Comments, Opinions, and Reviews

International Comparison of Stroke Cost Studies
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Purpose—With the rapid international spread of interventions, there is a need to understand the economic implications of these changes and to interpret these economic implications on the international level. The purpose of this study is to systematically compare total health care expenditures on stroke, the costs of stroke per capita, and the distribution of stroke costs within different countries, with special attention to the allocation of resources among different health care facilities.

Methods—Studies for this literature review were selected by conducting a literature search from January 1966 to July 2003. Key methodological, country-related, and monetary issues of the selected stroke cost studies were evaluated using a checklist.

Results—After selection, 25 stroke cost studies were reviewed. Although the selected cost of illness studies used different methodologies, the estimated expenditures for stroke are approximately similar. The proportion of national health care in the 8 countries studied is unequivocal for the more recent studies, i.e., ≈3% of total health care expenditures. A shift is observed from the inpatient treatment costs (in the first year) toward outpatient treatment and long-term care costs (in the latter years). Furthermore, it is remarkable that in the studies, little attention is paid to costs borne by the patient and family or to the costs of comorbidity.

Conclusions—This study highlights the importance of studying the economic consequences of stroke and of interpreting the results on the international level. The results of stroke cost studies provide insight into the distribution of the costs of stroke and the impact of stroke on the national expenditure on health care. (Stroke. 2004;35:1209-1215.)

Key Words: cost and cost analysis ■ internationality ■ health resources

Stroke is a major disease in both medical and economic terms. The prevailing emphasis on cost containment and managed care has led to increased interest in the economic aspects of stroke. A total overview of the economic aspects of stroke is given in cost of illness (COI) studies. Results of these COI studies can be used for resource allocation purposes. Over the years, there has been a marked increase in the number of these publications on the economic aspects of stroke.1–3 With the rapid international spread of new diagnostic interventions and care arrangements for stroke, there is a need to understand the economic implications of these changes and to interpret these economic implications on the international level. This article aims to systematically compare how the costs of stroke in different countries are affected by cross-national differences by using a quality checklist. No complete systematic international review of the quality of COI studies in stroke has been undertaken in the literature, although efforts2–4 have been made to illustrate the economic implication of stroke. The following study is a further elaboration of these earlier reviews. The purpose of this study is to present an international comparison of the total health care expenditures on stroke, the costs of stroke per capita, and the distribution of stroke costs within different countries, with special attention to the allocation of resources among different health care facilities.

Materials and Methods

Checklist
A checklist has been developed to enable a systematic comparison among the COI studies. The systematic review includes studies from January 1966 to July 2003.

The checklist used for the systematic review consists of 2 parts (Table 1): a design part and a costs part. This article presents an explanation of the most important aspects of the checklist. For details regarding all aspects of the checklist, please contact the first author.

Perspective of Analysis
In reviewing COI studies, and particularly when interpreting the results of these studies, it is essential to establish the perspective of the analysis. The perspective indicates from which point of view a COI study is being considered and determines which costs will be examined, and thus which conclusions can be drawn from any particular COI study. Ideally, the results of a COI study are to be used for resource allocation on the societal level; therefore, it is preferable to perform COI studies from the perspective of society.3 Alternatively, various other narrower viewpoints can be used, for example, that of the third-party payer, of the health care provider, or of the patient.

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1209
There are several approaches to estimating the costs of an illness. The most widely used are the prevalence-based method and the incidence-based method. Prevalence is the fraction (proportion) of the population that has the disease of interest during a certain period, for instance, 1 year. The idea underlying the prevalence-based method is that it is more useful to perform general COI studies, because these provide comparable estimates of different disease costs and put cost estimates within the total health care framework. The advantage of disease-specific COI studies, however, is that authors can focus in-depth on the particularities of a disease.

COI Study Design (Prevalence-Based or Incidence-Based)

There are several approaches to estimating the costs of an illness. The most widely used are the prevalence-based method and the incidence-based method. Prevalence is the fraction (proportion) of the population that has the disease of interest during a certain period, for instance, 1 year. The idea underlying the prevalence-based method is that costs should be assigned to the year in which they are borne or with which they are directly associated. In this approach, direct costs and productivity losses resulting from a disease are assigned to the year in which they occur.

Incidence is the fraction or proportion of a group initially free of the condition in which a disease develops over a given period of time. The incidence COI approach is based on the principle that the flow of costs associated with a disease should be assigned to the year in which that flow begins. All costs, both direct costs and productivity losses caused by morbidity and mortality, are discounted to present value and assigned to the year in which the disease first appears.

So, in a prevalence approach to COI analysis, the costs attributable to all individuals with the physical or mental health condition in question are accumulated over a particular year of analysis. In contrast, the incidence approach focuses on those people with newly diagnosed illness during a specific year, and it considers the present value of the expected lifetime costs of illness for those people alone. Consequently, whereas the prevalence approach examines the cost to society in a given year associated with all those with that disease, the incidence approach considers the lifetime costs at an individual level of new cases.
and PPPs were obtained from the World Bank. An overview of the correction factor used for each study can be obtained from the first author.

Figures for the national expenditure on health in different countries and demographic figures at the time of the study were obtained from the Organization for Economic Cooperation and Development (OECD) health data published in 2002. Another conversion factor had to be performed because some studies refer to regions (Massachusetts, Ontario) or countries (England, Scotland) that are part of a greater entity. In those cases, the number of inhabitants in that part in relation to the total population was taken as a distribution factor.

**Health Care Cost Distribution**

The list of cost items included in the health care cost estimations may vary from study to study. In the Microsoft Access database, all costs were first classified into 23 categories. To explore the distribution of the costs of stroke, the 23 health care costs categories were aggregated in the checklist into 4 main categories according to their health care function, ie, costs for inpatient treatment (mainly hospital costs), costs for outpatient treatment (general practitioner, outpatient and day care hospital services, allied health care, aids and appliances, pharmaceuticals), costs for long-term care (rehabilitation centers, nursing homes, retirement homes, home nursing), and patient and family costs (out-of-pocket expenses, transfer, informal care).

**Results**

A total of 58 publications were available for this review. Another 29 articles were eliminated from the analysis after reading. Despite what was suggested in the title or abstract, in most cases, the article did not refer to a COI study. In other cases, no separate stroke costs or only hospital costs were reported. Because we focus on all stroke subtypes, 2 studies were excluded because they were concerned only with a selected subtype of stroke. Furthermore, Porsdal published 3 separate articles based on the same sample of 588 patients, eg, 1 article each for infarctions (315 patients), 1 for hemorrhages (90 patients), and 1 for transient ischemic attacks (TIAs) (77 patients). Based on a weighted average (corrected for stroke type), the data of the 3 studies were combined. Two studies were published in 2 publications. This left a sample of 25 studies available for the review, referring to 29 articles. Evers et al International Comparison of Stroke Cost Studies

**TABLE 2. Main Items of the Selected Studies**

<table>
<thead>
<tr>
<th>Author</th>
<th>Year COI</th>
<th>Country</th>
<th>Study Type*</th>
<th>Discounting</th>
<th>Sensitivity</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adelman</td>
<td>1976</td>
<td>USA</td>
<td>Disease-specific, prevalence-based, both</td>
<td>Y</td>
<td>N</td>
<td>Year total population</td>
</tr>
<tr>
<td>Bergman</td>
<td>1991</td>
<td>Netherlands</td>
<td>Disease-specific, incidence-based, bottom-up</td>
<td>N</td>
<td>N</td>
<td>Lifetime cost+ first year cost</td>
</tr>
<tr>
<td>Carstairs</td>
<td>1974</td>
<td>Scotland</td>
<td>Disease-specific, prevalence-based, top-down</td>
<td>N</td>
<td>N</td>
<td>Year total population</td>
</tr>
<tr>
<td>Chan</td>
<td>1994/1995</td>
<td>Ontario</td>
<td>Disease-specific, prevalence-based, top-down</td>
<td>N</td>
<td>Y</td>
<td>Year total population</td>
</tr>
<tr>
<td>Dewey</td>
<td>1997</td>
<td>Australia</td>
<td>Disease-specific, incidence-based, bottom-up</td>
<td>Y</td>
<td>Y</td>
<td>First year cost</td>
</tr>
<tr>
<td>Drummond</td>
<td>1984</td>
<td>England</td>
<td>Disease-specific, prevalence-based, top-down</td>
<td>Y</td>
<td>N</td>
<td>Year total population</td>
</tr>
<tr>
<td>Evers</td>
<td>1993</td>
<td>Netherlands</td>
<td>Disease-specific, prevalence-based, top-down</td>
<td>Y</td>
<td>Y</td>
<td>Year total population</td>
</tr>
<tr>
<td>Hartunian</td>
<td>1975</td>
<td>USA</td>
<td>General, incidence-based, top-down</td>
<td>Y</td>
<td>Y</td>
<td>Year total population</td>
</tr>
<tr>
<td>Health Canada</td>
<td>1993</td>
<td>Canada</td>
<td>General, prevalence-based, top-down</td>
<td>N</td>
<td>N</td>
<td>Year total population</td>
</tr>
<tr>
<td>Hodgson</td>
<td>1995</td>
<td>USA</td>
<td>General, prevalence-based, top-down</td>
<td>N</td>
<td>N</td>
<td>Year total population=year per patient</td>
</tr>
<tr>
<td>Isard</td>
<td>1988</td>
<td>Scotland</td>
<td>Disease-specific, prevalence-based, top-down</td>
<td>Y</td>
<td>N</td>
<td>Year total population</td>
</tr>
<tr>
<td>Kavanagh</td>
<td>1994/1995</td>
<td>United Kingdom</td>
<td>Disease-specific, prevalence-based, bottom-up</td>
<td>Y</td>
<td>N</td>
<td>Year per patient</td>
</tr>
<tr>
<td>Koopmanschap</td>
<td>1988</td>
<td>Netherlands</td>
<td>General, prevalence-based, top-down</td>
<td>N</td>
<td>N</td>
<td>Year total population</td>
</tr>
<tr>
<td>Mills</td>
<td>1975</td>
<td>Massachusetts</td>
<td>Disease-specific, prevalence-based, top-down</td>
<td>N</td>
<td>N</td>
<td>Year total population</td>
</tr>
<tr>
<td>Persson</td>
<td>1985</td>
<td>Lund/Orup</td>
<td>Disease-specific, incidence-based, bottom-up</td>
<td>N</td>
<td>N</td>
<td>First year costs per patient+second year cost per patient</td>
</tr>
<tr>
<td>Polder (1997)</td>
<td>1994</td>
<td>Netherlands</td>
<td>General, prevalence-based, top-down</td>
<td>N</td>
<td>Y</td>
<td>Year total population</td>
</tr>
<tr>
<td>Polder (2002)</td>
<td>1999</td>
<td>Netherlands</td>
<td>General, prevalence-based, top-down</td>
<td>N</td>
<td>N</td>
<td>Year total population</td>
</tr>
<tr>
<td>Porsdal (3 studies)</td>
<td>1994/1995</td>
<td>Denmark</td>
<td>Disease-specific, incidence-based, bottom-up</td>
<td>N</td>
<td>Y</td>
<td>First year costs per patient</td>
</tr>
<tr>
<td>SBU</td>
<td>1991</td>
<td>Sweden</td>
<td>Disease-specific, incidence-based, both</td>
<td>Y</td>
<td>Y</td>
<td>Lifetime cost</td>
</tr>
<tr>
<td>Taylor</td>
<td>1990</td>
<td>USA</td>
<td>Disease-specific, incidence-based, unclear</td>
<td>Y</td>
<td>Y</td>
<td>First year costs per patient+second and third year per patient</td>
</tr>
<tr>
<td>Terent (1983)</td>
<td>1980</td>
<td>Sweden</td>
<td>Disease-specific, incidence-based, bottom-up</td>
<td>Y</td>
<td>N</td>
<td>First year costs per patient+second year cost per patient</td>
</tr>
<tr>
<td>Terent (1994)</td>
<td>1991</td>
<td>Sweden</td>
<td>Disease-specific, incidence-based, bottom-up</td>
<td>Y</td>
<td>N</td>
<td>First year costs per patient+second year cost per patient</td>
</tr>
<tr>
<td>Thorngren</td>
<td>1986/1987</td>
<td>Sweden</td>
<td>Disease-specific, incidence-based, bottom-up</td>
<td>N</td>
<td>N</td>
<td>First year costs per patient</td>
</tr>
<tr>
<td>Weill</td>
<td>1982</td>
<td>France</td>
<td>Disease-specific, prevalence-based, top-down</td>
<td>Y</td>
<td>N</td>
<td>Year total population</td>
</tr>
<tr>
<td>Zethraeus</td>
<td>1994</td>
<td>Sweden</td>
<td>General, incidence-based, bottom-up</td>
<td>N</td>
<td>N</td>
<td>Cost before stroke onset+first year costs per patient</td>
</tr>
</tbody>
</table>

*Both = top-down + bottom-up. Y indicates yes; N, no.*
were performed for developed countries: 6 for (part of) Sweden (SW), 5 for the Netherlands (NL), 5 for (parts of) the United States of America (US), 4 for (parts of) the United Kingdom (England [EN] and Scotland [SC]), 3 for Denmark (DE), 2 for (parts of) Canada (CA), and 1 each for Australia (AU) and France (FR). The majority (52%) of the COI studies mentioned the societal perspective as the viewpoint of analysis. In other instances, it was most likely that the analysis was from the societal viewpoint (40%), but this was not mentioned explicitly.

Methods of the COI Study
Table 2 presents an overview of the various methods used to calculate the costs of stroke. In 52% of the cases, the calculations were based on a prevalence-based study; in 45%, calculations were based on an incidence-based study. Looking at the COI estimation procedures, 48% of the studies performed a top-down COI study; the others were performed bottom-up, and in 2 studies both estimation procedures were combined. In general, prevalence-based studies were performed top-down and incidence studies were performed. Twenty-four percent of the COI (incidence-based) calculation was based on primary data. In the bottom-up studies, patients were recruited mostly from inpatient facilities (hospitals) and followed-up over a certain time period. A sensitivity analysis was performed in almost one third of the studies (30%). In addition to health care costs, which are undergoing study in this article, more than half of the studies also looked at indirect costs (59%); 1 study mentioned intangible (ie, not quantifiable in monetary terms) costs, and none of the studies paid explicit attention to the costs of comorbidity. Regarding the term of measurement, most COI studies (52%) refer to 1 average year; after that, the first year was most often chosen as the time period in which costs were calculated.

Study Population
In general (in 96% of the included studies), no age limits were applied, and the studies refer to all stroke subtypes. In 44% of the cases, TIA was included in the definition of the study population. Nine studies defined stroke using the International Classification of Diseases and 4 used the WHO definition.

National Stroke Health Care Expenditures
Based on the methods noted, the percentage of national health care expenditures, total expenditures, and the per capita costs per stroke were calculated for the top-down cost of illness studies, which calculated the average yearly costs for the total population. All but one of these studies were prevalence-based. For all studies included in Table 3, on the average 3% of health care costs were spent on stroke, with a minimum of 1.6% for the USA in 1975 and a maximum of 6.9% for Scotland in 1974. In the more recent studies, the variation between countries was much lower and the percentage spent on stroke was also lower. On average, 0.27% of the GDP was spent on stroke, which is $84 PPP if one looks at the per capita costs.

Health Care Costs Distribution
Figure A and B indicate the distribution of costs for the first year (in general, incidence-based and bottom-up) and the average annual costs for the total population (in general, prevalence-based and top-down). In the first year after stroke, an average of 76% of stroke costs are devoted to inpatient treatment. For an average stroke year, these costs are 58%, reflecting a shift from inpatient treatment costs to outpatient treatment and long-term care costs in the following years. This contrast might be even greater if first-month costs, rather than first-year costs, are compared with costs in the long-term, because in most countries stroke patients stay in inpatient treatment facilities (ie, hospitals) for only a short period of 10 to 15 days. In 4 studies included, an attempt was made to calculate the cost of stroke for the patient and family, and these costs were quite low (on average 1%).

<table>
<thead>
<tr>
<th>Year</th>
<th>COI Author</th>
<th>Country/Region</th>
<th>% Health Care Costs*</th>
<th>% Gross Domestic Product*</th>
<th>Per Capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974</td>
<td>Carstairs</td>
<td>Scotland</td>
<td>6.9</td>
<td>4.7†</td>
<td>0.36</td>
</tr>
<tr>
<td>1975</td>
<td>Hartunian</td>
<td>USA</td>
<td>1.6</td>
<td>0.5</td>
<td>0.15</td>
</tr>
<tr>
<td>1975</td>
<td>Mills</td>
<td>Massachusetts</td>
<td>6.1</td>
<td>0.47</td>
<td>0.18</td>
</tr>
<tr>
<td>1976</td>
<td>Adelman</td>
<td>USA</td>
<td>2.6</td>
<td>0.18</td>
<td>0.19</td>
</tr>
<tr>
<td>1982</td>
<td>Weill</td>
<td>France</td>
<td>2.3</td>
<td>2†</td>
<td>0.18</td>
</tr>
<tr>
<td>1984</td>
<td>Drummond</td>
<td>England</td>
<td>3.1</td>
<td>3.2†</td>
<td>0.19</td>
</tr>
<tr>
<td>1986</td>
<td>Isard</td>
<td>Scotland</td>
<td>6.2</td>
<td>4.3†</td>
<td>0.37</td>
</tr>
<tr>
<td>1988</td>
<td>Koopmanschap</td>
<td>Netherlands</td>
<td>3.1</td>
<td>2.9†</td>
<td>0.24</td>
</tr>
<tr>
<td>1993</td>
<td>Evers</td>
<td>Netherlands</td>
<td>3.8</td>
<td>3†</td>
<td>0.33</td>
</tr>
<tr>
<td>1993</td>
<td>Health Canada</td>
<td>Canada</td>
<td>2.0</td>
<td>2†</td>
<td>0.26</td>
</tr>
<tr>
<td>1994</td>
<td>Polder (1997)</td>
<td>Netherlands</td>
<td>3.6</td>
<td>3.2†</td>
<td>0.30</td>
</tr>
<tr>
<td>1994/1995</td>
<td>Chan</td>
<td>Ontario</td>
<td>2.0</td>
<td>2.7†</td>
<td>0.19</td>
</tr>
<tr>
<td>1995</td>
<td>Hodgson</td>
<td>USA</td>
<td>2.1</td>
<td>2.8†</td>
<td>0.28</td>
</tr>
<tr>
<td>1999</td>
<td>Polder (2002)</td>
<td>Netherlands</td>
<td>3.4</td>
<td>2.9†</td>
<td>0.28</td>
</tr>
</tbody>
</table>

*Percentages are calculated in PPP, base year 2000. †Based on the transferability information in the article.
To detect whether there is a correlation between time and the distribution of costs, the studies presented in Figure B were grouped into 3 decades (until 1984, until 1994, and from 1995 onward). This analysis showed that in time, the percentage spent on both outpatient and inpatient treatment costs decreases from 44% on the average to 24% on the average, whereas the costs of long-term care increase from 13% to 49% on the average for the more recent years. Only the recent studies pay attention to the patient and family costs, although this percentage is rather small, ie, 3% on the average. Looking at the cost items included, this is probably because of a more extensive cost measurement in the more recent COI studies. The same analysis was performed to see whether the distribution of costs varies from country to country. In general, the European countries, especially the Dutch and the Scottish, spend a smaller part of the total stroke costs on outpatient treatment (ie, 3% and 2%) as opposed to the Northern American countries (Canada [18%] and the United States [38%]). Remarkable is also that countries that spend a relatively large part on long-term care spend a relatively small part on inpatient care, such as the Netherlands and the United States. This might be explained by variations in the organization of care in these countries; for instance, in some countries, rehabilitation and nursing home care is part of the inpatient hospital organization, whereas in other countries these are separate facilities.

### Discussion

This article systematically compared the national and per capita expenditures of the costs of stroke in different countries on the basis of a well-designed checklist. The review supports the findings of earlier reviews, ie, that stroke poses a significant burden on society in all developed countries. The method of the review shows that it is feasible to compare results of similar COI studies performed in various countries at different times after correcting for inflation and for the various currencies used. One of the main problems, also highlighted in the review of Payne, is lack of uniformity regarding the cost categories included and the difference in COI methodology. Although a number of publications have addressed the methodology of COI studies, there is no single way of performing a COI study. By using a checklist, we have tried to make the COI studies transferable; and by using conversion factors, the results of these studies were calculated to US$ PPP in 2000. Although the selected COI studies used different methodologies, the estimated expenditures for stroke are approximately similar. On average, the amount of

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**A. Distribution of the first year costs in incidence-based bottom-up studies.** The study of the SBU is based on both bottom-up and top-down results. **B. Distribution of the total costs in prevalence-based top-down studies.** The study of Adelman is based on both bottom-up and top-down results. In the study of Isard and Forbes, care refers to home nursing, GP, pharmaceutical care, and outpatient hospital treatment; however, the care costs are the largest category. CA indicates Canada; DE, Denmark; EN, England; FR, France; NL, Netherlands; SC, Scotland; SW, Sweden; US, United States.
medical care expenditures spent on stroke is unequivocal (≈3% of health care costs), especially in the more recent studies. Based on the general COI studies, a comparison can be made with the impact of other diagnostic categories in relation to stroke. The problem, however, is that some studies are restricted to distinctive diseases, such as circulatory diseases, whereas others looked at only a limited number of subcategories. The Dutch studies made a ranking of all the diagnostic groups.

In the most recent study, the costs of Dutch health care for the year 1999 are allocated using the division in disease groups based mainly on the Dutch version of the International Classification of Diseases (ICD 9). In this study, the total health care costs in the Netherlands are allocated based on the primary diagnosis. Looking at the overall diagnosis groups, mental disorders score the highest with 21.6% of all health care costs in the Netherlands in 1999, followed by additional categories (17.8%), diseases of the circulatory system (10.1%), and diseases of the digestive system (6.6%). In this overview, neoplasms, which are often regarded as very costly, are ranked at the 10th place, consuming 4.0% of total health care costs. Looking at the separate diagnosis by share, stroke (with 2.9%) is ranked at the 6th place, after dental diseases (3.2%), dementia (4.9%), other mental disorders (5.3%), symptoms (ill-defined conditions) (6.6%), and mental retardation (7.7%).

Looking in our study at the costs per capita spent on stroke, these are more diverse. This might be explained by the different periods in which the different studies are performed and the relative increase in expenditures on health care costs in several developed countries. An alternative explanation might be the difference in data collecting and calculating methods between the several COI studies.

The total omission of informal care costs in the majority of the COI studies is noteworthy. In most cases in which informal care is taken into account, only out-of-pocket expenditures are reviewed and not informal care time. This is particularly remarkable because it is known from the literature that stroke puts a substantial burden on the informal caregivers. Also, the costs of comorbidity caused by stroke are not taken into account. However, it is known that the effects of stroke have a high somatic and psychiatric comorbidity inducing several costs.

Some conclusions can be made regarding the quality of the studies performed. Traditionally, COI studies, especially if performed top-down, are based largely on secondary data. Consequently, the estimation of the costs of stroke greatly depends on the assumptions made and on the quality and precision of the data used. This might induce some bias, which should be checked in a sensitivity analysis; this has been performed by less than one-third of the reviewed studies.

This review is based on COI studies. A number of criticisms can be made in relation to COI studies. Some authors disputed the value of COI studies overall, noting that the decision for allocating scarce health care resources should not depend on the economic burden of a certain disease, but rather on the availability of treatment options for a certain disease. A related criticism is that illness is neither an activity nor a consequence of a conscious decision; therefore, costs do not arise from the illness per se but from specific decisions in health policy and clinical practice to commit resources to the treatment of a disease.

Meanwhile, we believe that these limitations do not invalidate the conclusion that performing a review of COI studies in the field of stroke provides insight into the economic consequences of stroke at an international level. Finally, as is shown in this article, there are many methodological differences in the COI studies performed. The checklist that was developed for this study can be used to examine these issues in a more systematic way. For future research, it might also be relevant to have information not only on the international expenditures for stroke at an aggregate level but also on the influence of such underlying characteristics as the health care system, the socio-economic features, and the epidemiology and risk factors for stroke in a certain country.

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