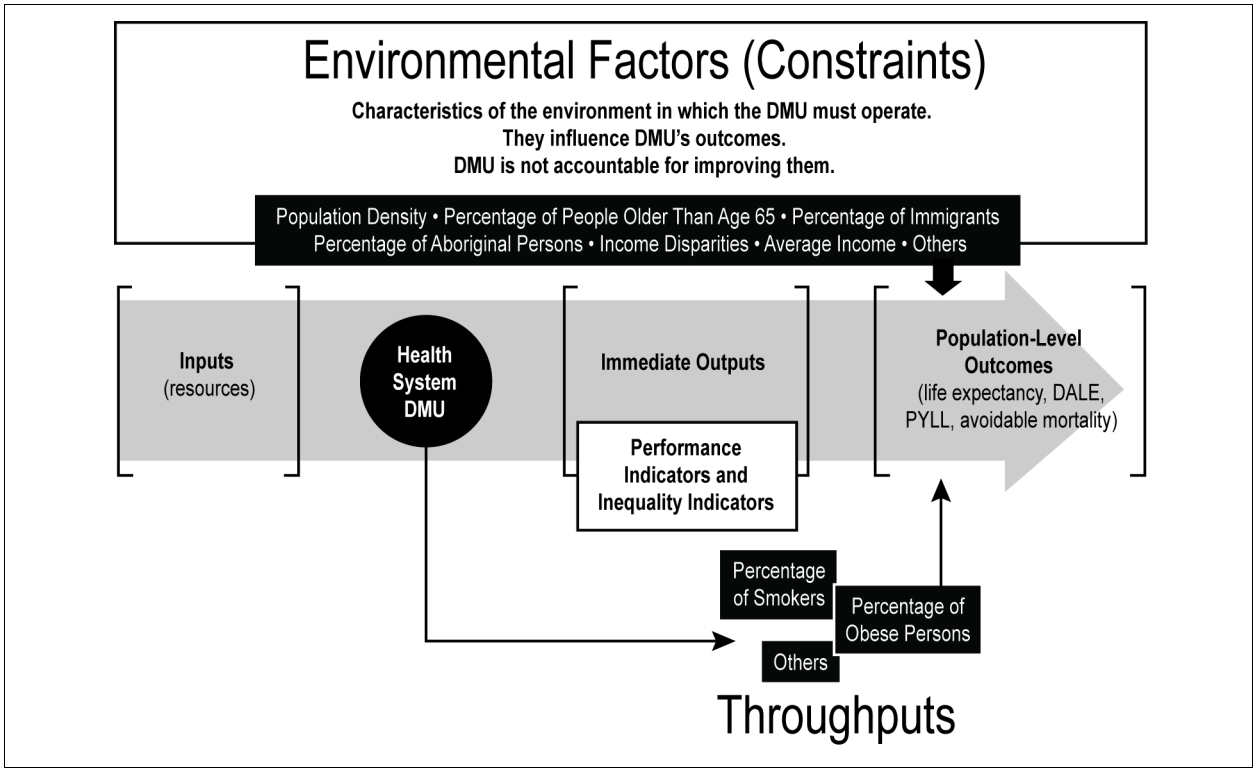


Table 8: Health System Boundary Components in the Efficiency Model

Boundary Components	Examples	Role in the Efficiency Model
System Inputs	Capital resources, human resources, treatment modalities, technologies	Used in the calculation of an efficiency score for each DMU
Environmental Factors (Constraints)	Geographic characteristics, demographic characteristics	Must account for these factors to eliminate differences between the DMUs that cannot be controlled by the DMUs. Depending on the analysis methods used, there are several ways to account for environmental factors in an efficiency model. For example: • Stochastic frontier analysis (SFA): environmental factors can be included when defining the maximum possible outcomes (called an efficiency frontier) • Data envelopment analysis (DEA): DMUs can be grouped by environmental characteristics, and efficiency of a DMU can be calculated in comparison with other DMUs operating under similar environmental conditions
Throughputs	Prevalence of obesity, prevalence of smoking[ii] System performance indicators	Including throughputs in the second stage of analysis by incorporating into a regression analysis to explore factors responsible for efficiency improvements. A sensitivity analysis may be used to identify the most important throughputs.

Stakeholder Views on Health System Boundaries

As with choosing the health system objectives to be included in the efficiency model, it is equally important to understand the perspectives of health system stakeholders on the question of which health system boundaries should be included. The qualitative interviews and stakeholder dialogue that informed this project explored opinions around appropriate inputs and the most important environmental factors and constraints to accurately calculate efficiency scores for DMUs. Neither of these consultation methods attempted to quantify the collected information; rather, they were designed to understand views more generally.

In the qualitative interviews, participants prioritized a number of specific inputs mainly related to labour and capital resources including physicians, nurses, pharmaceuticals, other allied human resources, hospitals, clinics, private offices, long-term care homes, community clinics and public health. They did not favour a specific way of measuring health system inputs nor did they exclude any specific physical or financial resources.

Conversely, stakeholder dialogue participants agreed that health system expenditures should be the principal input to the analysis. Participants did raise some concerns over the comparability of data between provinces because health provider salaries vary so much and, in most cases, fee negotiation structures and processes have become increasingly complex and variable across jurisdictions. However, participants felt that using health system expenditures allowed for greater

ii. Prevalence of obesity, prevalence of smoking and other lifestyle factors could be considered as throughputs or environmental factors and the choice depends on preferences of the system stakeholders.

flexibility and was better able to capture new types of health system providers or new ways of delivering health services that may arise in the future. Participants also advised that health system expenditures should include funding for disease prevention and health promotion initiatives. Participants felt that once an efficiency measurement had been established, additional efforts to broaden future analyses could include other measures of capital and labour inputs, with a focus on exploring optimal skill and provider mix, and effective technological innovations.

During the stakeholder interviews, participants prioritized a number of environmental constraints, including health system structures and arrangements (for example, jurisdictional boundaries and the varying roles and influence of physicians in health governance) and internal analytic and managerial capacity. However, currently, these constraints could not be readily integrated into the efficiency model, as there is a lack of indicators that describe them.

Establishing environmental constraints was challenging for stakeholder dialogue participants; however, they did note some environmental factors that lie outside the responsibility of the health system but that would be important for efficiency measurement. Examples include the proportion of new immigrants, levels of socio-economic deprivation, geographic characteristics and characteristics of the physical environment (for example, road quality, which may impact health care access and utilization). There was also some discussion about jurisdictional responsibility in providing health resources and about how much responsibility could be placed on regional decision-makers.

In exploring throughputs, system stakeholders identified that the prevalence of smoking, sedentary lifestyles and healthy diets could be considered as factors that come under the responsibility of the health system; however, the stakeholders also noted that these lifestyle factors could be viewed as characteristics of the environment that the health system operates under.

In addition, stakeholders suggested that a range of health system performance indicators could be useful when exploring factors that could encourage or hinder efficiency. Their recommendation was to start with indicators commonly used as part of current provincial priorities and to add indicators to the model in following years.

Data Availability

CIHI and Statistics Canada provide an array of indicators that could be used as health system inputs, throughputs and environmental factors in the measurement of efficiency. These indicators are all available at the provincial, territorial and health regional levels. Table 9 presents some examples of these indicators; additional information on these and other indicators are included in the companion report *Developing a Model for Measuring Health System Efficiency—Data Availability*.

Table 9: Examples of Indicators Representing Inputs, Environmental Factors and Throughputs (Including Quality and Access)

Indicator Category	Examples of Indicators
Inputs	• Hospital cost • Other health system institutions • Physicians (including GP and specialist) • Nurses • Other professionals (for example, dental and eye specialists) • Inflow/outflow rate • Public health spending (at the provincial level only) • Prescription medication (at the provincial level only)
Environmental Factors	• Population density • Unemployment rate • Average income • Proportion of people age 65 and older • Proportion of Aboriginal population • Proportion of immigrants • Income inequality (GINI coefficient) • Gender distribution
Possible Throughputs	• Proportion of smokers • Physical activity • Fruit and vegetable consumption • Obesity rate • Alcohol consumption
Quality and Access Performance Indicators	• 30-day AMI in-hospital mortality • 30-day stroke in-hospital mortality • AMI readmission • Asthma readmission • Prostatectomy readmission • Hysterectomy readmission • 30-day readmission for mental illness • Whether you have a regular family doctor • Wait time for hip fracture surgery • Wait time for other procedures (such as knee replacement, cataract surgery, and radiation therapy) and emergency departments

Summary of Health System Boundaries

Based on stakeholder consultations, there are a range of factors that could be considered as boundaries of the health system and that would inform the building of an efficiency model. These factors include

- Inputs to the health system—health system expenditures on hospitals, other institutions, doctors, nurses, other health care professionals, prescription medications and public health;
- Environmental factors—geographical and population-based characteristics at the regional level (for example, population density, proportion of residents age 65 and older, proportion of residents identifying as Aboriginal, proportion of immigrants, unemployment rate, average income, income inequalities and gender distribution);
- Throughputs—due to lack of clarity on whether the health system is responsible for making improvements in lifestyle factors (for example, proportion of smokers, obesity rates, indicators of physical activity, fruit and vegetable consumption and alcohol consumption), the model will include these factors as throughputs in one set of analyses and as environmental factors in another set. More details are provided in the Proposed Efficiency Model chapter of the report. Other throughputs include a variety of system performance indicators related to access and quality; and
- Health inequality indicators related to health status, health service access and health service use (listed in Table 7).
- A more detailed list of indicators contributing to the efficiency model is presented later in this report.

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Chapter 6: Decision-Making Units

A decision-making unit (DMU) is an entity that designs and controls the process that converts inputs into outputs and outcomes (for example, a hospital) or one that designs and controls the rules to which system stakeholders must adhere (for example, a government department or ministry).[3] A health system–level analysis uses DMUs at any level above an individual organization, such as a hospital, physician practice or residential care facility. The literature review conducted for the purposes of this project indicates that system-level studies of efficiency are typically carried out at a national level (that is, where the DMUs are countries),[32, 75] a sub-national level (that is, where the DMUs are provinces or states)[76, 77] and a regional level (that is, where the DMUs are regional authorities).[78]

In Canada, the health system consists of 10 provincial and 3 territorial sub-national health systems, which are responsible for administrating and delivering health care services and co-funded by the federal government. In most cases, these health systems are further divided into smaller health regions or health authorities. Each health region has a degree of authority to plan, fund and integrate health care within the region. Overall, there are more than 100 health regions in Canada. The number of health regions has changed over the years as a result of health system restructuring in some jurisdictions. The federal government is also responsible for administering and delivering health care services to particular groups in Canada.

Health regions exhibit enough difference in system-level inputs and outcomes to effectively compare health system efficiency across Canada. This report therefore proposes to use health regions as the system DMU for the final efficiency model. This decision is motivated by the following considerations:

- Health regions have the authority to make decisions that affect the use of resources at the local level;
- There are a large number of health regions in Canada, allowing the application of more robust statistical methods to calculate efficiency, which would not be possible if using only 10 provinces and 3 territories;
- Analysis at the local level allows provincial and territorial health ministries to exercise their stewardship role to identify best performers within their jurisdictions and use these examples for benchmarking; and
- Health system stakeholders consulted as part of this project support measuring efficiency at the regional level and using health regions as DMUs.

In taking this approach, some caution is required because health regions in some provinces do not actually control resource allocation in a way that is useful for efficiency purposes. For example, in Ontario, even though the health regions (that is, local health integration networks or LHINs) must carry out the implementation of certain initiatives (for example, a pan-Canadian electronic health record), the provincial government often makes key strategic decisions about how those initiatives will be designed and implemented.[79] In those cases, when resource decisions are made at a provincial level, it will be important to engage provincial governments in identifying efficiency improvements and opportunities suitable for collaboration with health regions.

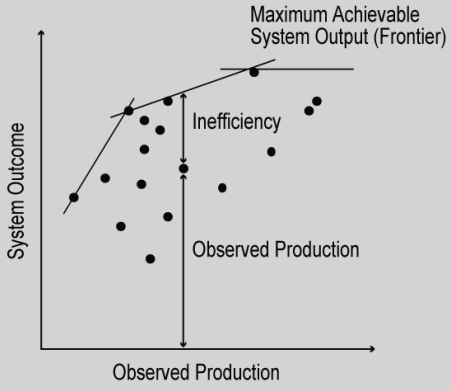
There are two broad statistical approaches for measuring efficiency: those that estimate a production frontier and those that do not estimate such a frontier. The production frontier is calculated by assessing the gap between the output of an individual DMU and the maximum possible output that it could produce. Technical efficiency is defined as the ratio of the quantity of output achieved (O) to the maximum possible output (O*), given the quantity of inputs (resources) available. Conversely, approaches that do not calculate a production frontier are concerned with the average relationship between inputs and outputs. This report focuses on production frontier methods (see Box 9 for related key concepts).

Box 9: Key Concepts

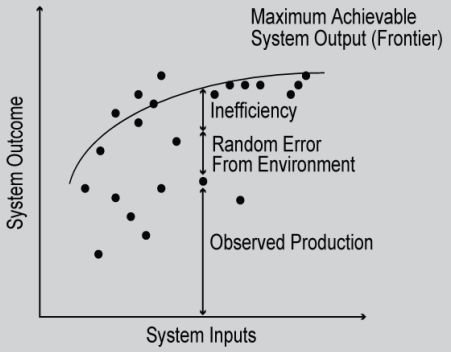
Frontier production function represents the maximum achievable level of output that can be obtained from a given amount of inputs (resources), or the same amount of outputs with minimum possible cost.

Frontier analysis is a method that allows one to infer the frontier (and maximum achievable output) from observations of the actual outputs achieved by a given DMU. The two main methods for frontier analysis are data envelopment analysis and the stochastic frontier analysis.

Data envelopment analysis (DEA) is a non-parametric approach to measuring efficiency. It is a linear programming approach, which does not require assumptions about the frontier (or the distribution of inefficiency). Therefore, it can easily estimate frontiers with multiple outputs and multiple inputs. However, it is sensitive to outliers and makes the assumption that several units are 100% efficient and that any distance between a DMU's output and the frontier is due to systematic inefficiency.



Stochastic frontier analysis (SFA) is a parametric approach that uses assumptions on the shape of the frontier, as well as the distribution of random errors, to disentangle random from systematic inefficiency, evident in the distance between what units produce and the frontier. The method is less sensitive to outliers than DEA and is only as good as the assumptions made regarding the shape of the frontier. Furthermore, it cannot handle multiple outputs as easily as DEA.



In the academic literature, there are two main approaches to estimating a production frontier based on the actual behaviour of a DMU: parametric approaches (stochastic frontier analysis or SFA) and non-parametric approaches (data envelopment analysis or DEA). Researchers typically use one of these two methods, although there a few instances in the literature where studies have used both.[30] The following discussion provides an overview of these two methods including information on main limitations. More detailed information on these methods can be found elsewhere.[5]

Parametric Approaches: Stochastic Frontier Analysis

Stochastic frontier analysis (SFA) is considered to be a parametric approach because it requires the creation of a function to build the frontier. It is labelled as “stochastic” because the method takes into consideration randomness in calculating efficiency. This form of analysis is similar to a regression analysis; however, where a regression analysis would involve the mean relationship between the level of output and the level of input, SFA involves the maximum relationship between these variables.

SFA requires the creation of a function to define how inputs and outputs relate to each other. There is no predefined way of establishing this function and researchers must create their own based on several assumptions. The function creates an efficiency curve that defines maximum efficiency and an efficiency score for each DMU. The distance between a DMU score and the efficiency curve is termed an error. This error is not assumed to result entirely from inefficiency, and is further broken down into a random element (calculated based on a set of environmental factors) and an inefficiency element. The environmental factors that account for the random element must be predefined and entered into the function. If too many factors are entered, all DMUs could achieve high efficiency scores; if there are too few factors, few DMUs could achieve high efficiency scores. Defining environmental factors is therefore a complex process with many assumptions.

The use of SFA requires researchers to use a single output and/or outcome in calculating efficiency. Use of multiple outputs and/or outcomes would require assigning weights to the various ones chosen, which can be cumbersome and often requires making too many judgments and assumptions. SFA is sensitive to under-performing outliers, as they lower the entire frontier. It is not an appropriate approach to use with a small sample size.

Non-Parametric Approaches: Data Envelopment Analysis

Data envelopment analysis (DEA) uses a non-parametric approach to calculate (rather than estimate) the production frontier using linear programming techniques. It does not require a function to build the frontier. Instead, researchers assume that the DMUs, which obtain the most output for their input, are operating on the frontier. Researchers then connect the best performers with linear segments, thus creating a curve. DEA is considered a flexible approach to estimating efficiency because, unlike parametric approaches, it does not require the estimation of a functional form, nor any of the model testing that is required of statistical techniques. In addition, researchers are able to account for multiple outputs and/or outcomes and multiple inputs. However, there are some limitations:

- Researchers must assume there are several DMUs that are 100% efficient to define the frontier; if any of these DMUs are outliers, the results would be skewed; and
- DEA does not allow for accounting of statistical error and considers any distance from the frontier as inefficiency.

Comparing DEA and SFA

Overall, the main difference between DEA and SFA is the ability to distinguish between a random element (or statistical error) and true inefficiency. If there is evidence that certain external factors, which are random over time, can partially explain the relationship between actual outputs and maximum achievable outputs, then SFA may be a more appropriate method. Conversely, if there is evidence that the gap between actual outputs and maximum achievable outputs could be explained entirely by a DMU's inefficiency, then DEA may be a better choice for calculating efficiency. Another distinguishing factor is that DEA methods allow for the use of more than one output and/or outcome in calculating efficiency, whereas SFA requires the use of a single output and/or outcome. Further information on advantages and disadvantages of these methods is included in Table 10.

Table 10: Advantages and Disadvantages of DEA and SFA Methods

Characteristic	Data Envelopment Analysis (DEA)	Stochastic Frontier Analysis (SFA)
Sensitivity to Extreme Observations (Outliers)	High Consequences: Atypical observations could be easily mistaken for high-performers and set a high bar for others	Low
Sensitivity to Under-performing DMUs	None	High
Separation of Random Error From Inefficiency	Impossible Consequences: Random factors could account for DMU inefficiency, making certain DMUs look more inefficient compared with other methods	Possible
Assumptions About Functional Form and Error Distribution	None	Strong Consequences: Analysts need to make choices about both functional form and the distribution of the error term
Possibility to Use More Than One System's Output	Yes	No Consequences: In case of multiple system outputs and/or outcomes (for example, PYLL), an efficiency score will need to be produced for each of the outputs and/or outcomes separately
Impact of the Sample Size	Moderate	Strong Consequences: Small number of DMUs is not sufficient for the analysis
Assumption That Several Units Are 100% Efficient	Present Consequences: A few outliers can set the efficiency frontier very high; the results would then be skewed and inefficiency over-estimated	Absent

Research suggests that DMU ranking and efficiency scores are sensitive to the method used. If input and output and/or outcome variables are the same, half of the differences in efficiency scores would result from the ability of the method to account for environmental factors.[80] Because SFA does account for environmental factors, efficiency scores calculated using this method tend to be lower than scores produced using DEA, which does not account for these factors. For these reasons, research suggests that using both methods together is a means of validating the final assessment of efficiency. In this way, the final assessment would be more robust if efficiency and inefficiency results were highly correlated and point to similar conclusions.[4] In addition, research findings indicate that testing the robustness of the results under different assumptions using sensitivity analysis is recommended.[81] Caution should be taken to ensure that relevant factors are included in the sensitivity testing and irrelevant variables omitted.[82] The stakeholder consultation process informing this project helped to ensure that all relevant variables are included in the final model and efficiency assessment process.

After using SFA and DEA to calculate efficiency scores for each DMU, a series of regression analyses is required to identify correlations between efficiency scores and selected factors that might influence efficiency. Some researchers argue that in the case of DEA, this second step is not valid because of complicated and unknown serial correlation among the estimated efficiencies;[73] however, other research proposes certain solutions to this problem (for example, the use of re-sampling techniques such as bootstrapping).[83] Further complicating this second step, the regression analysis may not produce meaningful results for decision-makers if efficiency scores consider the effects of the external constraints. To eliminate these weaknesses, some researchers suggest the grouping of DMUs by external factors to allow different groups of DMUs to have different frontiers.[30]

An efficiency analysis can be performed for a specific point in time (that is, a cross-sectional approach)[77] and for a series of observations (that is, a panel data approach).[84] Using panel data allows researchers to more precisely distinguish random variations in performance from persistent variations that can be interpreted as inefficiency.[2] However, if the series of observations making up the panel occurs over too long a period, it becomes harder to accept the notion that technical inefficiency remains constant over the whole period.

This chapter outlines the proposed model for measuring health system efficiency in Canada and CIHI's response to the questions and considerations outlined thus far. The most significant input in creating this model resulted from the health system stakeholder consultation process described earlier, which included a review of federal, provincial and territorial documentation, semi-structured interviews and a stakeholder dialogue with leaders from various health system groups in Canada. To supplement this information, CIHI also conducted a range of literature review activities to collect information on the current state of measuring efficiency in health care and other industries. To assess the feasibility of the proposed efficiency model, CIHI also conducted a review at the provincial, territorial and regional levels to evaluate availability of data, including an assessment of quality and information gaps. The following discussion is an overview of the main decision points. More detailed information can be found in Table 11. The final set of components that make up the efficiency calculations may vary depending on circumstances arising during the analysis. CIHI will add any new appropriate indicators to the analysis as they become available.

Decision-making unit: Due to characteristics of the Canadian health system and statistical considerations, the analysis will be conducted at the regional level, therefore using health regions, or the equivalent, as the DMUs.

Analysis methods: Following advice from health system stakeholders and recommendations based in the literature, both types of economic modelling—DEA and SFA—will be used to assess efficiency. This approach will improve the robustness of efficiency measurement and alleviate the impact of the inherent limitations of both methods. In addition, the use of both methods will help to test internal validity of the model specified and to cross-check the results of the regression analysis.[4]

As a base model, each method (DEA and SFA) will include a range of health system expenditures as the main input (see Table 11) and a single outcome related to one of four mortality measures: premature mortality, avoidable mortality, preventable mortality and treatable mortality. This approach will result in eight efficiency scores per DMU. Bootstrapping techniques could be employed to obtain bias-adjusted estimates and confidence intervals for DEA.

Environmental factors: To minimize the effects of environmental differences between health regions on efficiency scores, environmental factors will be controlled when estimating the production frontier using SFA (see Table 11 for a more detailed list of environmental factors). When using DEA methods, health regions will be grouped based on similar environmental factors. Each DMU will therefore be compared with other similar DMUs, and best performers will be defined for each group. Sensitivity analysis will also be conducted to identify the most influential environmental factors.

Throughputs, performance indicators and inequity measures: Throughputs and various health system performance indicators listed in Table 11 will be used in the analysis to shed some light on how DMUs can improve efficiency and ultimately health outcomes. A Concentration Index (CI) and Horizontal Inequity Index (HI) will be used to account for income-related health inequalities at the second stage of analysis when regression methods are applied. The indices will be calculated for the indicators listed in Table 11.

Time period: The time period for calculating efficiency is influenced by data availability. The most recent system outcome indicators (that is, the four premature mortality indicators) are available for 2006, 2007 and 2008 (three years combined). Information on input, throughputs and environmental factors will be collected for the same years.

Table 11: Health System Indicators Selected for Efficiency Measurement

	Indicators	Data Source
Outcomes (One at a Time)	• Premature mortality (measured as PYLL) • Avoidable mortality • Preventable mortality • Treatable mortality	Statistics Canada (CANSIM database)
Inputs (Combined)	• Cost of hospitals (including costs of beds, nurses and drugs distributed in the hospital) • Cost of other institutions (for example, publicly funded long-term care facilities) • Cost of physicians (including family physicians and specialists) • Cost of nurses (those who work for hospitals and long-term care will be excluded to avoid double-counting) • Cost of other health professionals • Inflow/outflow rate for certain procedures (to measure hospital patients from another health region) • Public health expenditures (provincial-level data will be assigned to each region as a percentage) • Drugs expenditure (provincial-level data will be assigned to each region as a percentage)	CIHI (NHEX, NPDB, CMDB databases)
Environmental Factors	• Population density • Unemployment rate • Average income • Proportion of people age 65 and older • Proportion of Aboriginal population • Proportion of immigrants • Income inequality (GINI coefficient) • Gender distribution	Statistics Canada (CANSIM)
Lifestyle Factors (as Throughputs or Environmental Factors)	• Proportion of smokers • Obesity rate • Physical activity • Fruit and vegetable consumption • Alcohol consumption	Statistics Canada (CANSIM)
Inequalities	• Concentration Index or Horizontal Inequity Index for – Self-reported health status – Self-reported visits to general practitioners and specialists – Self-reported hospitalization – Self-reported access to family physicians	Statistics Canada (CCHS, CANSIM)

Table 11: Health System Indicators Selected for Efficiency Measurement (cont'd)

	Indicators	Data Source
Health System Performance Measurement	Quality of health care: • 30-day AMI in-hospital mortality • 30-day stroke in-hospital mortality • AMI readmission • Asthma readmission • Prostatectomy readmission • Hysterectomy readmission • 30-day readmission for mental illness Access to health care: • Whether you have a regular family doctor • Wait time for hip fracture surgery • Wait time for other procedures (such as knee replacement, cataract surgery, and radiation therapy) and emergency departments	CIHI (Health Indicators)

Figure 8 depicts a simplified approach to the first step of the health system efficiency measurement process proposed by CIHI. The result of this step will be four efficiency scores per DMU from SFA (one per each outcome indicator) and four efficiency scores per DMU from DEA. The DEA results will be grouped by environmental factors (Figure 9).

Figure 8: Calculating Efficiency Scores Using SFA

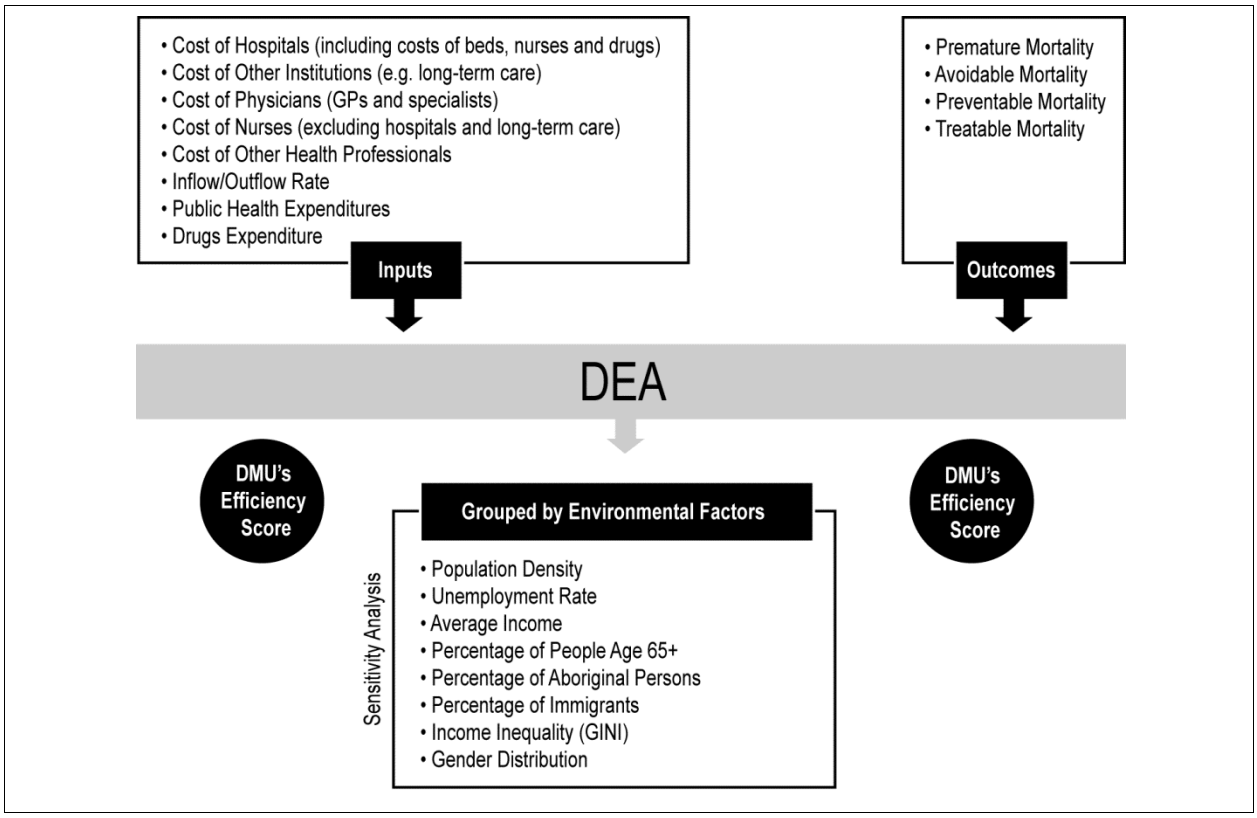


Figure 9: Calculating Efficiency Scores Using DEA

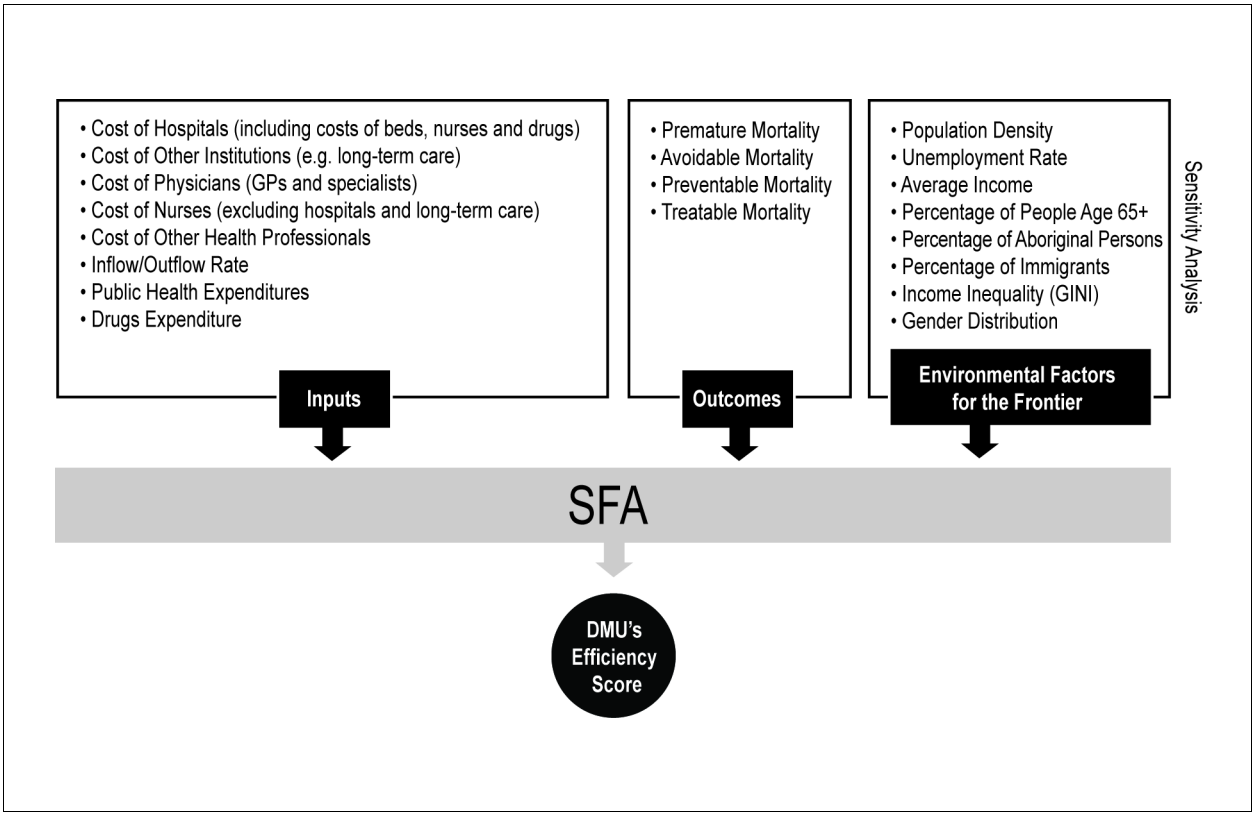
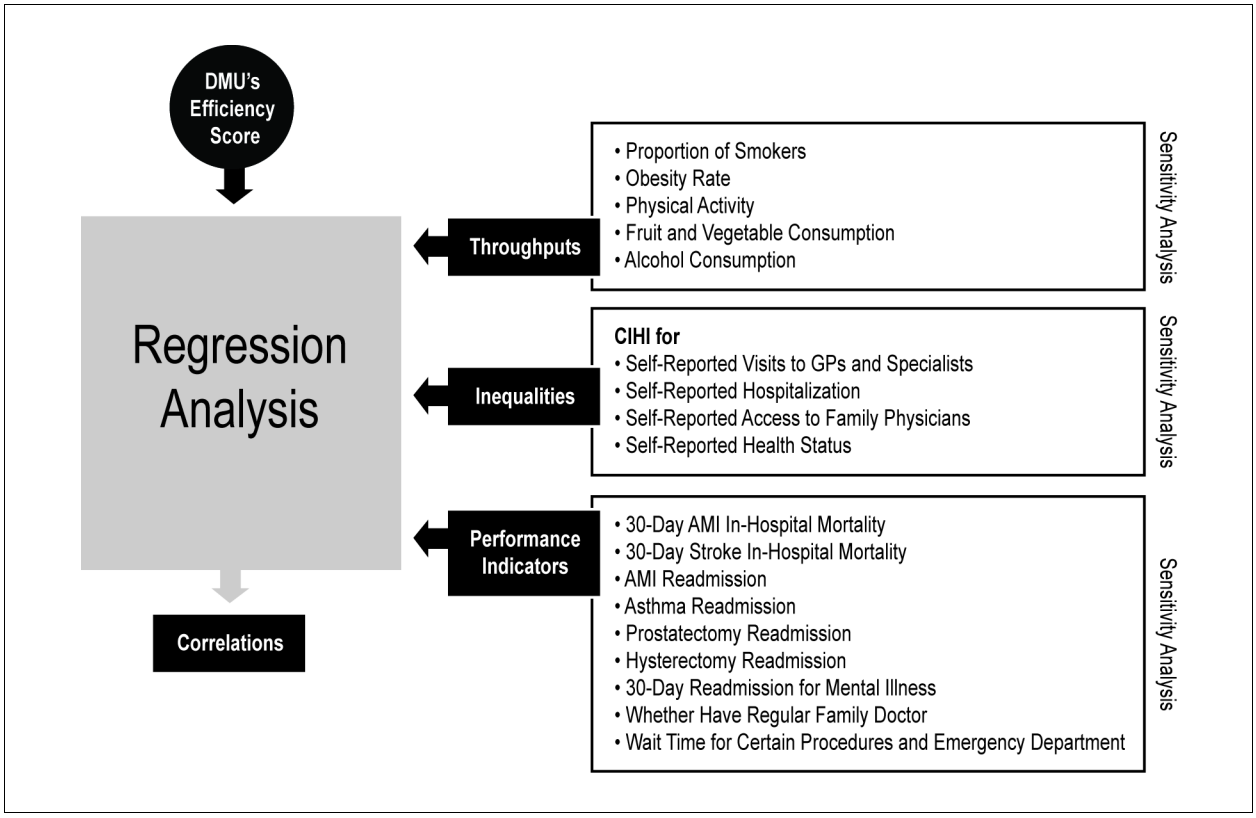


Figure 10 illustrates the second step in the health system efficiency measurement process, which includes a regression analysis with health inequality indicators and system performance indicators. Lifestyle factors will be used in the analysis either as throughputs (as in Figure 10) or as environmental factors (not shown). In the latter case, the regression analysis will not include the lifestyle factors.

Figure 10: Regression Analyses



Chapter 9: Challenges, Limitations and Next Steps

In any study of health system performance or efficiency, there are several challenges in finding quality data that is accurate and comparable over time and across jurisdictions. Lack of data and the need to frequently omit variables in efficiency calculation are common problems in health system studies. CIHI and Statistics Canada work together to collect data at various geographic levels and to provide data to facilitate better decision-making processes. However, in conducting a review of the literature and data availability in Canada, this report identified a number of challenges and data gaps that will need to be resolved in the final report exploring efficiency. This chapter provides an overview of these challenges.

Missing data: Missing data and indicators create a challenge for measuring economic efficiency of the health system and may result in less meaningful, inconclusive or invalid results in the final calculations. For this reason, CIHI will be identifying the most appropriate and meaningful data when conducting future analysis and will provide an overview of ways future data collection could be improved. The following lists some of the strategies CIHI will be using to account for some select data gaps:

- **Missing region-level data**—CIHI will be using regions as the DMU; however, certain indicators are available only at the provincial level and not at the regional level. For example, expenditures on public health and the public portion of drug expenditures or public payments to specialized health care professionals (for example, dentists or optometrists) are not available at the regional level. CIHI will assess whether health regions are truly responsible for providing these services and are actually receiving money to provide them. If health regions are excluded from responsibility and do not receive funds, expenditures will not be included in the calculation of efficiency scores. Alternatively, if responsibility is apparent, provincial-level data will be used for each health region in the province (for example, as a percentage to total spending).
- **Missing regions**—Most indicators selected for the analysis (listed in Table 11) are available at the regional level; however, there are a few indicators that do not capture information from certain health regions. Missing regions will need to be excluded from the entire analysis or from certain parts of the analysis if certain indicators are not available. This will impact the amount of data points used for the analysis and potentially reduce statistical significance (particularly in the case of the SFA approach).
- **Missing years**—Not all health regions have data for all three targeted years (2006, 2007 and 2008). For regions with missing years, the average will be calculated based on the years available.

Health region differences: Health regions are structured differently across Canada; subsequently, there are often inconsistencies in data that must be considered in measuring efficiency. Main concerns involve

- **Differing levels of responsibility**—The level of authority given to health regions varies across Canada. For example, in some provinces, health regions are responsible for providing home care and public health, but in other provinces they are not. CIHI will need to assess these differences and account for them in the final model.
- **Data compatibility**—It is possible that various provinces and territories, and subsequently health regions, could use varying methods to collect their data. These differences can lead to data incompatibility across the country. To ensure data compatibility, methodological differences among regions and provinces will be assessed and accounted for in the final model.

Limitations of measures: The outcome indicators proposed for this project serve the purpose of capturing health system objectives and measuring health system efficiency in a way that is meaningful for decision-makers. However, these measures are not without their limitations. The outcome indicators proposed do not capture success in reducing mortality for people after age 75 resulting from conditions that are amenable to the health system, nor do they focus on length of life as opposed to quality of life.[30] As a result, health regions that disproportionately target and spend more resources on elders after age 75 than other regions may appear as inefficient. To address this challenge, the final model will ideally account for expenditures spent on older populations (for example, physicians' expenditure by age of patients or expenditure on long-term care facilities) and on alternate level of care (ALC) hospital beds. At the time of this report, this information was not available; however, further model enhancement will be conducted to more accurately calculate efficiency once the data becomes available. In addition, conducting sensitivity analyses of various mortality and life expectancy indicators will assist in capturing quality of life information. It is also possible to include other outcome measures that capture quality of life—such as DALE and other similar measures of health status—in future analyses.

Lack of real-time data: Another data challenge is the lack of data available for recent years. The most recent data available for the mortality indicators proposed in the efficiency model relates to 2006, 2007 and 2008, providing only a partial assessment of the state of health system efficiency in Canada. This situation is very common in the health industry, since most performance monitoring relies on historical data.[4] However, using DEA and SFA methods, CIHI is able to adapt the efficiency model and include new data as soon as it is available. Therefore, after defining the model, establishing a process and producing a set of initial results, future analyses will have greater potential for producing timely results as soon as data is available.

Information challenges: The stakeholder consultations that informed this project did not provide all of the input required to finalize the health system efficiency model. For instance, stakeholders were unable to provide sufficient information about health system boundaries and almost no information on the time lags between inputs to the health system and their effect on outputs and outcomes. Final decisions will be based on data availability or the results of preliminary analyses.

Model acceptance challenges: The consultation efforts that informed this project provide only partial information for health regions, provinces and territories. All jurisdictions will require additional information and continued communication on the proposed model for measuring efficiency. CIHI in turn will need the support of these jurisdictions as development of the model progresses. To increase communication and understanding of the proposed health system efficiency model, CIHI will engage jurisdictions and explore potential opportunities to adapt the final model to better meet the needs of policy- and decision-making bodies in Canada. CIHI will also report efficiency results in a non-competitive manner and encourage jurisdictions to view the model as a tool to identify inefficiencies and recognize and learn from the better performers.

Internationally, there is no agreed-upon method for measuring health system efficiency, and CIHI does not aim to create an ideal or unique method for efficiency. Instead, CIHI wishes to establish a sound method that can be used in Canada to improve health system efficiency and will be cooperating and consulting with world-renowned researchers in the field for their advice and expertise as the project progresses.

Next steps: Measuring health system efficiency will ultimately provide useful information for creating actionable next steps for Canadian policy- and decision-makers. The immediate next step for this project will be to apply the available data to the final efficiency model and produce preliminary results on health system efficiency at the regional level in Canada. As recommended by a number of stakeholders, during the process of producing these initial results, CIHI will continue its engagement with provincial, territorial and regional governments to explore possible factors leading to inefficiency and successful policies that can support a more efficient health system. Preliminary analyses may also lead to model refinement, enhancing data collection methods and defining new indicators, which in turn, could lead to further model modification and subsequent iterations of the analysis.

Appendix: Academic Literature Review Methods

Health System Efficiency Measurement—Literature Review

The literature search and review that informed this project used comprehensive and transparent procedures to obtain the most up-to-date and relevant literature on the topic of health system efficiency measurement. CIHI did not seek to present an exhaustive review of the literature nor create a systematic review. The procedures involved in the literature review process are outlined below.

Purpose

The overall purpose of the literature review was to identify and compare approaches that have been used to measure health system efficiency. In addition, reviewers sought to consider, in greater detail, approaches that are more prevalent. The review includes a synthesis of selected sources and trends in the use and elements of various theoretical models. Special consideration was given to the choices made in deciding elements of an efficiency model (that is, health system inputs, outputs and outcomes) and the rationale for those choices.

Methods

A search protocol was developed to identify studies in the area of health system efficiency measurement. The protocol outlined databases of peer-reviewed publication, appropriate search terms, web-based grey literature sources and specific items targeted for hand-searching (that is, using snowball techniques to identify references in the available sources already obtained).

A formal search using Econlit and Medline databases was supplemented by using the results of an existing systematic literature review performed for a similar purpose by the McMaster Evidence-Based Practice Centre and by hand-searching. The health system efficiency project team members then applied inclusion and exclusion criteria and reviewed the remaining articles, which were obtained in electronic or paper format either online or through the CIHI library.

Econlit- and Medline-Based Search

Search Parameters

- Search terms: (“health care system” OR “health system”) AND (“productivity” OR “efficiency”)
- Limits: 1995 to current, English language
- Result: 138 titles

The team members performed title and abstract reviews to narrow the list of relevant sources using the following inclusion and exclusion criteria:

- Inclusion—studies of productivity and efficiency at the health system level: international, national, sub-national, local.
- Exclusion—studies of productivity and efficiency at the sub-sector level (such as hospital, long-term care facility); studies of productivity and efficiency at the disease level (such as heart attack, diabetes); studies of productivity and efficiency at the treatment/intervention level (such as use of drugs); studies of efficiency of country-specific policies (such as comparisons of a single health system before and after system-level changes).

Hand Search

The hand-search process included

- Obtaining references using snowball techniques and the references from preliminary sources;
- Critically reviewing the titles included in "A Systematic Review of Methodologies and Approaches Used to Evaluate Productivity and Efficiency of Health Care Systems" produced by the McMaster Evidence-Based Practice Centre in 2006; and
- Searching for grey literature published in 2006 and later (grey literature published up to 2006 was captured in the review produced by the McMaster Evidence-Based Practice Centre).

Occasionally, academic sources of interest were identified in the process of critical review of the available articles or as a by-product of interaction with fellow researchers at various venues (for example, conferences and symposia). These included articles that were not captured in the formal literature search due to restrictive search terms as well as those that represented very recent academic work (including work in progress).

The grey literature search approach used by the McMaster Evidence-Based Practice Centre was used to search for grey literature that has become available since 2006. Site-specific searches were conducted for 36 organizations operating at the international, national and provincial levels.

The same inclusion and exclusion criteria were applied to the entire collection of hand-search results.

Review and Synthesis

A total of 290 titles were reviewed; 119 articles were removed because they did not meet the inclusion criteria. The remaining 171 studies were sorted into three groups:

- **Measurement of efficiency** (reviewed and summarized in a table), n = 56 (one also fits under “Inputs/Outputs”). Common purpose: to estimate efficiency or evaluate performance for a group of health systems. In most cases, either data envelopment analysis or stochastic frontier analysis was used.
- **Measurement of inputs and outputs of the health system**, n = 28. Discussion of methods for measuring inputs and outputs of health systems.
- **Methodological and other relevant literature**, n = 88. Discussion of merits and limitations of each of the methods was used to estimate efficiency or productivity.

Time Lag Effect

The literature search found only two studies that accounted for temporal differences (that is, time lags) between health system–level changes and changes in population health. However, many studies had acknowledged the existence of such time lags but did not factor them into calculations for different reasons. To obtain additional information on time lags, a separate search was performed. The scope of this search was broadened to include studies that accounted for time lags between any actions or changes and their health-related consequences.

Search Parameters

- Databases: Econlit and Medline
- Search terms: “health care” AND “time lag”
- Limits: English language
- Result: 49 titles
- Retained: none

The review of titles and abstracts identified a lack of literature on this topic. To increase understanding of the topic, the inclusion and exclusion criteria were modified to capture articles that discussed time lags between socio-economic status and health status.

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