SPOkes in the wheel: Structure, Process, and Outcomes of healthcare. An examination of the quality of the relationships among indicators of hospital and general practitioner performance
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Chapter 1

General Introduction
The health of a nation’s population is one of its most valuable assets. Healthcare spending accounts for a significant proportion of gross domestic product (GDP) in a number of countries. Among Organization for Economic Cooperation and Development countries (OECD), it ranges from 5.9% in Mexico to 16% in the United States. In 2008, total per capita spending on healthcare in US$ Purchasing Power Parity was $7,538 in the United States, $4,063 in the Netherlands, $3,737 in Germany and $3,129 in the United Kingdom. Despite the differences in the organization of these four health systems and the varied balance between their public and private sector financing, the rise in healthcare spending is putting a strain on the budgets of all of them. The rise in costs has not correlated with better individual health or improved outcomes. Rising costs and limited budgets have increased the importance of identifying cost-effective healthcare quality improvement programs.

In the last few years, different countries have introduced reforms in various aspects of their healthcare systems with the aim of reducing costs and improving quality. In the Netherlands there is increased competition in the health insurance sector, and England is shifting from a top-down to a bottom-up system, empowering general practitioners with the aim of reducing bureaucracy and costs. Healthcare reform in the United States addresses the issues of cost and quality in a number of ways. In the search for efficiency in healthcare spending, the first question asked is how well the system performs.

**Measuring Health System performance**

Frameworks and standards have been devised to measure various aspects of the health system and provide transparency. At the international level, health status indicators give an overall sense of health in a nation. They include measures such as life expectancy, disability-adjusted life expectancy (DALE), neonatal mortality, under-five mortality rates, potential years of life lost (PYLL), and vaccination coverage. In 2000, the World Health Organization ranked health systems based on criteria related to three domains: health status, fairness of financial contribution, and responsiveness to non-medical expectations. The OECD routinely collects health systems data and publishes side-by-side comparisons of countries on a variety of indicators. Other international organizations, such as the Commonwealth Fund, publish international profiles of health systems. At the national level, health systems performance takes a different focus. The approach looks at quality, access, and costs with equity and efficiency cutting across these three areas. The Dutch Healthcare Performance report, the United States National Healthcare Quality report, and the Canadian Health Indicators report are examples of national reports issued periodically.

In comparison to cost and access, the quality of care field tends to draw the most attention. Various definitions of quality have been put forward over the years. A widely accepted description by the Institute of Medicine (IOM) refers to high quality care as
“health care that is safe, effective, patient centered, efficient, and equitable”. These key words make up the various dimensions of health system performance assessment. Performance indicators presumed to measure quality for the different conditions populate each of these dimensions. The major areas of research have focused on effectiveness, patient safety, and increasingly, patient centeredness. The aforementioned rise in costs has raised the prominence of efficiency. In England, the National Institute for Health and Clinical Excellence (NICE) provides evidence-based guidance on a number of issues aimed at improving quality and lowering costs. In the United States, the American Recovery and Reinvestment Act of 2009 with its associated funding, and the Patient-Centered Outcomes Research Institute established by Patient Protection and Affordable Care act of 2010, have placed comparative effectiveness research at the forefront of health services research. Using performance assessment, one method of controlling cost has been to link payments to performance as measured by performance indicators.

**Structure – Process – Outcome model**

The indicators used to measure the quality of healthcare can be classified, based on criteria first provided by Avedis Donabedian, into structure, process, and outcome indicators. Structure indicators are those related to the attributes of the setting in which care occurs. They include measures of the human and material resources available to a hospital such as funding, availability of a computerized tomography (CT) scanner or magnetic resonance imaging, specialists employed, hospital patient volume, and organizational factors such as deployment of staff and planning of shifts. Process indicators refer to the interaction between the doctor and patient reflecting what is done to, or communicated to the patient. They vary widely between conditions, but usually reflect specific recommendations in treatment guidelines. The recommendations may refer to specific treatments patients should have, advice patients should be given (e.g. smoking cessation), or tests that they should receive. Outcome indicators refer to the final disposition of the patient, or markers of treatment progress. They include health status measures such as mortality and morbidity measures, quality of life, and measures of patient satisfaction.

The structure-process-outcome model forming the Donabedian triad is ubiquitous in healthcare. It is flexible as it can be applied to the macro-, meso-, and micro-levels of care. It is a natural approach to categorizing performance information collected within dimensions of a performance framework. The simple triad was supposed to lend itself to performance evaluation and possibly, causal inference. For years, in measuring and monitoring the quality of care the question was one of what to measure. The pendulum has swung predominantly between process and outcome measures. Structure indicators have formed a natural measure of minimum requirements, or assessment of resources. Process measures have been viewed as amenable targets for
quality improvement programs. Outcome measures can serve as markers of progress or indicators of deficiency or disparity. In some cases, their application is logical: a hospital without renal dialysis facilities would be an inappropriate place for patients with renal failure. Initiatives such as those from the Leapfrog group have imposed minimum volume standards on hospitals with encouraging results.\textsuperscript{30} However, no specific aspect of the triad is sufficient to completely describe the quality of care.\textsuperscript{31, 32} In recognition of this, measurement frameworks have incorporated structure, process, and outcome indicators in order to provide a more complete picture of the quality of healthcare.\textsuperscript{33, 34}

The science of performance measurement has not kept up with its application.\textsuperscript{35, 36} Traditionally, the selection of indicators is based on criteria such as ease of measurement, availability of data, importance, validity, susceptibility to change, and consensus.\textsuperscript{37} The number of defined indicators has grown exponentially examining system level quality, diagnosis related quality, prescribing quality etc. However, it has not always been clear whether all measures selected reflect the underlying effect we are interested in, improving the processes and outcomes of healthcare for patients. Does improved performance on an indicator lead to improved outcomes (lower mortality, reduced morbidity etc.)? Do specific structures lead to better processes or outcomes? Are specific healthcare processes associated with other related processes? Are specific structure, process, and outcome indicators valid for their intended purposes? Are quality scores reflective of actual healthcare quality?

Discussions of validity have often focused on measurement validity in place of the equally important construct validity.\textsuperscript{38} Some studies have tried to demonstrate directly or indirectly the presence of construct validity among indicators.\textsuperscript{39-40} For example, in the United States, two quality frameworks from the Joint Commission on Accreditation of Healthcare Organizations, and Medicare displayed a surprising amount of discordance in their rankings of hospitals.\textsuperscript{41} The Quality and Outcomes framework in the United Kingdom aimed at improving adherence to a number of process measures by providing financial incentives to general practitioners. The program yielded the improved performance but this did not translate to improved patient health.\textsuperscript{42} Some studies have demonstrated relationships between condition specific indicators, but other indicators have failed to show the requisite improvement in quality of care in the real world that is theoretically expected.\textsuperscript{43-46}

In his book “An Introduction to Quality Assurance in Health Care”, Donabedian discusses the relative merits of structure, process, and outcome measures as the approach to assessing performance.\textsuperscript{33} He recommended that an approach that combines structure, process, and outcome measures would provide the best picture of quality. He also noted; “Inferences about quality are not possible unless there is a predetermined relationship among the three approaches...” He simplified this as shown in figure 1.\textsuperscript{33}
As he points out with the use of the ‘p’ these relationships are probabilities with the higher the probability, the more credible our judgments about quality can be. This relationship can be much more complicated with structure affecting multiple processes that in turn have different effects on other processes or outcomes. In turn, outcomes may have direct or indirect effects on structure or vice versa. Figure 2 shows some of these potential relationships.

Each of the arrows indicates potential bidirectional relationships that may exist between indicators. These relationships are potentially complex. As can be seen from the diagram, the theoretical relationships do not extend only between structure or

![Figure 2. SPOkes model - expanded potential relationships between structure, process, and outcome](image)

### Table 1. Overview of the chapters of the thesis showing the relationship examined

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Relationship examined</th>
<th>Data sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Hospital stroke volume and case-fatality revisited.</td>
<td>Structure - Outcome</td>
<td>Dutch Medical discharge register</td>
</tr>
<tr>
<td>4</td>
<td>A multifaceted look at time of admission and its impact on case-fatality among a cohort of ischemic stroke patients.</td>
<td>Structure - Outcome</td>
<td>Dutch Medical discharge register</td>
</tr>
</tbody>
</table>
process and outcomes, but also within and between each aspect of the triad. Beyond the relationships between indicators, there is a question of how the results should be interpreted and applied. The applications are obvious when the relationship with desired outcomes is well specified, but in the face of insufficient evidence the interpretation of performance should be more nuanced and its application circumspect.

**Aims and outline**

This thesis concentrates on the effectiveness domain of healthcare, and explores the relationships between indicators of structure, process, and outcome of healthcare using a series of case studies. It applies a high degree of methodological rigor to testing the relationships between performance indicators and questioning how they can be used to improve healthcare.

Each chapter of this thesis examines one of the potential associations displayed in figure two in the form of a case study (see Table 1). We use them to answer questions in the following broad themes.

1. To what extent are pre-specified process indicators related to expected outcomes of healthcare for a specific condition?
   
   Case study 1 (Chapter 2): What is the validity of the relationship between three time-dependent process measures and case-fatality, for myocardial infarction, hip fracture, and pneumonia patients?

2. To what extent are pre-specified structure indicators related to expected outcomes of healthcare for a specific condition?
   
   Case study 2 (Chapter 3): What is the relationship between hospital case-volume and case-fatality among ischemic stroke patients?

<table>
<thead>
<tr>
<th>Patient population</th>
<th>Analytical approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients with an:</td>
<td>Systematic review</td>
</tr>
<tr>
<td>Acute Myocardial Infarction</td>
<td>Multilevel binary logistic regression modeling</td>
</tr>
<tr>
<td>Hip fracture</td>
<td>Multilevel binary logistic regression modeling</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>Multilevel binary logistic regression modeling</td>
</tr>
<tr>
<td>73,077 ischemic stroke patients admitted to 114 Dutch hospitals in the years 2000 through 2004</td>
<td>Multilevel binary logistic regression modeling</td>
</tr>
<tr>
<td>82,219 ischemic stroke patients admitted to 115 Dutch hospitals in the years 2000 through 2004</td>
<td>Multilevel binary logistic regression modeling</td>
</tr>
<tr>
<td>Primary care patients treated for skin infections, sinusitis, acute throat pain or urinary tract infections at 118 Dutch general practices in the years 2000 through 2005</td>
<td>Multilevel binary logistic regression modeling</td>
</tr>
<tr>
<td>43,967 hip fracture patients admitted to 96 Dutch hospitals in the years 2003 through 2007</td>
<td>Multilevel multinomial logistic regression modeling</td>
</tr>
</tbody>
</table>
Case study 3 (Chapter 4): What is the relationship between time-of-admission and mortality among ischemic stroke patients?

3. To what extent are pre-specified process indicators related to other theoretically related process indicators?

Case study 4 (Chapter 5): What is the relationship between four guideline-based process indicators of prescribing quality used in general practice?

4. To what extent are pre-specified structure indicators related to subsequent process indicators?

Case study 5 (Chapter 6): What is the relationship between time-of-admission and time-to-surgery among elderly hip fracture patients?

In the general discussion, we integrate the various observations from each chapter and examine the validity of the presumed relationships between structure, process, and outcome.
References


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Chapter 1


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