United States General Accounting Office

GAO

Report to the Ranking Minority Member, Subcommittee on Health, Committee on Ways and Means, House of Representatives

March 1994

# CANCER SURVIVAL

# An International Comparison of Outcomes

GAO/PEMD-94-5

GAO

**United States**
**General Accounting Office**
**Washington, D.C. 20548**

**Program Evaluation and**
**Methodology Division**

B-255873

March 7, 1994

The Honorable William M. Thomas
Ranking Minority Member
Subcommittee on Health
Committee on Ways and Means
House of Representatives

Dear Mr. Thomas:

Your predecessor as Ranking Minority Member, the Honorable Willis D. Gradison, Jr., asked us to examine differences in the availability of health services and outcomes across developed countries. This report, one of two prepared in response to that request, examines survival from four specific forms of cancer across two locations, the United States and the Canadian province of Ontario. The other report, Bone Marrow Transplantation: International Comparisons of Availability and Appropriateness of Use (GAO/PEMD-94-10), describes the variation among the United States and nine other medically advanced countries in the use of an expensive and complex medical therapy.

If you have any questions or would like additional information, please call me at (202) 512-2900 or Robert York, Director of Program Evaluation in Human Services Areas, at (202) 512-5885. Other major contributors to this report are listed in appendix IV.

Sincerely yours,

Eleanor Chelimsky
Assistant Comptroller General

# Executive Summary

## Purpose

Health care reform is widely discussed today, and experts often recommend the health care systems of other countries as models for the reform of health care in the United States. However, little is known about how well foreign systems perform or how their outcomes compare to the U.S. outcomes. The purpose of this report is to compare the survival of patients from the United States and from the Canadian province of Ontario diagnosed with selected forms of cancer and to consider some of the factors possibly contributing to the observed results. The work is in response to a request from the Ranking Minority Member of the Subcommittee on Health of the House Committee on Ways and Means that GAO examine outcomes in developed countries for clinical conditions affected by "sophisticated medical services."

## Background

Comparisons of health care systems have focused on access and cost, and little has been done to measure their quality of care. Some global health measures have been presented (for example, average life expectancy), but they often do not directly reflect patient care. Examining other indicators would broaden the basis of comparison. In an effort to do so, GAO compared survival for cancer patients in the United States and Ontario.

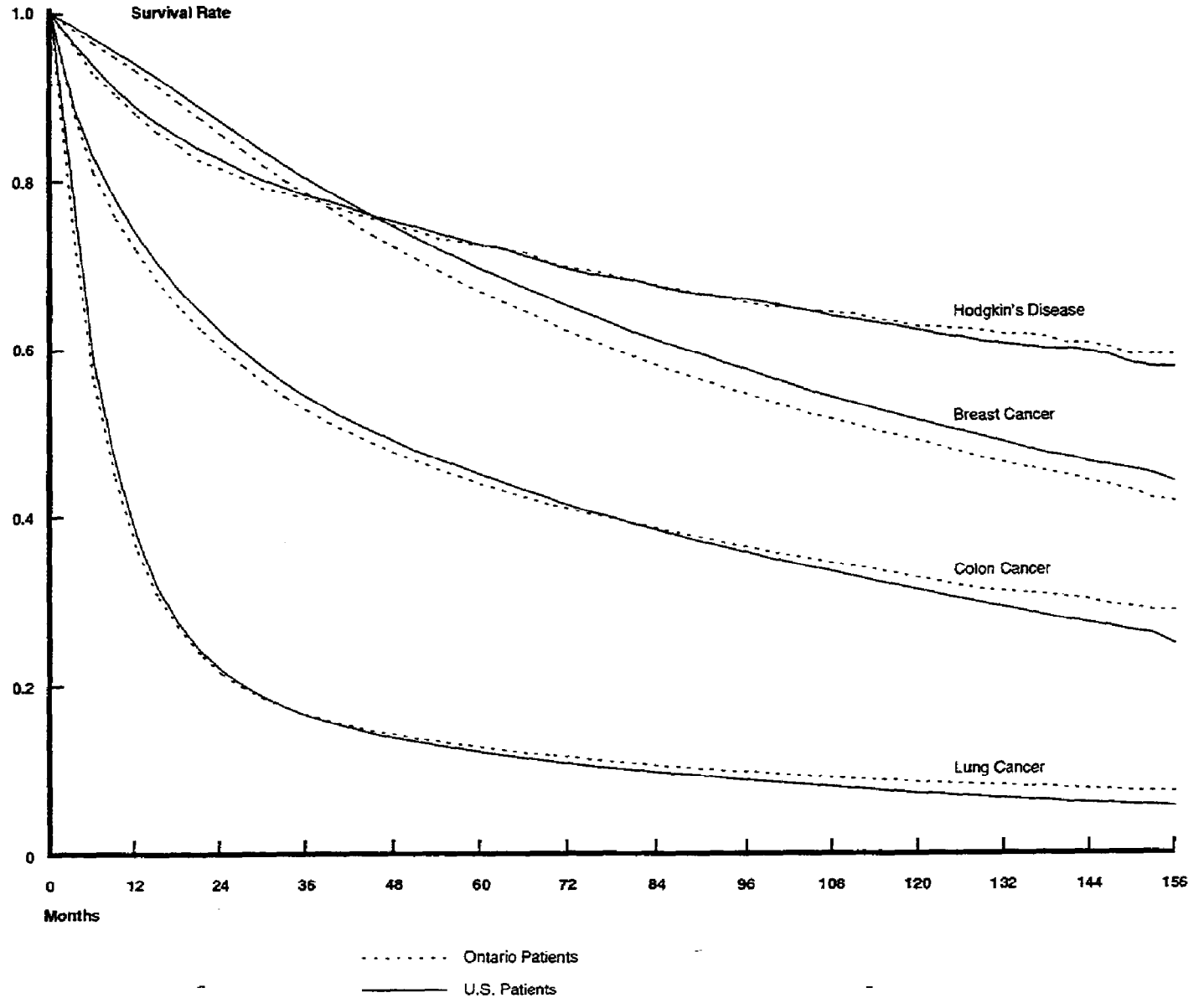
Survival, like average life expectancy, is not a pure indicator of quality of care. However, because measurement of survival begins with a diagnosis, it is more directly reflective of patient care than life expectancy, which is determined not only by the health care delivery system but also by myriad other factors (including population genetics and a nation's environment). The second advantage of measuring survival from a particular disease is that it is possible to select a disease with particular care requirements. Thus, for example, survival from one form of cancer may reflect the use of a particular medicine or technology without which survival is less likely and may thereby serve as a marker for the use of this treatment. Survival from specific forms of cancer has not previously been used as a health care indicator in international comparisons.

GAO compared the survival rates of large samples of patients from the United States and Ontario diagnosed with lung cancer, colon cancer, Hodgkin's disease, and breast cancer, over the years 1978-86 and followed until the end of 1990. The U.S. and Ontario data were obtained from the National Cancer Institute's SEER program and the Ontario Cancer Registry. The U.S. data arguably represent all U.S. patients with the four conditions (see appendix I). The Ontario data include records from virtually all Ontario's patients with those conditions.

## Results in Brief

As shown in figure 1, GAO found that the United States and Ontario share similar patterns of survival for four different forms of cancer: lung cancer,

**Figure 1: Cancer Survival in the United States and Ontario**



colon cancer, Hodgkin's disease, and breast cancer. Within this set of four conditions, a distinction can be made, however, between the data pattern for breast cancer and that for the three other conditions. Breast cancer patients in the United States experienced a higher level of survival consistently throughout the period 1978-90 than Ontario's breast cancer patients.

In contrast, U.S. patients with each of the three other diseases demonstrated a distinct pattern: higher survival rates than their counterparts from Ontario in the initial period after detection were followed by a loss of advantage. (The initially superior U.S. survival rate was statistically significant for all conditions except Hodgkin's disease.) The result is that after 9 or 10 years, U.S. survival rates, with differences in general population longevity taken into account, were either indistinguishable by conventional statistical criteria (in the cases of colon cancer and Hodgkin's disease) or lower (in the case of lung cancer) than the corresponding Ontario rates.

## Principal Findings

The observed survival rates of patients from the United States and Ontario following diagnosis can be seen in figure 1. The U.S. survival rate for breast cancer is consistently higher than the rate of Ontario. Ten years after diagnosis, the percentage of U.S. patients surviving is 50.7 and Ontario's percentage is 48.2, a difference of 2.5 percentage points. When differences between the locations in general population longevity are taken into account, the corresponding percentages surviving are 64.7 for the United States and 59.9 for Ontario, a difference of almost 5 percentage points. Although small, this difference translates into about 4,300 more Americans alive out of a study population of almost 90,000, or about 45,000 more alive out of the entire U.S. patient population (see appendix I), than would be expected if Ontario's rate held.

The U.S. survival rates for colon and lung cancer also start higher than the corresponding rates for Ontario. However, for colon cancer the initial U.S. advantage is erased after 6 years. Further, for lung cancer the small initial U.S. advantage is lost by 3 years and eventually reversed, so that by 10 years after diagnosis Ontario's lung cancer survival rate is higher by 1.7 percent. There are no statistically significant differences in rates for Hodgkin's disease.

Inspection of age-specific survival rates suggests two modifications to the overall results: (1) the initial U.S. advantage in colon cancer survival is

retained for patients under 60 (who constitute about 20 percent of all colon cancer patients) and (2) the apparent equality of survival rates for patients with Hodgkin's disease may be a product of age distribution differences such that, for three of the age-specific groups, Ontario's rate is actually slightly higher than the U.S. rate.

One possible interpretation of these findings is that quality of care for patients with breast cancer is better in the United States than in Ontario and that for the three other cancers it is roughly equivalent. Other interpretations involve differences in detection. Detection can influence survival in a number of ways. The earlier most cancers are detected, the more effectively they can be treated, thus improving survival. But earlier detection can also improve the measured survival time of a patient, without any substantive change in treatment or outcome, simply because the time between the diagnosis (which occurs earlier than it would have under conventional detection practices) and death has increased. In addition, aggressive detection practices can lead to the disproportionate inclusion in the records of cases with slowly developing disease that tend to have relatively long survival times. Until the effect on survival of differences in detection practices can be determined, the implications of these results for assessing quality of care in the two locations are unclear.

## Recommendations

This report contains no recommendations.

## Agency Comments

The National Cancer Institute was briefed on GAO's findings and its comments have been incorporated into the report where appropriate.

# Contents

## Abbreviations

| | |
|---|---|
| DCO | Death certificate only |
| GAO | General Accounting Office |
| NCI | National Cancer Institute |
| SEER | Surveillance, Epidemiology, and End Results |

# Objectives, Scope, and Methodology

## Introduction

One question that arises within the debate about reforming health care in the United States is "How good is the quality of U.S. health care compared to that of other developed countries?" Those who oppose changes in our health service delivery systems, such as changes to lower their sizable costs or to increase the proportion of the population covered by insurance, may do so in the name of retaining the high quality of health care services. But how high is that quality compared to that delivered by other nations' health care systems?

To the extent that our quality is superior, caution is required to ensure that changes do not lead to a decline in the level already attained. To the extent that quality is virtually equal with that of other comparably advanced countries, questions of cost-effectiveness would then arise in view of the relatively higher percentage of our gross domestic product that we spend on health care.[1] To the extent that our quality is inferior, further study of the discrepancy in health care quality would be needed to find ways of improving.

Quality of health care is a complex concept, requiring consideration of the inputs to a system (patient mix, physician supply, equipment, and so forth), the actual process of care (mainly diagnostic and therapeutic procedures), and patient outcomes for a complete assessment. This report provides a comparative perspective on one component of quality of care—namely, outcome. The perspective is attained by measuring a specific outcome: patient survival. In response to the request that we "examine the differences in . . . outcomes across developed countries" and, more specifically, "focus on a number of clinical conditions where the effect of varying levels of sophisticated medical services may have implications for different clinical outcomes," we have compared the survival rates of U.S. patients having specific forms of cancer with the corresponding rates for the province of Ontario in Canada, a country whose health care system is often contrasted with health care delivery in the United States. Our study is descriptive, focusing on the proportions of patients from the United States and Ontario with each form of cancer who remain alive at various times after their diagnoses.

This approach to measuring quality of care—looking at the outcomes for patients with specific clinical conditions—is similar to the more common approach of examining relatively global health care indicators such as infant mortality and average life expectancy. Both approaches attempt to

[1]G. J. Schieber, J.-P. Poullier, and L. M. Greenwald, "U.S. Health Expenditure Performance: An International Comparison and Data Update," Health Care Financing Review, 13 (Summer 1992), 1-15.

reach conclusions about health care on the basis of one or more specific indicators. It is clear that no single indicator or small set of indicators can sufficiently represent all health care outcomes to validly accomplish this, but expanding the indicators used to measure outcomes by adding a new one not previously used for this purpose is surely a step in the right direction. Therefore, although we have no basis for generalizing from cancer to all diseases, we do use a new indicator and approach, and these enable us to broaden our knowledge of differences in health care quality.

As an outcome measure, cancer survival has two advantages over the more global indicators (for example, life expectancy and infant mortality). One, it is less affected by circumstances beyond the control of the health care system as that system is usually understood. Global indicators are determined by conditions that include other factors as well as health care. The effects of these other factors may be difficult to control in interpreting differences between locations. That is, global indicators generally reflect both the health care that patients may or may not receive and the occurrences of disease, developmental abnormality, and injury that make health care necessary. These occurrences depend upon circumstances that may be little affected by health care, such as socioeconomic status, health habits, genetic make-up, environmental exposures, and violence. In contrast, survival starts with diagnosed patients and is less affected by the determinants of disease.

A second advantage of measuring survival from a particular condition is that it makes it possible to assess diseases with particular care requirements. This is desirable if, as in the case of this report, we seek outcomes that may be related to sophisticated medical services. Because the treatment of cancer often requires sophisticated medical services, differences between locations in their use of such services should be reflected in cancer survival.

Many outcomes, including survival from a particular form of cancer, are often not comprehensive indicators of the quality of medical care provided to patients. Indeed, while survival from any potentially fatal disease is an important outcome, it is only one of many possible outcomes, including the patient's ability to work or otherwise function, freedom from pain, and positive mood or morale, and a number of outcomes may be relevant indicators for patients with a given disease. In measuring survival, we are measuring one outcome in order to learn something about the quality of care provided to patients.

In addition, other differences between health care systems, besides the quality of care patients receive, may influence survival. For example, cases from one location may generally be detected earlier in the disease process than are cases from another because of differences in how screening procedures are organized and publicized. As a result, patients in the location with earlier detection may have longer survival times, on the average, than those in the other location even without differences in the quality of care provided by the two health systems. This is not, however, a real difference in how long patients live after their disease begins but instead a difference in how early in the process the diagnosis is made, known as "lead time" or "lead time bias."[2]

Thus, to draw conclusions about how care affects even a single health outcome requires more information than is often available. In the case of cancer survival, differences between health systems along dimensions other than medical care, including characteristics of the patients involved and, as in the example, screening practices, should be taken into account. When this is not possible, definite conclusions about the effects of care on survival cannot be drawn. In the case of the present study, although the survival data from the United States and Ontario are generally comparable, we do not have information on the extent of disease for Ontario's population and, therefore, cannot be certain if any differences in survival are the result of differences in the care patients receive, in the tendency to detect cancer earlier or more aggressively, or in some combination of these factors. Nevertheless, comparing the United States and Ontario with respect to patient survival from forms of cancer should provide an initial picture of the sizes and directions of any differences that more complete data will be needed to interpret and, thereby, stimulate further investigation.

## Objectives

This study was designed to compare locations with respect to health outcomes reflecting the use of sophisticated medical services. Its objectives are to (1) compare the survival experience of patients from the United States and Ontario diagnosed with selected forms of cancer and (2) clarify the meaning of this comparison by examining the roles of general population longevity, age, sex, and year of diagnosis.

[2]See, for example, Extramural Committee to Assess Measures of Progress Against Cancer, "Measurement of Progress Against Cancer," Journal of the National Cancer Institute, 82 (1990), 825-35.

# Scope

## Conditions

The four clinical conditions selected for study—lung cancer, colon cancer, Hodgkin's disease, and cancer of the female breast—are all forms of cancer. We chose to study cancer because it is a common and formidable disease and because some of its forms can be treated successfully by complex medical services.

The four forms of cancer represent a range of situations with respect to the proportion of patients surviving the disease. During the years relevant to this study, 1978-86, curative treatment for lung cancer was relatively ineffective. Most patients died within a few years of diagnosis. During the same period, treatment for colon cancer was fairly effective, and almost 60 percent of the colon cancer patients survived their disease for at least 5 years.

Treatment for Hodgkin's disease during the period was even more effective; over 70 percent of the U.S. patients survived it for at least 5 years. Finally, breast cancer presents a more complex picture. As in the case of Hodgkin's disease, over 70 percent of the breast cancer patients survived for more than 5 years, but there was considerable variation over the period in the type of treatment used for these patients. It is not clear how much of a difference this made for outcomes, nor is it clear how much documented differences in screening practices made.[3]

## Locations

As indicated in the introduction to this chapter, Canada's health care system has been pointed to as a model for health care in the United States, and it is therefore of particular interest to compare outcomes.[4] We used U.S. data from the National Cancer Institute's (NCI's) Surveillance, Epidemiology, and End Results (SEER) program, which collects data about essentially all cancer patients among residents of five entire states and four large metropolitan areas, representing almost 10 percent of the U.S. population. For Canada, we used data from the Ontario Cancer Registry, operated by the Ontario Cancer Treatment and Research Foundation. The

[3]For the effect of treatment differences, see U.S. General Accounting Office, Breast Cancer: Patients' Survival, GAO/PEMD-89-9 (Washington, D.C.: February 1989), and for the effect of screening (mammography) differences, see S. J. Katz, E. B. Larson, and J. P. LoGerfo, "Trends in the Utilization of Mammography in Washington State and British Columbia: Relation to Stage of Diagnosis and Mortality," Medical Care, 30 (1992), 320-8.

[4]See, for example, D. U. Himmelstein et al., "A National Health Program for the United States: A Physicians' Proposal," New England Journal of Medicine, 320 (1989), 102-8.

registry covers essentially all cancer patients residing in Ontario, and Ontario contains one third of all Canadians. (For more details on SEER and the Ontario Cancer Registry, see appendix I.)

The SEER regions are separate parts of the United States that collectively represent the general population with respect to selected demographic factors.[5] Ontario's health care system is similar to that in the other Canadian provinces in that it is a single payer system that provides care that is comprehensive, publicly funded, and privately delivered to all residents.

### Years

To consider only patients whose cancer experience began relatively recently and who have also had an opportunity to survive for at least several years after diagnosis, we restricted the analysis to those diagnosed over the years 1978-86. Patient vital status ("alive" or "dead") was monitored until the end of 1990.[6]

## Methodology

### Data

We obtained data from SEER by directly accessing tapes available at the National Institutes of Health. We obtained comparable data on a computer diskette from the Ontario Cancer Registry. We obtained each patient's dates of birth, diagnosis, and, if deceased, death. All patients not known to have died by December 31, 1990, were recorded as alive on that date.

We excluded patients for whom medical treatment for cancer was unlikely to have occurred: patients for whom the reporting source was a death certificate (or autopsy report) only (DCO) and patients with tumors not specifically classified as malignant. Further, we included only patients for whom the cancer was the patient's first. Finally, we excluded patients who were younger than 15 at the time of diagnosis because in Ontario these are handled by a special pediatric registry and may not be fully documented in the general registry.

[5]National Cancer Institute, Cancer Statistics Review 1973-1989 (Bethesda, Md.: 1992), p. I.1.

[6]This monitoring was passive, relying only on the registry's obtaining notification of the patient's death. Because Ontario does not actively follow up patients, we did not make use of SEER's methods of active follow-up.

To check the comparability of the data, we compared the United States and Ontario with respect to (1) the tendency for cases of each disease to reach the registry as DCOs and therefore be eliminated from the study and (2) the distribution of subtypes (defined by the specific kinds of cells involved in each case) within each disease. The data from each location were similar in terms of both the percentage of DCO cases and the distribution of subtypes within each of the four cancers. Data on the extent of disease were not available from Ontario and thus cannot be compared or otherwise taken into account.

## Outcome Measures

For each of the four cancers, we compared the observed survival rate of U.S. patients with that of the patients from Ontario. The survival "rate" is the proportion of all patients still alive at a given point in time after diagnosis. For example, if 10,000 patients are diagnosed with a disease, and 9,000 of them are still alive 1 year later, then the observed 1-year survival rate for that disease is 9,000 over 10,000, or 0.90. This rate reflects the cumulative tendency for patients to die over the interval between diagnosis and that point in time. If the survival rate from one location is consistently higher than that from another location, it means that patients from the location with the lower survival rate were dying faster than patients from the other location. If the gap between the rates gets smaller, disappears, or is reversed, it means that patients from the location with the initially higher survival rate were subsequently dying faster than the patients from the location with the initially lower survival rate.

Combining data from all patients diagnosed in 1978-86, we investigated monthly survival rates during a follow-up period whose length varied depending on date of diagnosis. It ranged from 4 years for patients diagnosed in the last month of 1986 who were then followed until the end of 1990 to 13 years for patients diagnosed in the first month of 1978 who were also followed until the end of 1990.

## Analysis

The life table method used to analyze the survival data is a way of computing survival rates that takes into account the differing periods of times patients are under observation. It has the advantages of (1) using all available survival information and (2) generating survival rates at all intervals (for example, months) from date of diagnosis. It combines the data from all patients, regardless of date of diagnosis, and (in our study) uses their survival times until death or December 31, 1990, along with vital status at that point in time as its basic data. Its use depends upon the

assumption that the survival experience of patients living after 1990 but followed for less than 13 years is similar to that of patients who were followed up for longer periods of time.

We implemented the life table method by using the life table procedures of the commonly used SPSS software package.[7] The main tool employed for examining the data was the survival curve that plots the observed survival rate as a function of time from diagnosis. For each condition, patient survival in the United States was compared with patient survival in Ontario by describing the two survival curves over the range of follow-up periods from 3 to 156 months after diagnosis.

For conditions in which at least 50 percent of the patients died during the follow-up period, it was also possible to compute each location's median survival time. This statistic cannot capture the details of an entire survival curve, but for diseases from which most patients die, it provides a summary measure of the time from diagnosis to death.

It is conventional in quantitative research to ask if differences between groups (in this case, between patients treated in the United States and those treated in Ontario) are "real" in the sense of being valid (here, reflecting differences in health care delivery) and reliable (in this context, not owing to chance). Reliability is assessed by determining whether a difference is known precisely enough so that its true value is unlikely to be zero—that it is "statistically significant." A problem arises in judging the importance of the differences observed between locations because the statistical significance of a difference is not the same as its clinical or public health significance. We have conducted statistical tests of differences and rely on the tests to decide the statistical significance of the differences (see appendix II). However, whether a difference is statistically significant or not depends on, among other things, how many separate measurements are involved. Because of the large numbers of patients included in most of the comparisons made in this report, some small differences between survival rates turned out to be statistically significant. Statistically significant differences in survival rates may represent a small proportion of the patients initially diagnosed and therefore be judged by some to be of minor clinical or public health importance.

The survival rates considered so far are "observed" survival rates. Another problem, one of validity, arises when comparing observed survival rates

[7]SPSS, Inc., SPSS for Windows Advanced Statistics, Release 5.0 (Chicago: 1992).

because some deaths do not result from the condition being studied. It is possible, for example, that differences between different locations result, wholly or in part, from differences in general population longevity rather than from circumstances specifically related to the condition itself. The solution we adopted presents relative survival rates as well as the observed survival rates. The relative survival rate for a period is the ratio of the observed survival rate to the proportion of survivors expected in a similar group from the general population. Like differences between the observed rates, differences between the relative rates can be tested for statistical significance (see appendix II). Relative survival rates indicate what the survival experience of the two populations would be if patients died only of cancer and are therefore presented in most displays of cancer survival.

Finally, to deal with another potential problem concerning the validity of the findings, we compared subgroup-specific survival curves according to sex, age, or year of diagnosis whenever there was a statistically significant difference between the United States and Ontario with respect to the distributions of one of these variables. In this way, we determined whether any observed survival rate differences between the entire patient groups were greatly affected by differences in the distributions of patients among different subgroups. When subgroup differences do not determine the overall pattern, the likelihood increases that it is determined by differences in health care systems.

# Comparative Survival

In this chapter, we compare the survival experience of patients from the United States and Ontario with the four forms of cancer under study. For each condition, we note its frequency of occurrence and typical rate of survival. Then, we present some basic demographic characteristics of the populations. Next, we describe the observed and relative survival rates of both locations throughout the survival interval. Finally, we report on subgroup-specific survival curves whenever it is possible that a difference in the distributions of a demographic variable contributes to the comparison of the overall survival curves.

## Lung Cancer

About 145,000 cases of lung cancer are diagnosed in the United States every year; in Canada, the number of new cases is about 15,000 per year.[1] Survival is not very high, with a relative rate of about 13 percent at 5 years.

Figure 2.1 presents, for both locations, the observed survival rates. We see U.S. superiority over the first year, followed by a period of about 3 years during which the curves are virtually indistinguishable but are crossing over one another, as evidenced by Ontario's superiority after about 5 years. The logrank test for equality of the curves rejects the possibility that there is a significant difference between the locations. This lack of difference is also evident in the median survival times: 7.0 months for both the U.S. patients and Ontario's patients.

[1]Cancer incidence varies over time. The yearly U.S. incidence numbers presented for this and other forms of cancer are based on the incidence counts for 1985-89 provided in table A-1 of B. A. Miller et al. (eds.), Cancer Statistics Review: 1973-1989 (Washington, D.C.: National Cancer Institute, 1992). The corresponding Canadian numbers are based on the incidence counts for 1984-88 provided in appendix A, table 1, of P. R. Band et al., The Making of the Canadian Cancer Registry: Cancer Incidence in Canada and Its Regions, 1969 to 1988 (Ottawa: Statistics Canada, 1993).

**Figure 2.1: Lung Cancer Survival: United States and Ontario**

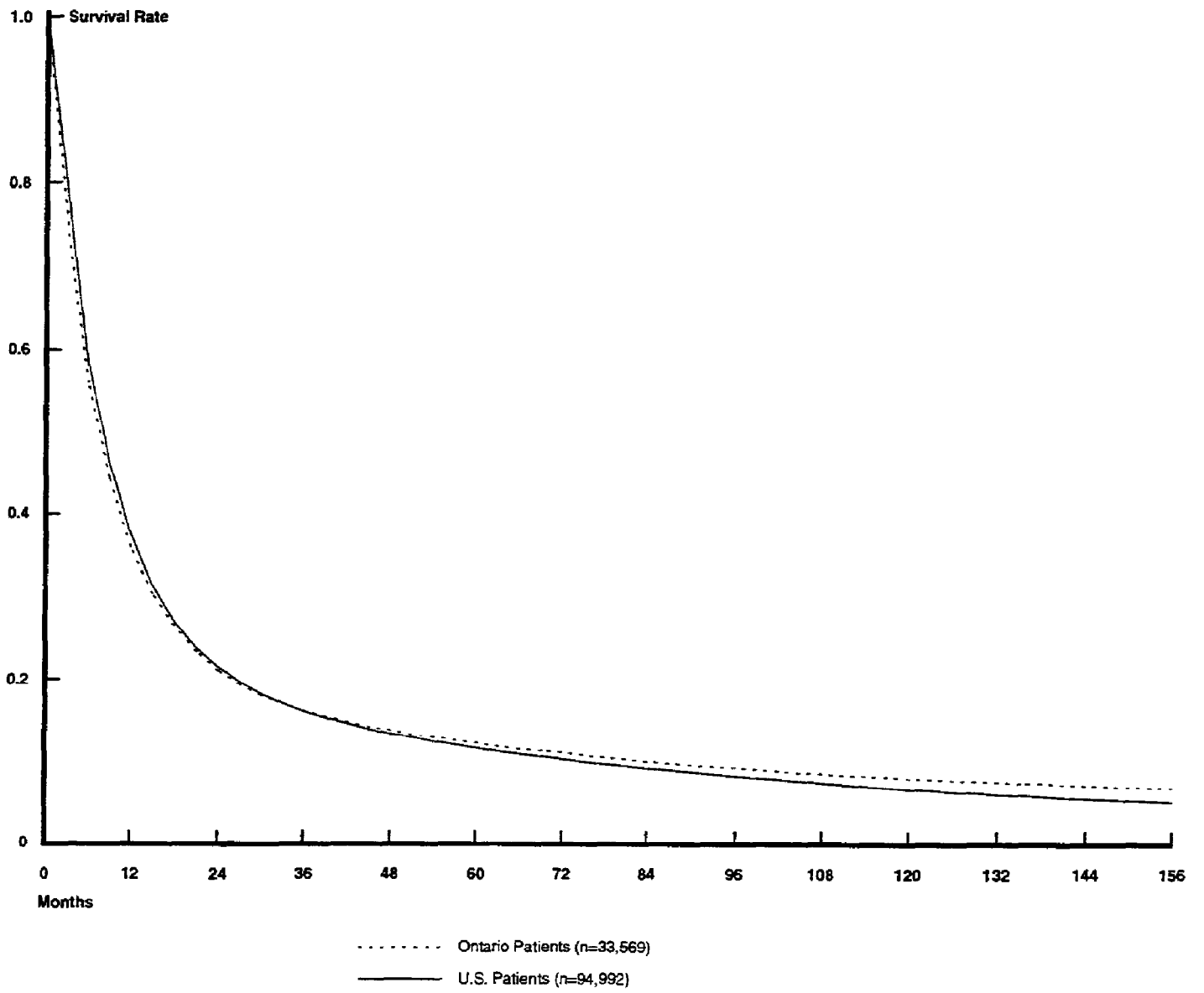



Table 2.1 presents distributions by age, sex, and year of diagnosis for the U.S. and Ontario data. Statistical tests revealed several significant associations between location and each of these variables. Although the

difference is small, Ontario's patients are more likely than U.S. patients to be in the younger age groups. Also, the proportion of male cases is greater in Ontario than in the United States. Finally, Ontario's patients are more likely than U.S. patients to be diagnosed in the more recent years (1984-86). It should be noted that the progressive increase in the proportion of cases over the years for almost all combinations of location and condition is to be expected on the basis of general population growth and does not necessarily mean that the incidence of any of the forms of cancer is increasing in either location.

**Table 2.1: Distributions of Lung Cancer Patients[a]**

| | U.S. | Ontario |
|---|---|---|
| Age | | |
| Under 55 | 15.9% | 16.4% |
| 55-64 | 31.1 | 31.9 |
| 65-74 | 33.9 | 33.3 |
| 75 and over | 19.1 | 18.5 |
| Male | 68.5 | 72.9 |
| Year of diagnosis | | |
| 1978-80 | 30.4 | 28.8 |
| 1981-83 | 33.7 | 33.6 |
| 1984-86 | 36.0 | 37.6 |

[a]Numbers of patients: United States, 94,992; Ontario, 33,569.

Table 2.2 presents observed and relative survival rates and their standard errors for selected follow-up intervals from 1 year to 10 years. For both observed and relative rates, U.S. survival is slightly, but significantly, higher than Ontario's survival early in the follow-up period. The U.S. relative survival rate exceeds Ontario's by 0.016 at 1 year. It is significantly lower later in the period, by 0.017 at 10 years. Despite the small difference in rates, this latter figure represents about 1,600 additional U.S. lung cancer patients in the SEER regions alone, out of the 94,992 diagnosed during 1978-86, who would have been alive 10 years after diagnosis if Ontario's survival experience had applied.

**Table 2.2: Observed and Relative Survival Rates of Lung Cancer Patients**

| | 1-year | | 3-year | | 5-year | | 10-year | |
|---|---|---|---|---|---|---|---|---|
| Location | Observed | Relative | Observed | Relative | Observed | Relative | Observed | Relative |
| U.S.[a] | 0.376 | 0.384 | 0.160 | 0.173 | 0.115 | 0.133 | 0.066 | 0.094 |
| Ontario[b] | 0.361 | 0.368 | 0.160 | 0.173 | 0.121 | 0.139 | 0.080 | 0.111 |

[a]All U.S. standard errors are .001, except for those of both observed and relative survival at 1 year, which are .002.

[b]All Ontario standard errors are .002, except for those of both observed and relative survival at 1 year, which are .003.

We compared the age-, sex-, and year of diagnosis-specific survival curves for the groups listed in table 2.1. The pattern seen in figure 2.1 is seen for each group: initial U.S. superiority followed by Ontario's eventual superiority. Thus, the crossover pattern does not depend on the distributions of age, sex, or year of diagnosis.

In summary, observed lung cancer survival rates in the United States and Ontario are very similar throughout the follow-up period, with the U.S. rate slightly higher within the first year or two after diagnosis, a crossing over of the rates at around 3 years, by which time most of the patients have died, and a slightly higher survival rate for Ontario thereafter. When differences between the locations in overall life expectancy are taken into account, the relative survival rate difference at 1 year, in favor of the United States, and the corresponding rate difference at 10 years, in favor of Ontario, are both about 1.7 percentage points. The basic crossover pattern is also observed for all subgroups.

## Colon Cancer

About 95,000 cases of colon cancer are diagnosed in the United States every year, about 9,700 in Canada. Relative survival is between 50 and 60 percent at 5 years.

Figure 2.2 presents colon cancer survival rates for the United States and Ontario. It is clear that patients are more likely to survive colon cancer than lung cancer. The U.S. rate is higher than Ontario's until about 6 years (72 months), when the survival curves cross, after which the rate for Ontario is higher. The logrank test for overall equality of the survival curves reveals no significant difference. The median survival time for U.S. colon cancer patients is 43.0 months, while for Ontario's patients it is 40.0 months, a difference of 3 months.

**Figure 2.2: Colon Cancer Survival: United States and Ontario**

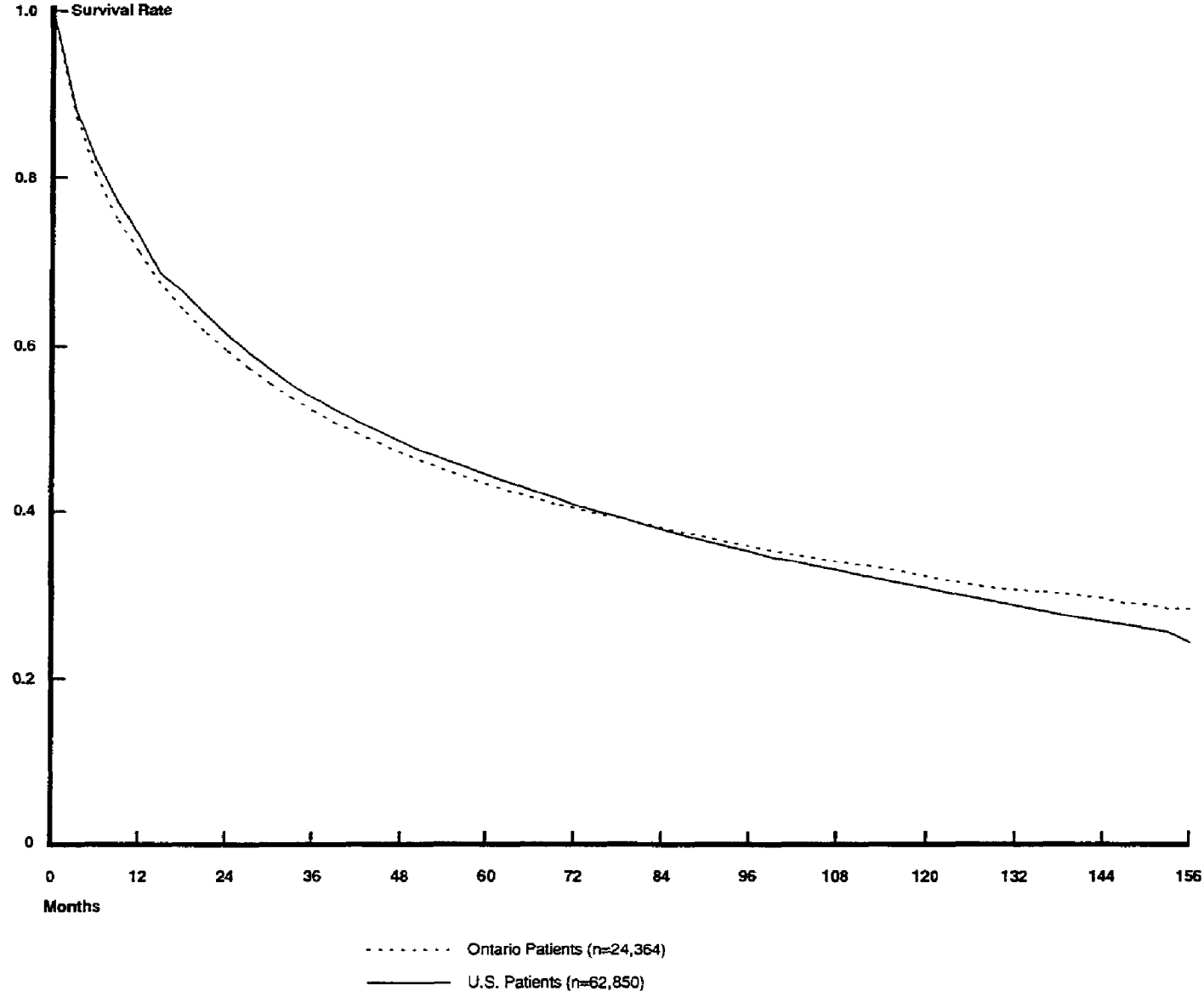



Table 2.3 presents U.S. and Ontario distributions of age, sex, and year of diagnosis. For colon cancer, the U.S. patients are significantly more likely to fall in the older age groups than are the patients from Ontario. There is

little difference between locations in sex distribution. As with lung cancer, a significant difference in year of diagnosis was observed, such that relatively fewer of Ontario's patients were diagnosed early (1978-80) and relatively more were diagnosed late (1984-86).

**Table 2.3: Distributions of Colon Cancer Patients[a]**

| | U.S. | Ontario |
|---|---|---|
| Age | | |
| Under 50 | 6.0% | 7.1% |
| 50-59 | 13.6 | 16.0 |
| 60-69 | 26.9 | 27.9 |
| 70-79 | 31.3 | 30.2 |
| 80 and over | 22.3 | 18.8 |
| Male | 47.4 | 47.8 |
| Year of diagnosis | | |
| 1978-80 | 30.8 | 28.8 |
| 1981-83 | 33.3 | 33.6 |
| 1984-86 | 35.9 | 37.6 |

[a]Numbers of patients: United States, 62,850; Ontario, 24,364.

Table 2.4 presents selected observed and relative colon cancer survival rates for the two locations. The superiority of Ontario's observed survival rate after the crossover seen in figure 2.2 is only 0.011 at 9 years after diagnosis, but it is statistically significant, just as is the larger difference (0.021) in favor of the United States at 1 year. The relative rates demonstrate a somewhat different pattern: initial U.S. superiority (a difference of 0.025 at 1 year) followed by eventual equality of rates (a common relative survival rate of about 0.51 at 9 years). The tiny relative survival rate difference at 9 years in favor of the United States is not statistically significant. The size of the difference between the observed rates in favor of Ontario increases as the follow-up interval lengthens, as can been seen in figure 2.2, reaching about 0.04 at 13 years. Although relative survival rates were not computed for intervals beyond 9 years, and although the difference in relative rates is likely to be smaller than the observed rate difference, it is possible that the Ontario relative survival rate begins to significantly exceed the U.S. rate at some interval beyond 9 years.

**Table 2.4: Observed and Relative Survival Rates of Colon Cancer Patients**

| | 1-year | | 3-year | | 5-year | | 9-year | |
|---|---|---|---|---|---|---|---|---|
| | Observed | Relative | Observed | Relative | Observed | Relative | Observed | Relative |
| U.S.[a] | 0.734 | 0.756 | 0.537 | 0.603 | 0.443 | 0.547 | 0.328 | 0.514 |
| Ontario[b] | 0.713 | 0.731 | 0.521 | 0.582 | 0.431 | 0.527 | 0.339 | 0.511 |

[a]All U.S. standard errors are .002, except for that of the relative survival rate at 9 years, which is .003.

[b]All Ontario standard errors are .003, except for those of the relative survival rates at 3 and 5 years, which are .004, and at 9 years, which is .005.

Because relative rates, unlike observed rates, take into account differences between locations in general population longevity, we infer from this analysis that the survival rate from colon cancer in the United States and Ontario is essentially the same 9 years after diagnosis.

We compared the age-specific survival curves of the age groups listed in table 2.3. For each of the three older age groups, the survival curves of the two locations cross, showing initial U.S. superiority followed by Ontario's eventual superiority. This pattern was not observed for patients in the two younger age groups. That is, for patients under 60 years of age, the U.S. survival rate was greater over the entire follow-up period (see figures III.1 and III.2 in appendix III). This exception, however, concerned only about 20 percent of the colon cancer patients. For the majority of patients, the crossover pattern was observed when age-specific groups were examined. Thus, the crossover characteristic of the overall survival curve was not an artifact of differences between locations in their age distributions.

For colon cancer, we did not take sex differences into account because the association between sex and location was not statistically significant.

We examined the survival curves of the year of diagnosis subgroups listed in table 2.3. For all three subgroups, crossover occurred, as it did for the overall curve, at about 6 years after diagnosis.

In summary, observed colon cancer survival rates in the United States and Ontario are very similar throughout the follow-up period. As with lung cancer, we observed a pattern of initial U.S. superiority followed by crossover and Ontario's subsequent superiority. For colon cancer, however, crossover does not occur until about 6 years after diagnosis. The crossover pattern is also observed for most survival curves by age and

year of diagnosis, but the survival rate superiority observed for the United States is maintained throughout the follow-up period for patients under 60 years of age at diagnosis. The relative survival rate difference at 1 year, in favor of the United States, is 2.5 percentage points, and at 9 years there is no statistically significant difference in relative rates between locations.

## Hodgkin's Disease

Hodgkin's disease is a variety of "lymphoma." About 7,300 cases of Hodgkin's disease are diagnosed in the United States every year, and less than 1,000 in Canada, making it a much less common disease than either lung cancer or colon cancer. Relative survival is between 70 and 80 percent after 5 years.

Figure 2.3 shows the survival rate curves for the United States and Ontario. Differences were very small, although, as with lung cancer and colon cancer, there was a tendency for U.S. survival to be greater over the first few years after diagnosis and for Ontario's survival to be greater thereafter. For Hodgkin's disease, too, the logrank test does not indicate a significant difference between the locations. Moreover, because more than half the patients are still alive at the end of the 13 years, median survival time cannot be computed for either location.

**Figure 2.3: Hodgkin's Disease Survival: United States and Ontario**

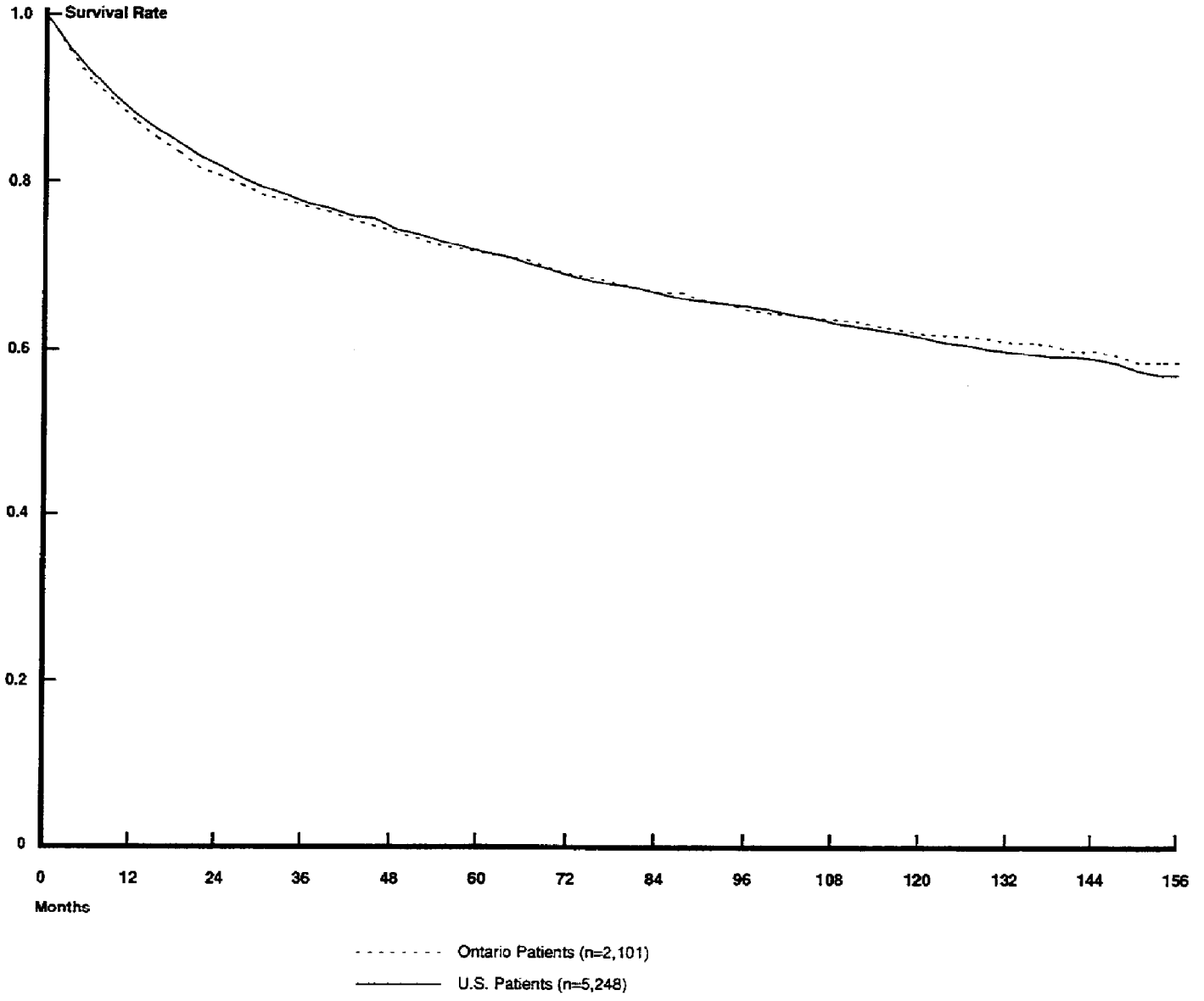



Table 2.5 presents the distributions of age, sex, and year of diagnosis for the United States and Ontario. Ontario's patients were significantly more likely to be in the older age groups. The differences between locations in

the sex and year of diagnosis distributions were not statistically significant.

**Table 2.5: Distributions of Hodgkin's Disease Patients[a]**

| | U.S. | Ontario |
|---|---|---|
| Age | | |
| Under 25 | 27.9% | 24.6% |
| 25-39 | 34.8 | 33.1 |
| 40-54 | 13.1 | 15.5 |
| 55 and over | 24.2 | 26.8 |
| Male | 56.4 | 58.2 |
| Year of diagnosis | | |
| 1978-80 | 31.2 | 30.8 |
| 1981-83 | 34.5 | 34.2 |
| 1984-86 | 34.3 | 34.9 |

[a]Numbers of patients: United States, 5,248; Ontario, 2,101.

Considering the observed and relative survival rates at selected follow-up intervals (table 2.6) does not change the picture very much. There was little or no difference between rates at any interval, and the differences are not statistically significant. At 10 years after diagnosis, the relative survival rates of both locations were 0.68.

**Table 2.6: Observed and Relative Survival Rates of Hodgkin's Disease Patients**

| | 1-year | | 3-year | | 5-year | | 10-year | |
|---|---|---|---|---|---|---|---|---|
| | Observed | Relative | Observed | Relative | Observed | Relative | Observed | Relative |
| U.S.[a] | 0.882 | 0.884 | 0.776 | 0.795 | 0.717 | 0.748 | 0.614 | 0.676 |
| Ontario[b] | 0.875 | 0.876 | 0.771 | 0.792 | 0.716 | 0.749 | 0.618 | 0.684 |

[a]The U.S. standard errors for both observed and relative rates are .004 at 1 year and .006 at 3 and 5 years; at 10 years, the standard errors are .008 for both the observed and relative rates.

[b]The standard errors are .007, .009, and .010 for both the observed and relative Ontario rates at 1, 3, and 5 years, respectively; at 10 years, they are .012 for the observed rate and .014 for the relative rate.

It is possible that the apparent equality in survival is affected by the age difference. To see if the tendency of Ontario's patients to be in the older age groups does affect the comparison, we compared age-specific survival curves for the age groups listed in table 2.6 (see figures III.3-III.6 in appendix III). Ontario's survival rate was at least slightly higher than the

U.S. rate over all or most of the follow-up period in each of the four age-specific comparisons, but in no case was this difference statistically significant according to the logrank test. Only one of the age-specific comparisons, that for the oldest age group, had a pattern somewhat similar to the crossover of the overall curve.

These results suggest that survival from Hodgkin's disease is greater for Ontario's patients when age distribution differences between the locations are taken into account. It is possible that the relative youth of the U.S. patient population prevents a small overall survival difference in favor of Ontario from being demonstrated.

We did not examine sex or year of diagnosis differences because of the similarity of both the sex and year of diagnosis distributions in the two locations. The associations between location and each of these two variables are not statistically significant.

In summary, observed Hodgkin's disease survival rates in the United States and Ontario are very similar throughout the follow-up period. Differences between locations in relative survival tend to be less than 1 percentage point, and none of those tested are statistically significant. Nevertheless, a pattern of initial U.S. superiority followed by crossover at about 5 years and subsequent Ontario superiority, not unlike that seen for lung and colon cancers, can be discerned in the overall curve. In the case of Hodgkin's disease, however, this pattern may be misleading. When age-specific curves are inspected, greater consistency is observed. For three of these, consistently or almost consistently higher rates for Ontario's patients are observed, and for the fourth, the oldest group, the crossover pattern is observed.

## Breast Cancer

About 150,000 cases of breast cancer are diagnosed in the United States every year, and about 12,000 cases in Canada. Relative survival is between 70 and 80 percent at 5 years.

Figure 2.4 indicates a greater survival rate for the United States than for Ontario consistently throughout the follow-up period. The logrank test confirms the statistical significance of U.S. superiority in overall survival. The median survival times are 123.0 months for the United States and 112.0 for Ontario, a difference of almost a year.

**Figure 2.4: Breast Cancer Survival: United States and Ontario**

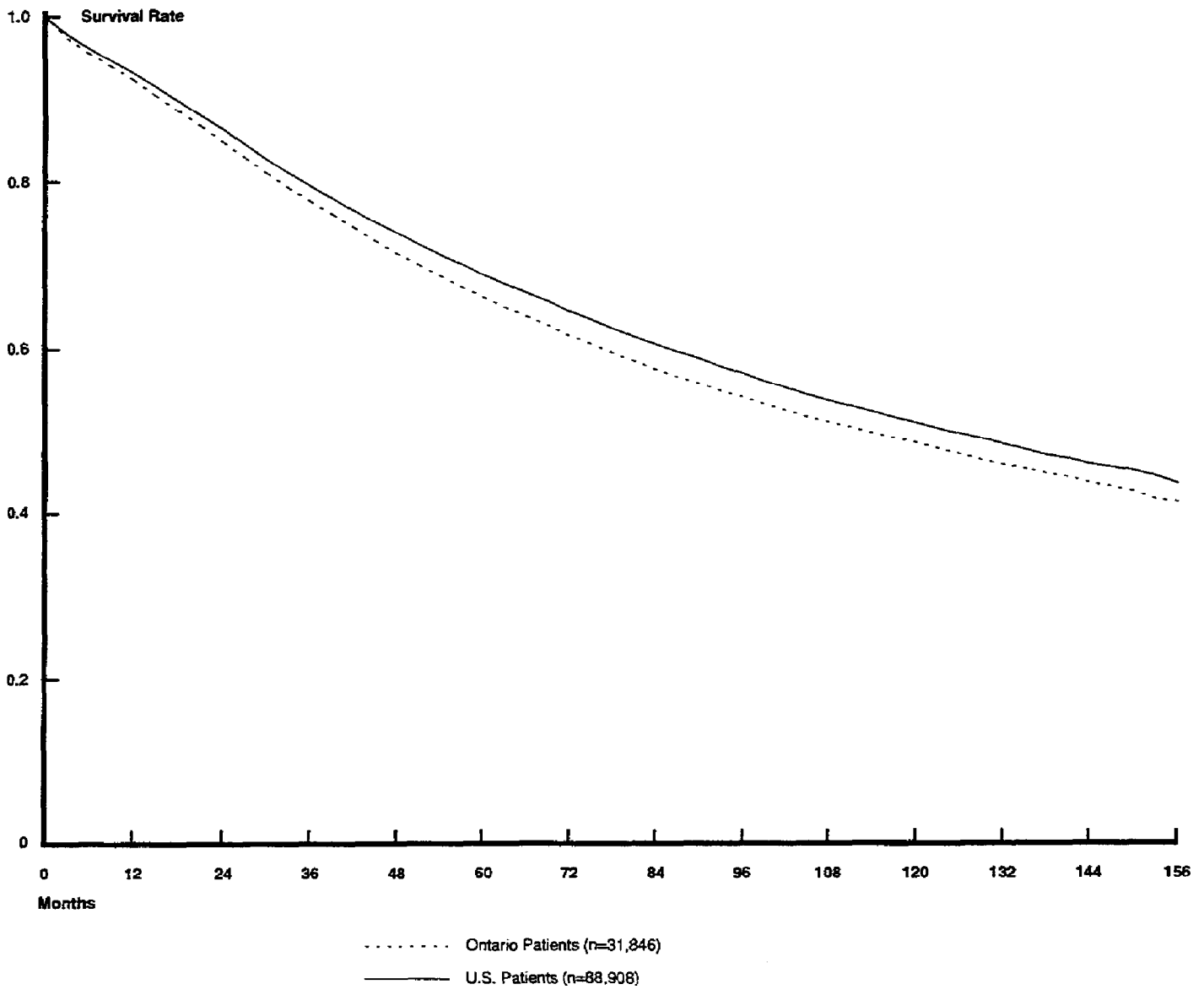



Table 2.7 presents distributions of age and year of diagnosis for the U.S. and Ontario data. The age distributions differ significantly, with the U.S. women falling more often in the older age groups. There is also a

significant but very small difference with respect to year of diagnosis. Unlike U.S. patients with the other cancers, the U.S. patients with breast cancer are somewhat more heavily concentrated in the late group than are the comparable patients from Ontario. This finding is consistent with the increased use of mammographic screening in the United States over recent years.

**Table 2.7: Distributions of Breast Cancer Patients[a]**

| | U.S. | Ontario |
|---|---|---|
| Age | | |
| Under 50 | 23.2% | 24.8% |
| 50-59 | 21.7 | 23.6 |
| 60-69 | 25.2 | 23.8 |
| 70-79 | 19.0 | 17.6 |
| 80 and over | 10.9 | 10.3 |
| Year of diagnosis | | |
| 1978-80 | 29.2 | 29.7 |
| 1981-83 | 32.7 | 33.1 |
| 1984-86 | 38.1 | 37.2 |

[a]Numbers of patients: United States, 88,908; Ontario, 31,846.

Inspecting relative survival rates for the breast cancer patients does not change the picture of consistent U.S. superiority. As indicated in table 2.8, the difference in relative survival increases throughout the follow-up period. By 10 years, the relative survival rate difference is 0.048 in favor of the U.S. patients. This represents about 4,300 U.S. patients from the study population of 88,908 who survived for at least 10 years but who would not have survived that long if Ontario's survival experience had applied.

**Table 2.8: Observed and Relative Survival Rates of Breast Cancer Patients**

| | 1-year | | 3-year | | 5-year | | 10-year | |
|---|---|---|---|---|---|---|---|---|
| | Observed | Relative | Observed | Relative | Observed | Relative | Observed | Relative |
| U.S.[a] | 0.934 | 0.944 | 0.795 | 0.840 | 0.687 | 0.758 | 0.507 | 0.647 |
| Ontario[b] | 0.925 | 0.933 | 0.777 | 0.816 | 0.660 | 0.722 | 0.482 | 0.599 |

[a]U.S. standard errors for both observed and relative 1- and 3-year rates are .001; standard errors are .002 for both 5-year rates and the observed 10-year rate and .003 for the relative 10-year rate.

[b]Ontario standard errors for both observed and relative 1- and 3-year rates are .002; standard errors are .003 for both 5-year rates and the observed 10-year rate and .004 for the relative 10-year rate.

We compared age-specific survival rates for the age groups listed in table 2.7. In all cases, U.S survival was higher, although for the 80 and over age group the two survival curves become coincident beyond 100 months, a time by which they are at least 88 and probably about as likely to die as comparable women without breast cancer.

Groups defined by year of diagnosis were examined separately. For all three groups, the U.S. rate was consistently higher, as it was for the overall curve.

In summary, observed breast cancer survival rates in the United States exceeded those in Ontario throughout the follow-up period. The difference between locations in relative survival was 4.8 percentage points at 10 years. A consistent observed survival difference in favor of the United States was characteristic of patients in all age groups except for those 80 and older.

# Conclusions and Implications

The data in chapter 2 show that the United States and Ontario share similar patterns of survival for four different forms of cancer: lung cancer, colon cancer, Hodgkin's disease, and breast cancer. Over a 10-year period (9-year for colon cancer) throughout which we tested for differences, the largest observed difference between locations was 2.5 percent. When differences in life expectancy were taken into account, survival differences changed little; the largest relative survival rate difference was 4.8 percent. For each of the four conditions, this overall similarity in levels of survival persisted when differences between U.S. and Ontario distributions of age, sex, and year of diagnosis were taken into account. However, although the percentage differences were small, some were statistically significant, and the number of patients represented by these differences can be substantial. For example, the 1.7-percent difference in lung cancer (relative) survival at 10 years after diagnosis corresponds to about 1,600 additional U.S. patients in the SEER regions alone who would have been alive 10 years after diagnosis if Ontario's survival (and general mortality) experience had applied to those diagnosed over the years 1978-86.

Beyond the general similarity in survival rates between the locations, a distinction can be made between the data pattern for breast cancer and for the three other conditions. Breast cancer patients in the United States experienced a consistently higher level of survival than Ontario's breast cancer patients throughout the follow-up period. In contrast, U.S. patients with each of the three other diseases demonstrated initially higher survival rates than their counterparts from Ontario (up to 1 or more years after diagnosis) followed by a loss of advantage occurring somewhere between 1 and 6 years. The result was that by 9 or 10 years, U.S. relative survival rates were either the same as (colon cancer, Hodgkin's disease) or lower than (lung cancer) the corresponding Ontario rates.

All the differences mentioned are statistically significant except in the case of Hodgkin's disease. Inspection of age-specific survival curves generally supports the consistent superiority of the U.S. breast cancer survival rate. With lung cancer, the age-specific survival curves manifest the crossover pattern seen for the entire lung cancer populations. That is, they start with a higher U.S. rate and end in superiority for Ontario.

For the two other diseases, age-specific curves present a somewhat more complicated picture than do the overall curves. Age-specific curves for the colon cancer patients suggest that the initial U.S. advantage in colon cancer survival is not lost entirely for patients younger than 60 (that is, no

crossover or even merging for patients in this age group). Age-specific curves for the Hodgkin's disease patients suggest that the apparent equality of survival rates for patients with Hodgkin's disease may result from differences in the ages of U.S. and Ontario patients. That is, for any age-specific group, Ontario's survival is higher than the U.S. rate at both 5 and 10 years after diagnosis. These findings are summarized in table 3.1.

**Table 3.1: Summary of Findings**

| Condition | Overall survival curves, results of statistical tests | Age-specific survival curves, results of inspection |
|---|---|---|
| Lung cancer | U.S. initially higher; Ontario eventually higher | Crossover for each group |
| Colon cancer | U.S. initially higher; eventual equality in relative survival | Crossover for age groups 60 and over, but U.S. advantage maintained for patients under 60 years |
| Hodgkin's disease | No significant differences | Ontario advantage for each age group by 5 years |
| Breast cancer | U.S. consistently higher | U.S. consistently higher, except for long-term survival of oldest patients |

It is not clear how to interpret the significant differences (those for lung, colon, and breast cancers) between the two locations. Whether consistent throughout the follow-up period (breast cancer) or not (lung and colon cancers), they could have resulted from differences in diagnostic practices (including screening programs, relevant for colon and breast cancers), therapeutic practices, or both. In the absence of comparable information from both locations on the extent of disease at diagnosis, we cannot distinguish between longer survival as a result of more effective treatment and longer survival as a result of earlier or more aggressive diagnosis.

Nevertheless, we have systematically compared selected cancer survival rates in the United States and Ontario for the first time. This is relevant to the discussion of quality of care and may be relevant to discussions of health care cost and coverage as well. Ideally, information on survival would be integrated with information on other patient outcomes (for example, disability), information on the processes of care (for example, promptness of treatment following diagnosis), information on system inputs (for example, extent of disease at initial patient presentation), and information on costs and coverage in order to fully understand the strengths and weaknesses of each location's approach to care. The present work is a first step in an ongoing research process.

Moreover, outcomes, whether for cancer or for other conditions, are always important to consider when examining health care. Our study has shown that it is possible to make international comparisons of survival. Comparisons between groups within the United States, using only SEER program data, may be even easier to conduct. The availability of analytic methods for survival data makes a detailed comparison of data from different systems feasible. Finally, for many potentially fatal medical conditions, it is plausible that survival reflects quality of care. Compared to traditional measures, such as average life expectancy, the likely interpretations of differences in disease survival are relatively few, and it is therefore possible to learn something about quality from studies of survival.

# Data Sources

Data on the survival of cancer patients is most readily obtained from cancer registries. To compare countries or other geographic locations with respect to the survival of their cancer patients, it is necessary that the survival data be population-based. This means that a vigorous attempt is made to ensure that all incident (newly found) cases occurring within the region are registered. The population-based registries used in this study are described in this appendix.

## SEER

The SEER program was begun by NCI in 1973. It includes a number of population-based registries. Of these, we used the ones upon which NCI has based its reports of incidence and survival data: Hawaii, Seattle-Puget Sound, San Francisco-Oakland, Utah, New Mexico, Iowa, Metropolitan Detroit, Connecticut, and Metropolitan Atlanta. The combination of these nine registries, which covers about 9.5 percent of the U.S. population (over 20 million), is believed by SEER to be "reasonably representative" of that population with respect to selected demographic and epidemiologic factors, although there are limitations to this representativeness.[1]

SEER attempts a complete ascertainment of cases of almost all forms of cancer, including the four of interest here, for residents of its area. Through contractors, it registers the cases on the basis of hospital records (including those outside its coverage area), death certificates (including those outside the coverage area), private laboratories, and other units providing diagnostic services. Extensive information is collected for each case, including date of diagnosis, and basic demographics, such as sex and date of birth, of interest here. SEER's contractors actively follow up living cases and in the course of this activity obtain notification of patient deaths from a variety of sources, including the hospital in which the patient was treated, National Death Index, the Health Care Financing Administration, and voter registration rolls. Although methods differ across registries, there is considerable incentive for contractors to find out about all case deaths, in state and out, in order to avoid futile attempts to contact deceased cases.

## Ontario Cancer Registry

We selected the Ontario Cancer Registry, operated by the Ontario Cancer Treatment and Research Foundation, for study because it covers a relatively large population (over 8 million), has population-based data since 1964, and has an estimated completeness of registration of

[1]C. M. Frey et al., "Representativeness of the Surveillance, Epidemiology, and End Results Program Data: Recent Trends in Cancer Morality Rates," Journal of the National Cancer Institute, 84:11 (1992), 872-77.

95 percent.[2] Its information on cancer cases derives from routinely recorded hospital discharges, voluntarily submitted reports of hospital pathologists, reports from specialized cancer treatment centers, and all provincial death records, including those of residents dying in other Canadian provinces. Although the registry does not actively follow up patients, its system for linking patient records with death certificates for all provinces of Canada is quite sophisticated and leads to its conclusion that it is "truly population-based" with regard to mortality as well as cancer incidence.

[2]S. C. Robles et al., "An Application of Capture-Recapture Methods to the Estimation of Completeness of Cancer Registration," Journal of Clinical Epidemiology, 41:5 (1988), 495-501.

# Statistical Tests

## Tests of Statistical Significance

One of the statistical tests employed is the logrank test, comparing the overall survival experience of the two locations for each form of cancer (at the .95 level of confidence). This statistic assesses the tendency for the survival rate of one of the groups being compared to be higher across all follow-up intervals, with each interval weighted equally. Because of this weighting, the logrank test tends to be equally sensitive to differences occurring throughout the follow-up period.[1]

Because the logrank test for the overall survival curve does not include information about differences between survival rates at particular follow-up intervals or their statistical significance, we used a second kind of statistical test that deals with this issue directly. It involves the comparison of specific survival rates, using standard errors computed by Greenwood's formula.[2] A common z-test was employed to test the statistical significance (at the .95 level of confidence) of the difference between the U.S. and Ontario rates at selected follow-up intervals.

We compared survival rate estimates at the follow-up intervals 1, 3, 5, and 10 years (9 for colon cancer) after diagnosis.[3] We did this to be able to detect significant differences characteristic of portions of the follow-up interval that might not be consistently observed throughout the interval. We selected the values to define a wide range of well-spaced intervals but stopped at 10 years to ensure that at least four yearly cohorts would contribute to each rate. (The four cohorts from 1978 to 1981 contributed to the 10-year survival rates.)

## Relative Survival

Relative survival for a period is the ratio of the proportion of survivors over the period in the patient group (observed survival rate) to the proportion of survivors expected in a similar group without the disease (or in a similar group a negligible fraction of which has the disease). For example, if the observed 10-year survival rate of 60-year-old female bladder cancer patients from the United States diagnosed in 1974 is 0.60, and if the proportion of all U.S. women 60 years old in 1974 who live at least 10 more years is 0.80, then the relative survival rate of the patients is

[1]R. E. Tarone and J. Ware, "On Distribution-Free Tests for Equality of Survival Distributions," Biometrika, 64 (1977), 156-60.

[2]J. D. Kalbfleisch and R. L. Prentice, The Statistical Analysis of Failure Time Data (New York: Wiley, 1980), p. 14-6.

[3]Nine-year rather than 10-year survival was examined for colon cancer because the available general population life tables make it possible to compute 9-year but not 10-year survival for the two populations of especially old patients.

0.60 divided by 0.80, or 0.75. General population mortality tends to be somewhat lower in Ontario than in the United States for people at most ages before 80. It is unlikely that differences in general population mortality are large enough to affect differences between the locations in the observed survival rates of cancer patients at shorter follow-up periods. It is possible, however, that in a comparison of the longer survival periods, during which the effects of the general population mortality differences for each year accumulate, the difference between locations in general mortality could have an effect on the difference between observed survival rates. We used the simple approximate method of calculating expected survival rates and their standard errors from U.S. and Ontario general population life tables for the period of interest.[4]

## Demographic Comparisons

We tested differences between locations in the demographic variables age, sex, and cohort for statistical significance using a chi-square test for association (at the .95 level of confidence).

[4]On relative survival rates, see F. Ederer et al., "The Relative Survival Rate: A Statistical Methodology," National Cancer Institute Monograph, 6 (1961), 101-21. See also National Center for Health Statistics, Vital Statistics of the United States, 1983, vol. 2, Mortality, Part A (Washington, D.C.: Public Health Service, 1986); National Center for Health Statistics, Vital Statistics of the United States, 1988, vol. 2, Mortality, Part A (Washington, D.C.: Public Health Service, 1991); Statistics Canada, Life Tables, Canada and Provinces, 1980-1982 (Ottawa, Canada: 1984); and Statistics Canada, Life Tables, Canada and Provinces, 1985-1987 (Ottawa, Canada: 1989).

# Subsample-Specific Survival Curves

Most of the subsample-specific survival curves examined, presenting data for a particular age group, sex, or range of years of diagnosis, are similar in general appearance (we are not considering statistical significance in this appendix) to the overall survival curves for the same disease. For example, all age-, sex-, and year of diagnosis-specific curves describing the survival experience of lung cancer patients from the United States and Ontario manifest the crossover pattern wherein initial U.S. superiority is followed by eventual Ontario superiority.

The most important exceptions occur for colon cancer and Hodgkin's disease. The overall colon cancer curve and most of the subsample-specific curves examined show a pattern somewhat similar to that observed for lung cancer: initial U.S. superiority is followed by its loss, either crossover or a merging of the curves. For the two youngest age groups, however, U.S. superiority is never lost. With Hodgkin's disease, the overall curve shows little difference between locations, with a suggestion of crossover from initial U.S. to eventual Ontario superiority, but three of the four age-specific survival curves show consistent or nearly consistent Ontario superiority. These exceptions are presented in this appendix.

Figure III.1: Colon Cancer Survival, Patients Younger Than 50: United States and Ontario

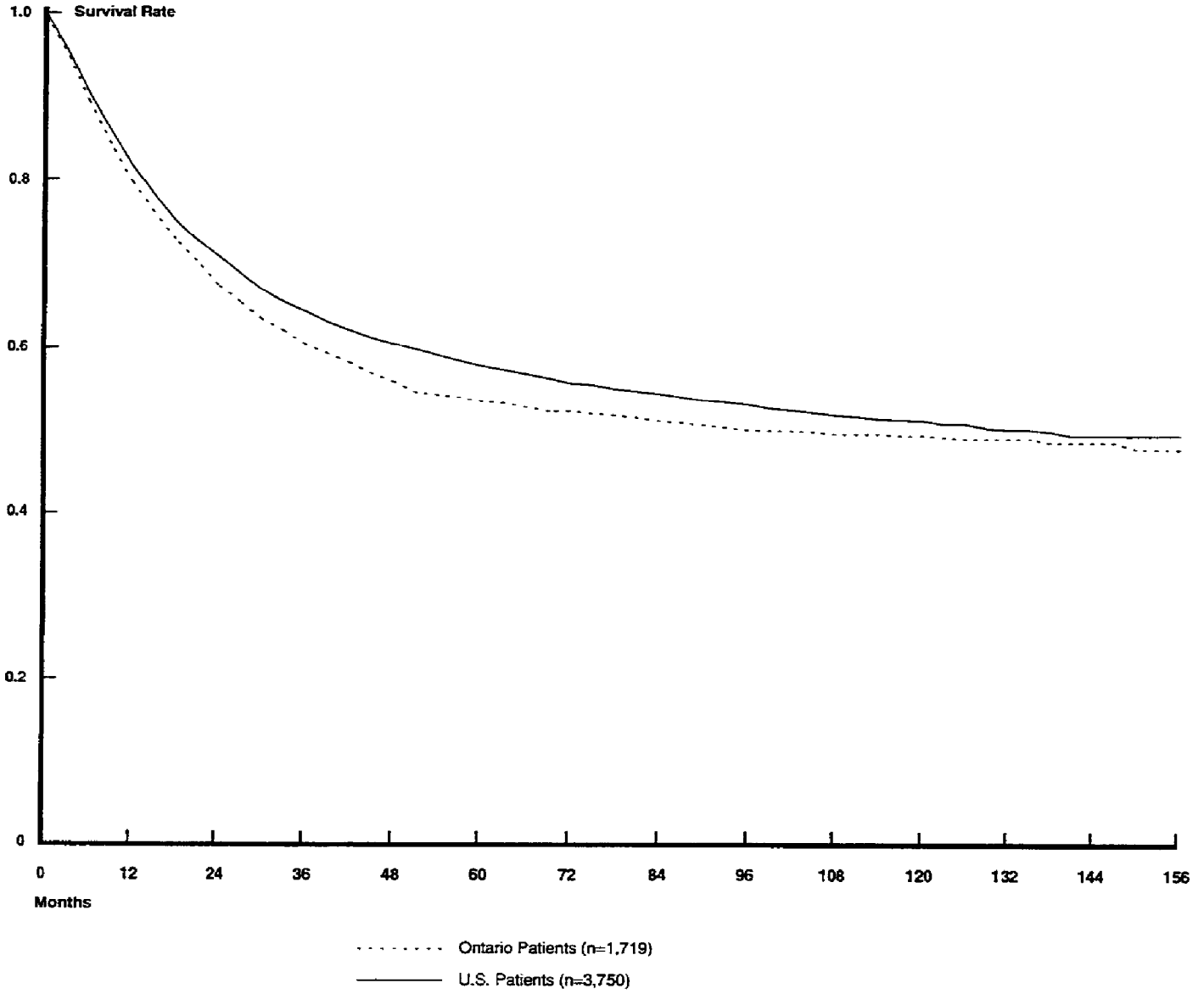


**Figure III.2: Colon Cancer Survival, Patients 50-59: United States and Ontario**

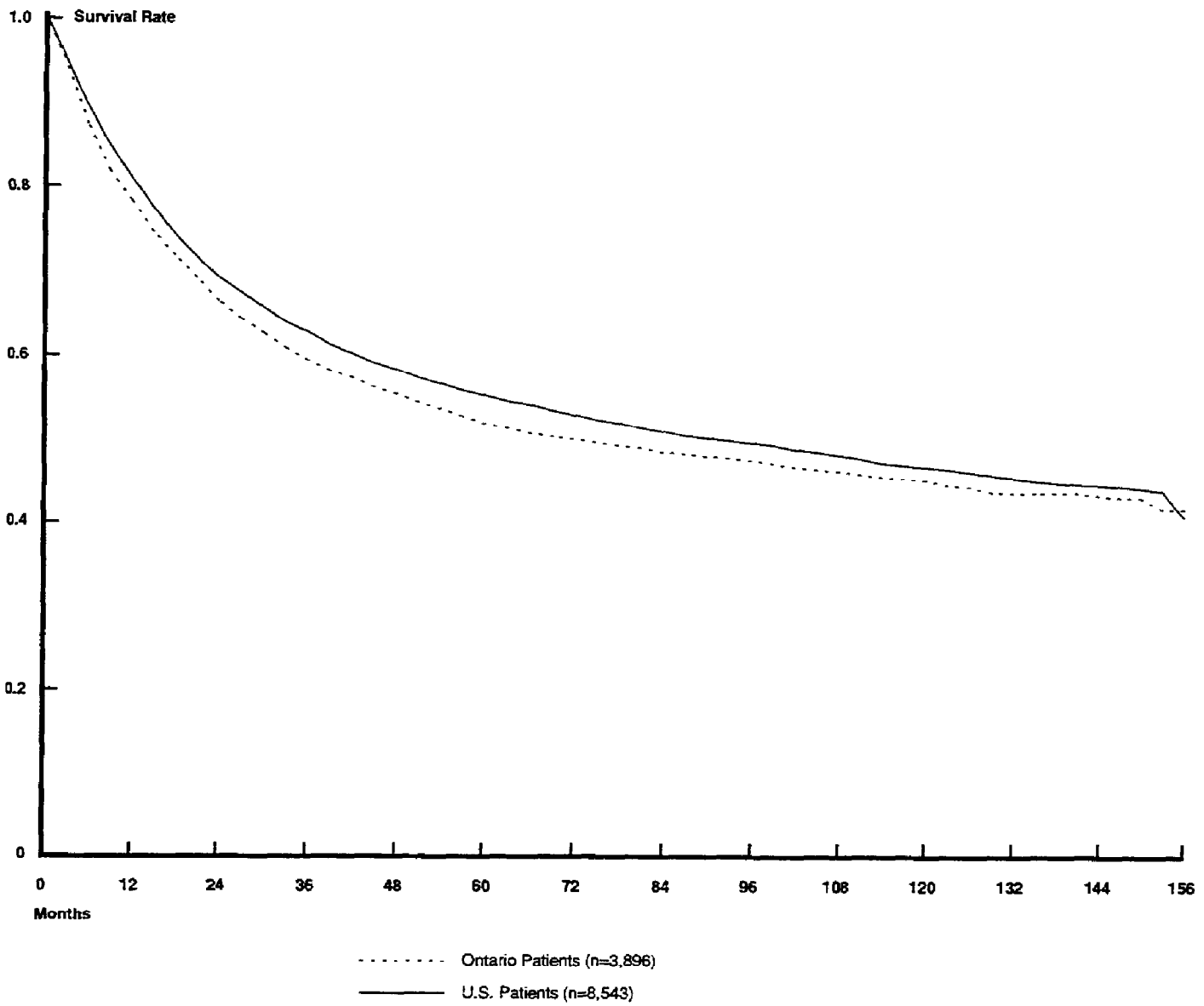


**Figure III.3: Hodgkin's Disease Survival, Patients 15-24: United States and Ontario**

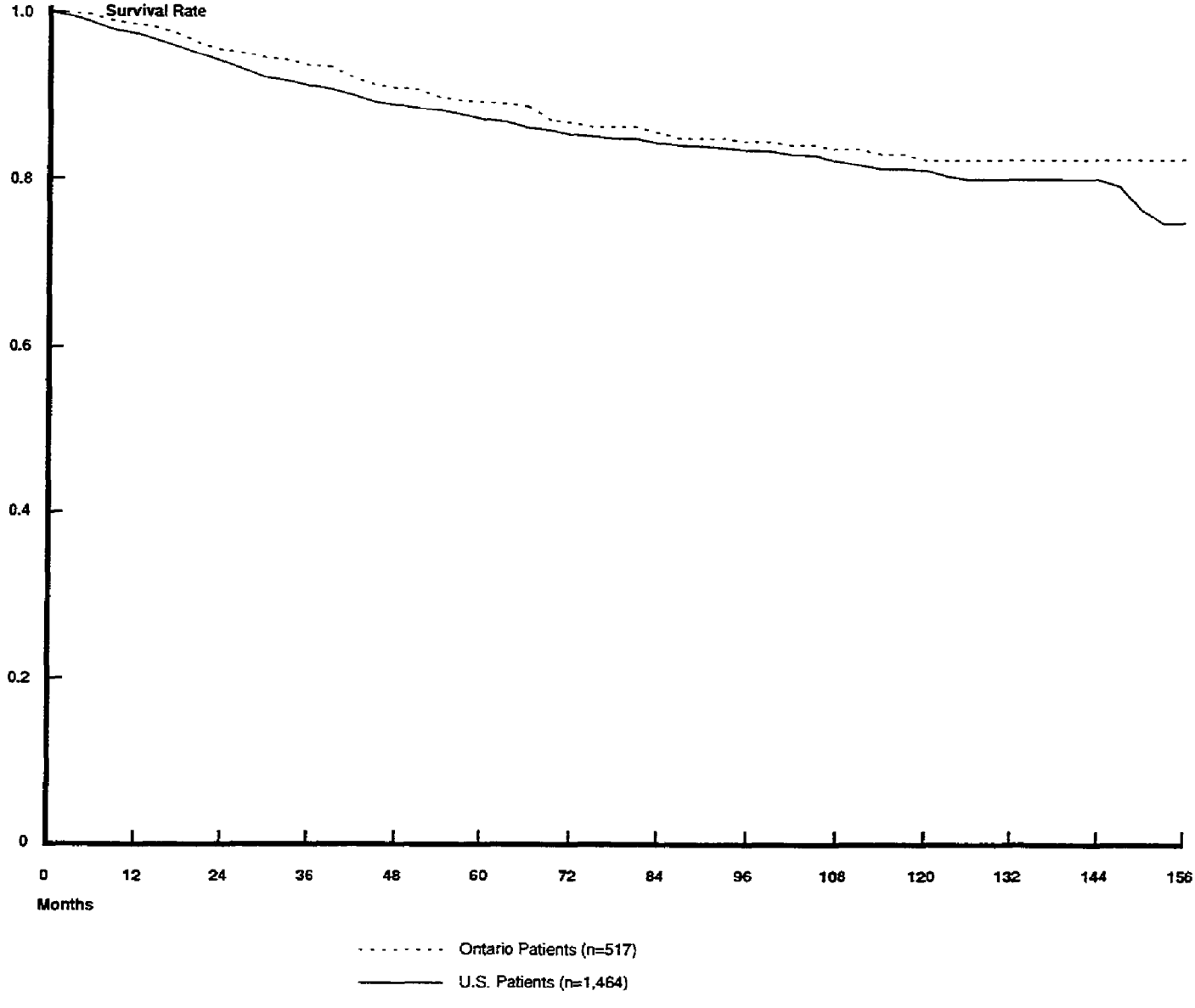
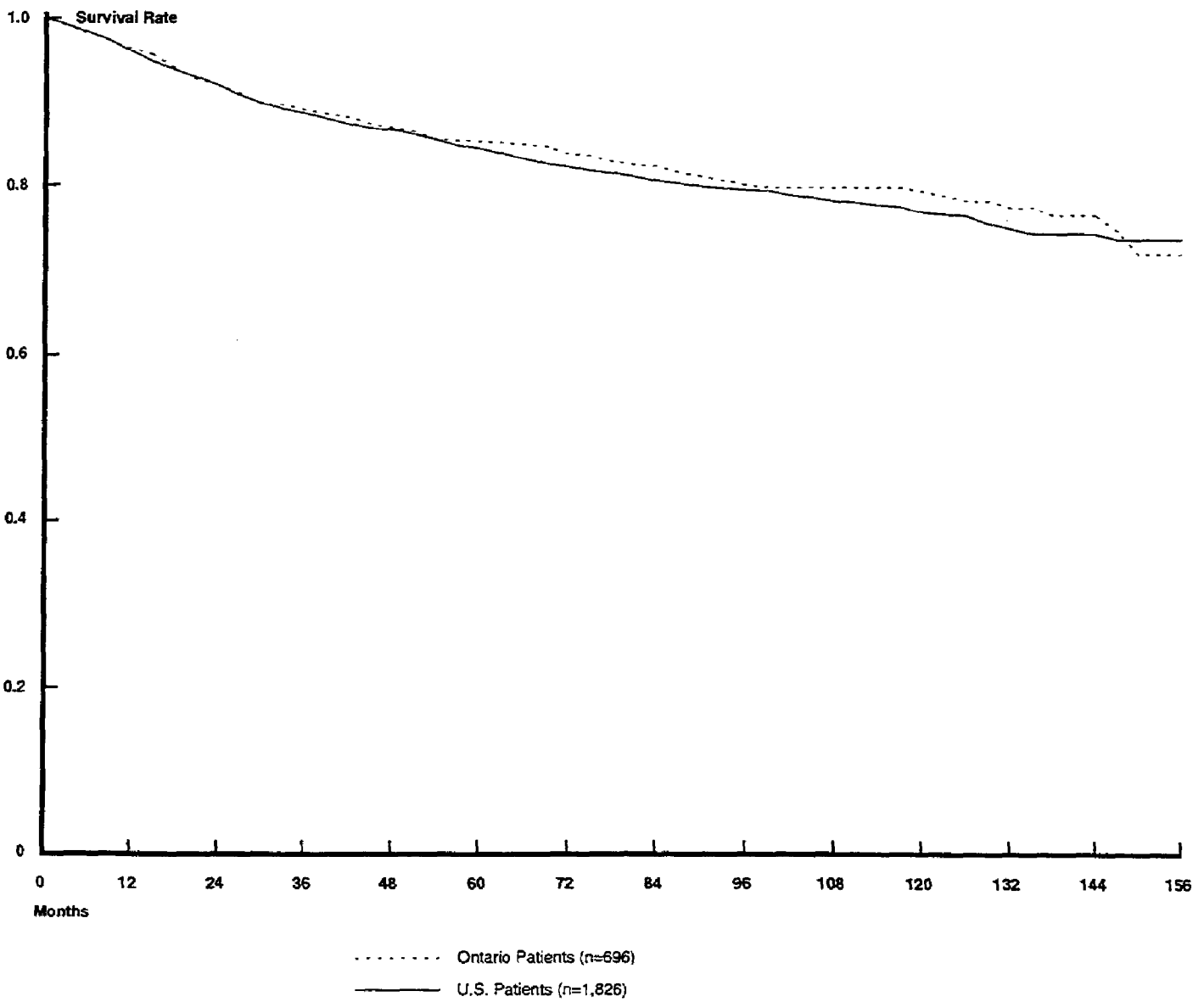


**Figure III.4: Hodgkin's Disease Survival, Patients 25-39: United States and Ontario**



igure III.5: Hodgkin's Disease Survival, Patients 40-54: United States and Ontario

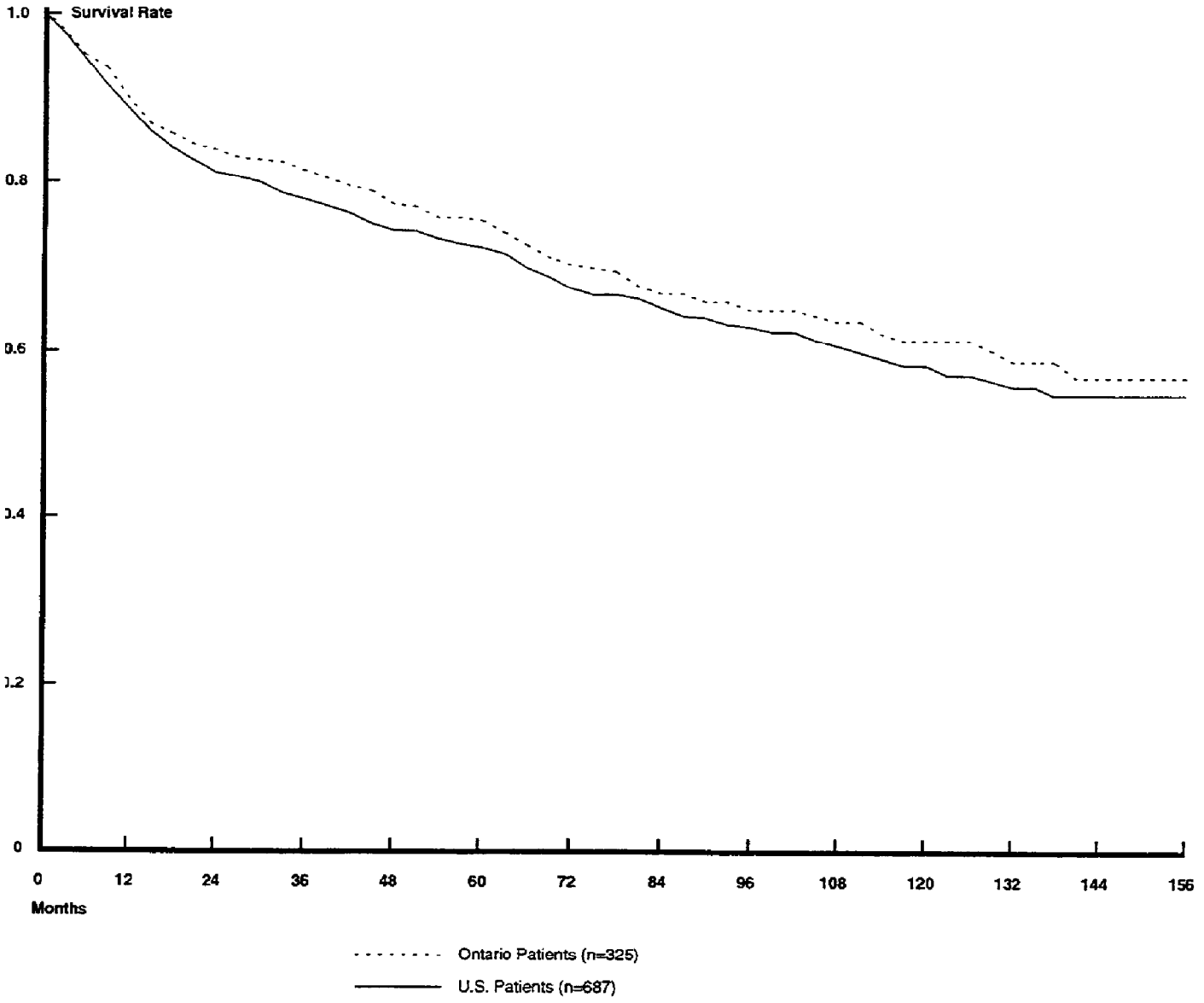
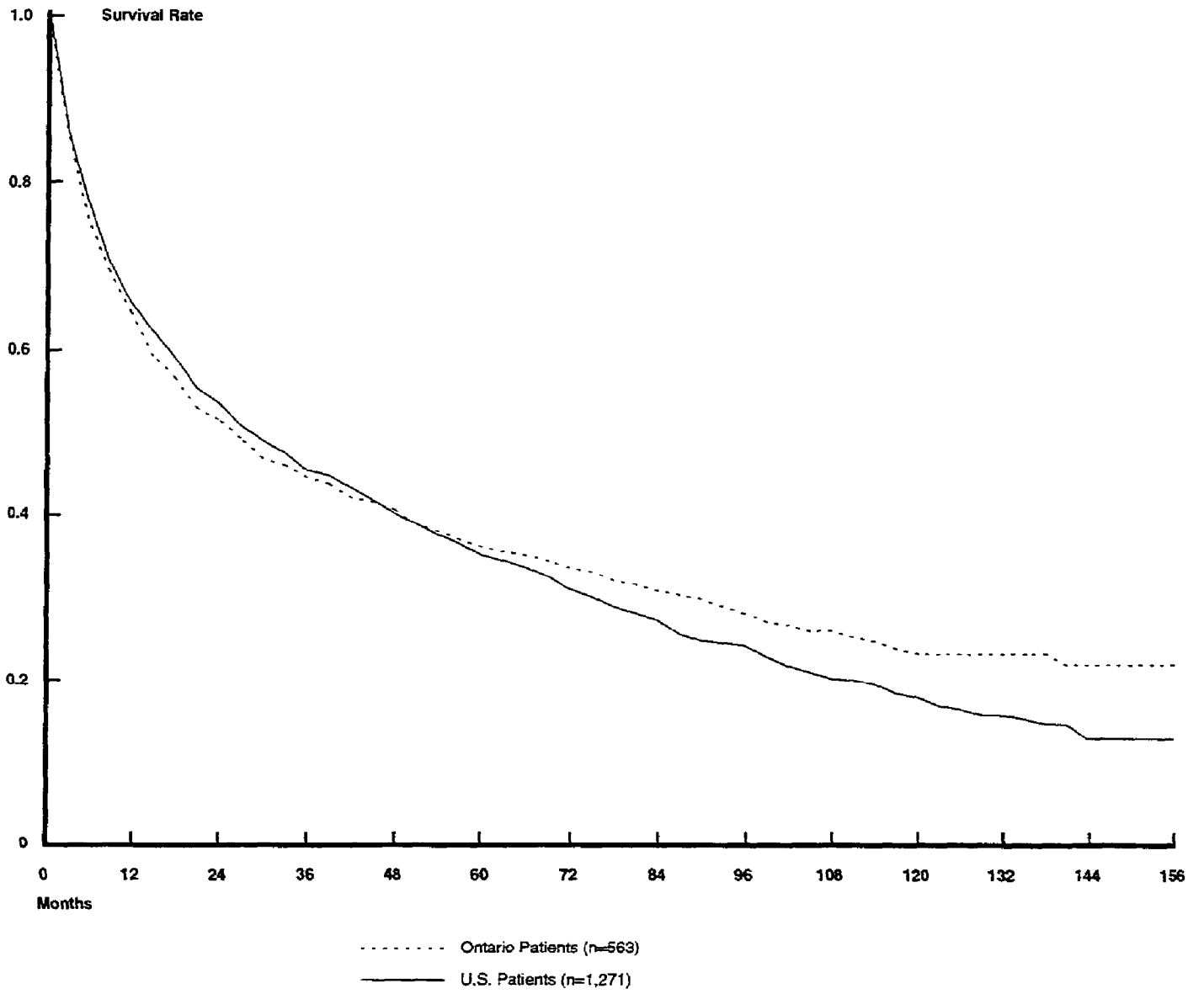


**Figure III.6: Hodgkin's Disease Survival, Patients Older Than 54: United States and Ontario**



# Major Contributors to This Report

## Program Evaluation and Methodology Division

George Silberman, Assistant Director
Donald M. Keller, Project Manager
Eric Peterson, Adviser

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