

IMPLICIT RATIONING IN THE PHYSICIAN-PATIENT CHOICE  
OF LUNG CANCER TREATMENT

ACCEPTED

UNIVERSITY OF GRADUATE STUDIES



Evidence from the Victoria Clinic of the  
British Columbia Cancer Agency

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We accept this thesis as conforming to the required standard



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### **ABSTRACT**

This study uses data collected from non-small cell lung cancer patients attending the Victoria Clinic of the British Columbia Cancer Agency to analyze implicit rationing in the physician-patient choice of lung cancer treatment. An ordered logit model is estimated to identify the impacts of disease states and personal attributes on the probability of a patient receiving alternative degrees of treatment aggressiveness. Logistic probability estimates for the various treatment strategies are linked to corresponding treatment costs, and expected cost-age profiles are calculated for an illustrative patient profile. Direct comparisons of expected cost-age profiles are conducted within a *ceteris paribus* framework to investigate implicit non-disease criteria in the rationing of lung cancer treatment.


The results indicate that non-small cell lung cancer treatment is implicitly rationed according to several personal attributes of a patient. Main empirical results are: (a) Significant differences in expected costs are attributable to patient age, with progressively lower levels of treatment expenditures among older age categories; (b) Patients who have never been married sustain 48 percent to 68 percent less in expected treatment costs than patients who are


widowed, divorced, or currently married; (c) Physician perceptions of patient health status, as revealed by the Karnofsky Performance Index, contribute to differences among expected treatment costs for patients assigned a rank of 100 or 90, a rank of 80, or a rank of 70 or less; (d) Expected costs of treatment do not significantly differ with respect to patient gender. The study concludes that high cost lung cancer treatments may already be rationed implicitly to a much greater degree than is generally assumed.

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### **DEDICATION**

This study is dedicated to the 162 lung cancer patients of the Victoria Cancer Clinic who graciously participated in the Lung Cancer Cost Effectiveness Study. Through their selfless generosity at a most difficult time in their lives, improvements in care may be possible for all.

## **1. INTRODUCTION**

Never before has the scarcity of social resources been so widely recognized, nor the call for responsible use of such resources so universally expressed. Of the various institutions confronting resource constraints, none perhaps is of greater concern to Canadians than the public health care system. Any discussion of availability and accessibility to health care resources must proceed delicately, since the implications associated with such issues are often personal and ethical in nature. Many find the idea of restraining the provision of health care in any way too repugnant even to consider. In spite of this, it is increasingly recognized that it is not economically feasible to treat every individual's condition as aggressively as medically possible.

The notion that an individual could be denied services which medical science is capable of providing is generally met with offense and moral outrage. In the context of health care debates, there is perhaps no image which provokes more public fear and alarm than the rationing of medical services. The term rationing has become value-laden, implying an impersonal, callous, and calculated approach to delivering health care and establishing priorities. To many, its exact meaning is ambiguous, and policy-makers and

health care providers alike have learned to avoid using the term except in a depreciative sense.

Because of the connotations surrounding the word rationing, the term allocation has often been used instead when discussing the distribution of scarce medical resources (Childress, 1978; Moody, 1978). More recently, however, a distinction has been drawn between rationing and allocation on the basis of level, timing, and the decision-making agents involved (Evans, 1983b). In the context of economic analysis, this distinction provides a useful framework for investigating the consumption of scarce health care resources.

Evans (1983b), in his discussion of rationing, argues that the concept of allocation applies well at the institutional or health care program level, but breaks down when applied at the level of the individual patient. Resources may be allocated to particular health care programs on the basis of a rule or criterion such as those afforded by cost-benefit, cost-effectiveness, or cost-utility analyses (Weinstein and Stason, 1977). In this manner, global amounts available to address various conditions or diseases can be established across a range of health care programs. Allocation decisions therefore precede rationing decisions, and tend to define the limits and parameters within which rationing decisions are made.

Rationing decisions generally involve resource choices at the level of the individual patient. Physicians may ration their time among patients in accordance with their case load, or institutions may indirectly ration care through waiting lists. In the case of the critically ill, rationing of treatment may take a more subtle form. As the variety of medical treatments and technology available to the critically ill increases, physicians and patients find themselves choosing among therapies whose costs range from relatively inexpensive to astronomical. In the event of resource constraints, rationing decisions are required for the selection of patients who are to receive more aggressive, and hence more expensive treatments. The process underlying this decision is complex, and its outcome is jointly determined by the physician and the patient in a type of principal-agent relationship. As a consequence, explicit rules or criteria such as those utilized in allocation decisions are unlikely to be acceptable to all those involved. Nevertheless, much recent interest has been expressed in developing a set of decision criteria for the explicit rationing of health care resources (Aaron and Schwartz, 1984; Bayer *et al.*, 1983; Callahan, 1987; Churchill, 1987; Evans, 1983a; Ginzberg, 1990; Kearsley, 1989; Menzel, 1983; Schelling, 1984).

Because we do not speak explicitly of rationing in the Canadian health care

system, there is a popular belief that it plays no role in the choice of medical services we receive. However, health care institutions are allocated resources and are expected to operate within limited and relatively fixed global budgets. To provide each patient with the most aggressive treatment medically possible would result in costs quickly escalating to an exorbitant amount. It would appear, therefore, that decisions regarding the number and the intensity of expensive medical services offered to an individual patient are occurring at some point, suggesting that some form of implicit rationing is taking place.

The purpose of this study is to investigate whether non-small cell lung cancer treatment is implicitly rationed according to non-disease criteria at the Victoria Clinic of the British Columbia Cancer Agency. It is hypothesized that aggressive treatments are rationed according to patient age, functional status as measured by the Karnofsky Index, marital status, and gender. If this is true, it is worthwhile examining in some detail differences in the expected costs of treatment associated with individual patient attributes.

In this study, the set of alternatives from which the choice of therapy is selected is conceptualized as a continuum of available treatment or care

reflecting increasing levels of aggressiveness. Probability distributions defined over a range of treatment options are identified for an illustrative patient profile based on the hypothesized rationing criteria. This is accomplished by employing the ordered logit multiple regression technique (McKelvey and Zavoina, 1975; Greene, 1990, pp. 703-707). The estimated probabilities are used to calculate expected cost profiles relating to the treatment of patients who exhibit a given set of characteristics. The estimation is done using data collected as part of a cost-effectiveness study of the treatment of lung cancer at the Victoria Clinic of the British Columbia Cancer Agency.

The objective is to conduct direct comparisons of the expected cost profiles in order to identify the impact of the hypothesized rationing criteria on treatment expenditures. Following this methodology, differences in expected costs among patient profiles will provide a measure of implicit rationing as expressed by expected willingness to spend on treatment. Inferences may be drawn regarding rationing criteria not relating directly to the disease itself, but revealed through the physician-patient choice of lung cancer treatment.

The study is organized as follows. In chapter 2, a review of the literature regarding cost differentials in the treatment of specific groups of critically ill patients is presented. Chapter 3 consists of a review of the literature

pertaining to the choice of medical treatment. The sample and data are described in chapter 4, and a cross tabulation analysis is conducted in chapter 5. In chapter 6 the ordered logit technique is introduced and the econometric model is derived. Chapter 7 presents the empirical results and tests of significance. The calculation of expected cost profiles is demonstrated in chapter 8. In chapter 9, evidence of implicit rationing is revealed through direct comparisons of the expected cost profiles and a discussion of the results is given. This is followed by summary and concluding remarks in chapter 10.

## 2. THE COST OF TREATMENT

There is much research which suggests that a disproportionate amount of high-cost treatment is expended on specific groups of patients (Detsky *et al.*, 1981; Lubitz and Prihoda, 1984; Long *et al.*, 1984; Spector and Mor, 1984; Scitovsky, 1988). This has led to the belief that excessive efforts to prolong the life of many of the critically ill may be an inappropriate use of scarce health care resources. Such views have prompted calls for explicit measures to limit the amount of expensive care dedicated to the critically ill, and for the development of specific rationing criteria as a means to achieving that end (Callahan, 1987; Churchill, 1987; Aaron *et al.*, 1984; Cooper, 1975).

Evidence of the need for rationing criteria is often drawn from cost studies relating to medical treatment in the last years of life. Studies of this nature tend to focus on samples of critically ill or terminally ill patients receiving treatments reimbursed through a public or private medical insurance plan. The costs associated with patient care are analyzed, and inferences are drawn based on differences in related expenditures.

In an attempt to identify factors which affect the physician's role in rationing resources, Detsky *et al.* (1981) examined the relationship between

prognosis, survival, and hospital expenditures on critically ill patients in an intensive care unit. Physicians were asked to estimate the prognosis for each patient at the time of admission to the hospital, and subsequent medical costs incurred in their treatment were computed during the single hospital stay. At the time of discharge, the actual outcome for each patient was recorded and analyzed in relation to initial prognosis and treatment expenditures.

The results of the Detsky *et al.* study indicate that a significantly greater amount of resources are dedicated towards non-surviving patients, particularly if their initial prognosis is estimated as favourable. Survivors tend to be less expensive to treat, with expenditures falling as the initial prognosis becomes more favourable. The degree of prognostic uncertainty associated with a patient's condition significantly affects the total cost and *per diem* expenditures related to subsequent treatment. Among survivors and non-survivors alike, increases in prognostic uncertainty led to distinct increases in treatment expenditures.

Results of the Detsky *et al.* study imply that a physician's estimation of a patient's health status and prognosis impact greatly on the level of expenditures dedicated to treat that patient's condition. Since the highest level of expenditure is incurred by those whose prognosis is relatively

uncertain, it may prove difficult to apply a set of explicit rationing criteria to the treatment decision. There is always some degree of uncertainty in the prognosis of an individual patient. The Detsky *et al.* study suggests that when confronted with this uncertainty, there is an incentive for the physician to recommend a slightly more aggressive treatment strategy in the hope that the patient's condition will respond favourably. The alternative would be to withhold more expensive medical care, and to accept the risk that the treatment would not have improved the patient's health status. Hence, it may be the case that a physician will give the benefit of the doubt to the patient, and opt for a more, rather than less, aggressive treatment recommendation.

In their investigation of the use and cost of Medicare services, Lubitz and Prihoda (1984) found similar expenditure patterns in the last two years of patient life. They examined the types of services used by critically ill patients as they approach death. Consistent with the Detsky *et al.* study, their research suggests that expenditures directed towards physician's services, medical services, and hospital care were considerably higher for non-survivors than for survivors. However, their study also uncovered that the use of Medicare services by non-surviving patients tends to decrease with age.

Such evidence may *prima facie* suggest that a large proportion of health care resources are consumed by critically ill patients who will die regardless of the treatment they receive. It might be argued, therefore, that explicit measures are needed to address the rationing of medical treatment to a more effective end. It would be inappropriate, however, to conclude that resources may not already be rationed in some implicit manner without much greater knowledge of the distribution of costs among critically ill populations. The extent of the costs incurred in actual medical therapy may be quite different from those associated with a hospital stay or inpatient care. It does not follow, therefore, that specific treatment should be rationed based primarily on evidence drawn from overall expenditures.

In efforts to further identify expenditure patterns within a sample of critically ill patients, Long *et al.* (1984) employed methods of ordinary least squares regression analysis to estimate three medical expenditure equations. Individual equations for total spending, hospital services, and physician services were estimated as a function of patient age, gender, type of cancer, and other factors relating to medical insurance coverage. The scope of their study included all relevant expenditures claimed through three regional Blue

Cross and Blue Shield Plans within the last year of a patient's life.

Long *et al.* found that, *ceteris paribus*, total spending rises at an increasing rate as a patient approaches death. It appears that the largest share of this increase comes from a shift towards more services per month, or more costly types of services. Hospital inpatient services accounted for the largest share of expenditures throughout the last year of life. In the last six months of life, physician's services seem to fall substantially as a proportion of total expenditures. This is accompanied by a dramatic increase in the amount of inpatient care in the final two months prior to death. Neither the type of cancer nor the patient's gender were significant in explaining differences in expenditures within the estimated equations.

However, the researchers did identify a significant difference in expenditures directed towards physician services between the younger patients and the older patients. Their study suggests that, *cet. par.*, patients in the under-45 age group receive much more physician care than those patients in the older groups. This result, in addition to the Lubitz and Prihoda study, implies that age may significantly affect the amount of resources dedicated to treat a patient who is critically ill.

Further evidence that patient age may influence the level of treatment

expenditures was presented by Spector and Mor (1984) in an examination of cancer patient claims to Rhode Island Blue Cross and Blue Shield health care plans. Expenditures were categorized as hospital charges, physician charges including outpatient clinics, and home health/home nursing charges. Their findings indicate that the cost of hospitalization is the predominant factor in expenditures towards critical illness. The researchers elected to use total expenditures as the basis for their regression analysis. They estimated a per capita expenditure equation as a function of patient age, type of cancer, insurance coverage, care delivery organization, and various demographic variables.

Contrary to the results of Long *et al.*, Spector and Mor established a significant relationship between total expenditures and the type of cancer, although they also found that patient gender did not result in a discernible difference. The type of care delivery organization and the age of the patient contributed most to explaining the pattern of expenditures. An inverse relationship between age and expenditures was established, further supporting the hypothesized impact of age on health care expenditure decisions. Among the remaining demographic variables, neither race nor marital status were found to contribute significantly to explaining cancer

treatment expenditures.

It appears, therefore, that the age of a patient has a substantial influence on the amount of resources directed towards medical treatment, and towards cancer treatment in particular. Although the literature suggests that older patients receive less expensive care, it is difficult to know by analysing costs alone whether that is the result of physician biases or the wishes of the patient. It does, however, appear that all critically ill patients are not treated identically. Hence, in addition to age, there may be other identifiable patient characteristics which contribute to the distribution of expenditures among the critically ill.

Scitovsky (1988) recognized the need to more fully link the characteristics of the patient with the pattern of treatment expenditures. She investigated the relation between patient age, functional status, and expenditures in a fee-for-service medical clinic in the last twelve months of patient life. To account for possible differences in personal income among the study sample, only data on fee-for-service patients covered by Medicare were included. Similar to others, her results indicate a significant decline in medical expenditures as the patient's age increases. In addition, the types of treatment that the oldest group received were different from those of the younger groups. In

Scitovsky's study, older patients tended to receive much less aggressive treatment than their younger counterparts, largely obtaining supportive or palliative therapies rather than curative measures.

The most novel aspect of the Scitovsky research is the explicit inclusion of an indicator of patient health status into the cost analysis. An indicator of the functional status of each patient was recorded through questionnaires completed retrospectively by the deceased patient's next of kin. The resulting estimates imply, *cet. par.*, that expenses for hospital and physician services decline sharply as a patient's functional status declines. In addition, the intensity or aggressiveness of treatment appears to also fall with declining functional status. Hence, Scitovsky concludes that health care resources may already be rationed in some manner in accordance with both the age and functional status of the patient.

The results of Scitovsky's study raise important questions regarding the perceived need for an explicit program of rationing. Most of the cost research used as evidence in support of explicit rationing is subject to several criticisms. First, these studies largely neglect the decision-making process associated with treatment choice. The choice of medical therapy and related

expenditures is influenced by the interests of physicians, patients, and the reimbursement agency. The relationship among these partners should explicitly be recognized in the analysis of health care resource rationing. In particular, information regarding factors which may influence the physician-patient relationship and ultimately affect the decision outcome should be included among the explanatory variables. An examination of expenditure outcomes alone, without recognizing the decision-making process, will not fully reveal priorities, and hence decision criteria, in the physician-patient choice of treatment.

Second, rarely do these studies compare the costs of treatment alternatives or treatment aggressiveness in relation to a specific condition or disease. Since rationing decisions occur at the level of the individual patient, it is important that research directed towards identifying rationing criteria be carried out at that same level. This implies a need for disease-specific research relating the costs of treatment alternatives to non-disease patient characteristics.

And third, prior cost studies say little about the distribution of expenditures related to the severity of the patient's disease or condition. In general, the most that is cited is the patient's cause of death. The stage of disease, size of the tumour, and most other factors which affect the physician-

patient choice of treatment are seldom explicitly included. Hence, it is difficult to conclude that resources should be rationed differently without a comprehensive knowledge of the current distribution priorities.

In the following chapter, I shall review relevant literature regarding the agency relationship involved in treatment choice, and related empirical evidence of factors which appear to affect this choice. Such studies may provide valuable insight into the treatment choice process, and hence contribute to a deeper understanding of health care expenditure priorities.

### 3. THE CHOICE OF TREATMENT

#### 3.1 The Professional Agency Relationship

The analysis of treatment choice is subject to many of the same conceptual difficulties which hamper other theories of demand for health care services. Individuals do not value medical treatment *per se*, but value it for its anticipated contribution to health status. The effectiveness of various medical therapies in improving health status is the subject of professional expertise, which leads to considerable asymmetry of information between health care providers and consumers. Additionally, the Canadian health care market is characterized by public insurance which ensures access to most services at a private money-cost of nearly zero. The subsequent interaction between physician, society, and patient results in a unique form of the principal-agent problem in health care provision. This relationship has strong implications for the decision-making process associated with treatment choice, and contributes to appreciable empirical difficulties in identifying conventional choice determinants.

The physician-patient relationship is not a traditional principal-agent problem, but is more accurately described as a professional agency

relationship (Evans, 1984, pp. 78-81). Contrary to the usual principal-agent problem, the theory of professional agency suggests the objectives of the agent are not entirely separable from those of the principal. The role of the physician in treatment decisions is threefold: agent for patient, agent for self, and, as gatekeeper to the public health care system, agent for society. Although ostensibly a physician's first obligation is to the patient, the complex and uncertain nature of health care decisions render it virtually impossible for a physician to act as a perfect agent for either the patient or for society. The objective of professionalization is to assist the physician in finding a balance between self-interest, patient interest, and the interests of society.

If physicians were perfect, complete agents for their patients, they would recommend medical treatments which patients themselves would choose if they possessed the medical knowledge of the physician. This implies that both individual preferences and professional expertise must play equal roles in reaching a treatment decision. However, an examination of the treatment preferences of oncologists regarding non-small cell lung cancer revealed that physicians do not select the same treatment for patients as the physicians would for themselves (Mackillop *et al.*, 1987).

The personal treatment preferences of the oncologists indicate a strong aversion to chemotherapy and a generally conservative approach to radiotherapy. Moreover, the physician's preferences were clearly different from the treatment recommendations in the standard textbooks, and different from observed treatment patterns. Unless it is true that physician preferences are systematically different from patient preferences, these results suggest that physicians may not fully consider the preferences of the individual patient when recommending a cancer treatment. Hence, recommendations based chiefly on standard medical protocols appear to minimize the role of individual preferences and compromise the professional agency relationship. How these biases influence the care of patients is the subject of much conjecture, but clearly the physician does not act as a perfect agent for the patient.

If physicians were perfect, complete agents for society, they would choose medical treatments for their patients on the basis of some social rule or tenet of greater distributive justice. Such decision principles may arise from an egalitarian, utilitarian, or other type of social ethic which society has deemed acceptable. In reality, physicians are not social planners, and are not exclusively motivated in their decision-making by possible impacts on total

social welfare. The accountability and obligations of a physician are principally to the patient, as expressed in the Hippocratic Oath. Yet, social concerns and economic constraints cannot be completely overlooked. Therefore, in recommending medical therapy, the physician must always consider a continuum of treatment compromises between the interests of the patient and the interests of society.

The presence of limited health care resources introduces a serious conflict between the interests of the patient and the interests of society. The approximate relative cost of treatment is generally known only by the physician, who may reveal this to the patient in some circumstances, although seems unlikely to do so. The total cost of the medical treatment, however, is predominantly incurred by the whole of society, as reflected in the public health care system. Therefore, in addition to self-interest, the professional agency relationship demands that a physician place considerable weight on both patient concerns and social priorities in recommending a choice of medical treatment.

Since the physician is not a perfect agent for the patient, nor a perfect agent for society, it is important to recognize any significant differences in the

priorities of these groups which may influence the treatment decision. Geller *et al.* (1993) examined the treatment perspectives of physicians, healthy citizens, and legislators to uncover any significant discrepancies in the perceptions of the three groups. A variety of issues relating to treatment options for seriously ill patients were examined, leading to the conclusion that the concerns of each group are more similar than different. There appear to be, however, significant differences in opinion between physicians and citizens regarding the appropriateness of certain treatment decision-making criteria. The physicians rated the monetary cost of treatment more highly than did the citizens, and also placed greater emphasis on the patient's family circumstances. In general, all three groups rated the patient's wishes and prospects for recovery as the two most appropriate criteria in choosing among treatment alternatives. Individual ability to pay and responsibility for the illness were the two criteria judged of least importance. Although the criteria were ranked the same, physicians and patients placed considerably different weights on each of the individual factors.

Clearly, the roles of each partner in the professional agency relationship and their impact on the choice of cancer treatment are not well defined. Understanding the treatment decision process requires more than simply

understanding physician views. Physicians may believe their patients prefer a more authoritative relationship, rather than participatory, or may seek to protect patients from bad news regarding their own prognosis. To test these assumptions in a professional agency context, Blanchard *et al.* (1988) examined cancer patient preferences for information and participation in treatment decision-making. They found that almost all participants in their study prefer their physician share all information regarding their case, good or bad. However, the results also suggest that approximately one-fourth of the participants who desired all information also prefer a more authoritative relationship with their oncologist. In total, close to one-third of the participants were more comfortable leaving decisions about their medical care and treatment up to their physician. The results of the Blanchard *et al.* study also imply that older patients are more likely to prefer an authoritative physician-patient relationship than younger patients. The elderly appear more willing to defer the responsibility of treatment choice to their physician, trusting them as the agent of professional expertise.

It is essential to recognize, therefore, that the responsibility for treatment choice does not belong to the physician alone. All patients are free to lobby their physician for more aggressive treatment, or to refuse treatment

completely. The physician may enjoy the most influential and informed role in the choice of therapy, but ultimately it is a decision which is mutually agreed upon. Hence, any apparent priorities in treatment patterns or related expenditures must be interpreted not only as reflecting physician preferences, but also implicitly the values of the patient and of society.

Given the extent and complexity of interaction among the various factions, it is exceedingly difficult to empirically isolate each of the elements which lead to the choice of one therapy over another. The diversity of interests associated with treatment decisions is reflected in the variety of analytical viewpoints found in the literature (Drummond, 1987, p. 19; Mehrez and Gafni, 1987). In spite of such complexities, the problem of deciding among treatment alternatives for various medical conditions has been the subject of occasional empirical study.

### 3.2 The Determinants of Treatment Choice

Effort has been extended in investigating factors which may influence a physician's choice to treat specific types of patients with particular therapies. Such studies appear primarily in medical journals and usually present treatment choice from the perspective of the health care provider. As a consequence, these studies tend to emphasize the role of the physician in the

treatment decision, and often highlight the disease factors and related professional expertise which affect the choice of therapy. Except in relatively recent times, the patient's role in the decision-making process has been largely overlooked.

It has long been recognized that multiple factors contribute to the process leading to a physician recommending a medical therapy (Staquet, 1975, pp. 185-198; McNeil *et al.*, 1978; Hartunian *et al.*, 1981, pp. 194-5; Mayer and Patterson, 1988). However, early studies often concentrated on prognostic factors and survival times rather than the choice of specific treatments *per se*. Through an examination of symptomatic patterns, biologic behaviour, and their relation to prognosis, Feinstein (1964) developed an index to classify lung cancer symptoms according to the rate of growth and invasiveness of the tumour (see Appendix A). In addition, several other clinical prognostic indicators, such as tumour size and differentiation, were noted by Feinstein as valuable in choosing among treatment alternatives (see Appendix B). Coy *et al.* (1981) indicates that Feinstein's index is of particular prognostic value when palliative therapy is the only treatment to be offered. In such instances, Feinstein's index and related symptom indices appear to be more effective in

prognostic evaluations than other disease measures such as the tumour stage (see Appendix C).

Lipworth *et al.* (1970) examined relations between clinical prognosis, treatment choice, and socio-economic influences regarding the long-term survival of cancer patients. Their investigation of mean patient survival times from low-income Boston communities versus more favorable socio-economic areas in Connecticut led them to several conclusions. Factors related to higher income levels appear to contribute to a more favorable prognosis and to greater survival time. As for the treatment decision, Lipworth *et al.* could not relate differences in survival time to differences in selected treatments. In the case of a critical illness such as lung cancer, it appears that patients with a better prognosis are treated more aggressively than others; however, more aggressive treatment does not necessarily lead to a better outcome. Although researchers could not establish a definitive relationship between the actual treatment choice and socio-economic status, they suggest that individuals enjoying more favorable socio-economic status may tend to seek treatment earlier.

McNeil *et al.* (1978) clearly recognized the role of prognosis and probable impact on health status as a fundamental basis for deciding among treatment

alternatives. However, their study is among the first to explicitly acknowledge the role of the patient in the decision-making process, and to argue that a patient's own attitudes should prevail in the choice of treatment. They suggest the value of a treatment outcome and its impact on health status can only be judged by the patient; therefore, it is the patient who should ultimately select the preferred treatment. The role of the physician as informer and advisor is still intrinsic to the decision-making process, but the patient's own attitude towards risk and health status should determine the choice of treatment.

The McNeil *et al.* study attempts to quantify the importance of choosing medical therapies not only on the basis of professional clinical indicators, but also on the basis of individual patient concerns. Through a series of interviews employing a standard gamble technique (Drummond, 1987, pp. 126-8), McNeil *et al.* constructed utility curves reflecting patient attitudes toward risk. Various treatment strategies were developed by combining survival data and the expected utility data, and direct comparisons were made between those and treatment strategies based on survival data exclusively. The results imply that many patients are highly risk-averse in treatment decisions, and physicians who routinely recommend therapy based only on

survival time may be acting as poor agents for their patients.

The McNeil *et al.* paper explicitly addresses the challenge of conflicting interests within the professional agency relationship. Prior to their study, empirical attention was focused on relatively objective disease factors employed by physicians in recommending treatment options, and relegated the patient's role to passive recipient. To better understand the decision-making process and subsequent outcome when choosing medical treatment, alternative non-disease factors such as patient attitudes, family concerns, or implicit physician biases are increasingly the subject of investigation.

Mor *et al.* (1985) employ the multiple logistic regression technique with a dichotomous dependent variable to evaluate the relationship between age at diagnosis and the treatments received by cancer patients. Indicators of co-morbidity are included in the equations, as well as the stage of the tumour at diagnosis. Their research implies that, for most cancers, age has a significant role in predicting which patients receive more aggressive treatments. They suggest that oncologists historically have followed the unsubstantiated medical belief that older patients are unable to tolerate the occasionally toxic side effects of more aggressive therapies, and therefore do not offer them such

treatments. If this is true, the results do not indicate rationing *per se*, but more a problem of incomplete or imperfect information on the part of the physician. Mor *et al.* did not, however, confirm these findings in the use of radiation therapy among non-metastatic lung cancer patients.

Further evidence of an age criterion in cancer management is presented by Samet *et al.* (1986) in their study of the use of potentially curative therapies in New Mexico. Methods of log-linear modeling, with a variety of stratifications, are used to test relations between the choice of curative therapy and age, while accounting for gender, ethnicity, and tumour stage. Their results show little evidence of gender or ethnicity influencing the relationship between age and treatment. They do, however, show strong evidence that the proportion of cases receiving potentially curative, and hence aggressive, treatment declines steadily with age, regardless of the stage of the tumour. In addition, the proportion of cases receiving no treatment at all seems to increase with age for all local-stage cancers.

Goodwin *et al.* (1986), using the same data set and a similar methodology as Samet *et al.* (1986), suggest that older lung cancer patients are more likely to be diagnosed at an earlier tumour stage than are younger patients. If this is true, older patients exhibiting earlier stages of cancer receive less aggressive

treatments than younger patients exhibiting later stages of cancer. This result supports the hypothesis that social agism is appreciably influencing physician's recommendations regarding more aggressive cancer treatments.

Following their earlier study, Goodwin *et al.* (1987) explored the effect of marital status on tumour stage, treatment choice, and the survival of cancer patients. A logistic regression technique with a dichotomous dependent variable is used to model treatment choice as a function of marital status, age, gender, and the stage of the cancer tumour. The resulting odds ratio indicates that, *ceteris paribus*, unmarried patients are significantly more likely to receive no treatment for their cancer than patients who are married.

Other research has suggested that the presence of a spouse or family member has a clear impact on the physician-patient interaction and the decision-making process (Labrecque *et al.*, 1991; Wu, 1990-1). Physicians tend to spend more time with patients when family members are present. It also appears that, in general, physicians provide a greater amount of information about current health status and future treatment to those patients accompanied by family members. Relating these results to those of Goodwin *et al.* (1987), it may be argued that patients attending with a spouse are better informed and are more active participants in the physician-patient choice of

treatment. It appears that greater participation, or at least greater representation, tends to lead to the selection of more aggressive therapies in cancer management.

The positive effect which a spouse has on the probability of receiving more aggressive cancer treatment is also cited by Greenberg *et al.* (1988) in their study of social and economic factors influencing treatment choice. The stage of the tumour, and the patient's functional status as measured by the Karnofsky Index, are likewise found to be strong predictors of the type of treatment a patient receives (see Appendix D). In addition, Greenberg *et al.* reveal that patients in the United States with private health insurance tend to receive more aggressive treatments than patients without private insurance. As with other studies, their research shows the probability of receiving aggressive treatment declines steadily with age, regardless of the extent or severity of the cancer tumour.

Therefore, it appears that several trends may exist concerning the treatments received by critically ill patients. Indicators of disease-specific factors alone do not fully explain the type of treatment that a patient will receive. The physician-patient choice of treatment may differ substantially between two patients exhibiting identical states of disease, but different

personal attributes. For example, it seems that older patients are less likely to receive more aggressive treatments, regardless of the extent of their disease. In addition, the presence of a spouse or family member often results in more aggressive therapies being selected. It is ambiguous whether a patient's gender significantly affects the choice of treatment. However, evidence does suggest that the physician's perception of patient health status, as indicated by the Karnofsky Index, plays an important role. Hence, it is possible that society's willingness to spend on treatment will implicitly vary depending on these patient attributes.

It is clear that research into treatment choice has provided many valuable insights regarding factors which affect the selection of distinct medical therapies. However, each of the choice studies reviewed lack sufficient detail to link progressively more aggressive treatments to their costs. Those studies which apply regression analysis to the choice problem generally employ a multiple logistic regression technique with a dichotomous dependent variable. This method can be very useful in estimating the likelihood a patient will receive a distinct and discrete treatment for their condition (Amemiya, 1981). However, it fails to account for the inherent ordinal nature

of the degree of aggressiveness among several treatment alternatives, or of ranks within a global treatment.

Physicians and patients who select radiotherapy, for example, must also decide upon the intensity of treatment which they are willing to undergo. There may be significant differences in personal attributes, such as age or family circumstances, among patients who receive similar treatments but to different degrees of aggressiveness. By grouping together all patients who receive radiotherapy, prior research has failed to adequately address this possibility. The methodology employed in this study is designed to explicitly account for different levels of treatment aggressiveness, and to reveal the extent to which specific personal attributes affect treatment choice. In the following chapter, I shall discuss the sample and data set which enables my study to explore in greater detail the costs of alternative lung cancer treatments in relation to non-disease patient attributes.

#### 4. THE SAMPLE AND DATA

##### 4.1 Definition of Study Sample

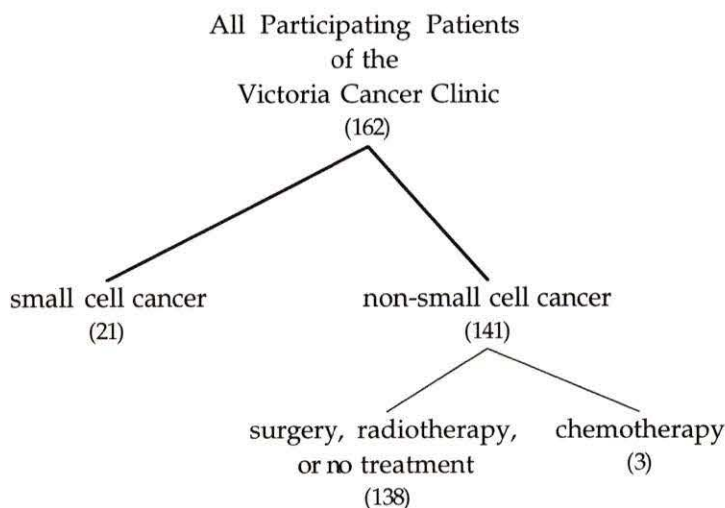
The data employed in this study was obtained through the co-operation of the Victoria Cancer Clinic (ViCC) of the British Columbia Cancer Agency. The Victoria Clinic is a free-standing treatment centre located on the grounds of the Royal Jubilee Hospital in Victoria, British Columbia. The attending professional oncologists and related care providers are compensated on a salary basis. The Clinic delivers a variety of out-patient services such as oncological consultation and assessment, radiotherapy, chemotherapy, and activities relating to the follow-up of patients. Surgical procedures undertaken by patients of the Clinic are performed at the Royal Jubilee Hospital.

Researchers at the Victoria Clinic allowed access to data collected concerning lung cancer patients as part of a ViCC Lung Cancer Cost Effectiveness (LCE) Study. The LCE data was gathered at the Clinic for the period of February, 1990 to the end of January, 1992. Patients were deemed eligible if they had attended the Clinic for their new patient assessment and initial oncological consultation and resided within the Capital Regional

District (Victoria Cancer Clinic, 1990, 1992).

Those patients who wished to participate in the LCE study agreed to authorize access to their medical records as compiled by their health care providers. At the close of the data gathering there were 162 eligible patients in the LCE study sample, and these provide the basis of the data set regarding treatment choice and implicit rationing. The medical and personal data compiled by the Clinic are captured from patient charts and provide a comprehensive overview of a patient's general health and the severity of the lung cancer at the time of treatment choice.

**FIGURE 1 - Definition of Study Sample**



The full LCE study sample was not employed in my investigation of the choice of lung cancer treatment. The definition of the study sample is

described in Figure 1. All patients whose cancer was of the small cell variety were immediately excluded from the analysis on the basis that treatment protocols and disease characteristics of small cell cancer are distinctly different from those of non-small cell cancer (Cancer Control Agency of British Columbia, 1988; Cohen and Selawry, 1975; Murray, 1987).

The exclusion of small cell cancer patients reduced the sample size to 141. Of the remaining participants, only three patients elected for the primary treatment of chemotherapy. The lack of observations and dissimilar nature of chemotherapy, as compared with the other treatment alternatives, led to these observations also being excluded from the study sample. The remaining sample of 138 non-small cell lung cancer patients is the basis of this study.

#### 4.2 Definition of the Treatment Choice Set

The global treatment alternatives for the sample population are no primary treatment, radiotherapy, or excise of the tumour by surgery. The choice of radiotherapy, however, leads to more decisions regarding the goal of the therapy, the total amount of radiation to be received, and the number of visits over which the complete course of radiotherapy will be administered (Margolis and Meyler, 1992; Kostashuk *et al.*, 1987). The total number of

visits is referred to as the fractionation schedule, and each visit counts as one fraction. In general, if the goal of the treatment is palliative, the radiotherapy will involve a lower radiation dose and fewer fractions (Latimer and Dawson, 1993). A course of palliative radiotherapy can involve from one to twenty fractions, depending upon how aggressively the physician and patient choose to address the patient's condition.

If the goal is curative, then the radiation dose is higher and the standard course of therapy involves twenty fractions over a four week period (Coy *et al.*, 1992). Table 1 illustrates the distribution of patients in the sample and the primary treatment they received, including the number of fractions for those who selected radiotherapy.

A total of 17 patients, or 12.3 percent of the sample, opted for no primary treatment for their cancer. The decision to decline primary therapy was clearly the least aggressive treatment alternative a patient could select. Conversely, 14 of the participants, or 10.1 percent of the sample, elected to receive surgery as the primary treatment for their cancer. This choice was designated as the most aggressive treatment alternative in the study, and all other treatments are assumed to rank somewhere between it and no therapy (Evans, 1987).

The remaining 107 patients, or 77.5 percent of the sample, elected for the

**TABLE 1 - Treatments Received by Sample Population**  
(*n* = 138)

Treatment	Frequency
<b>No Primary Treatment</b>	17
<b>Radiotherapy</b>	
1 fraction	7
3 fractions	1
4 fractions	11
5 fractions	9
6 fractions	1
9 fractions	1
10 fractions	32
12 fractions	1
15 fractions	4
18 fractions	1
19 fractions	1
20 fractions	38
<b>Surgery</b>	14
<b>TOTAL</b>	138

primary treatment of radiotherapy to address their cancer. The total number of fractions received by each patient ranged from a single fraction to a full course of twenty fractions. Those receiving fewer fractions generally opted for a palliative goal, while the higher numbers of fractions were indicative of curative intent.

For estimation purposes, the various therapies received by the sample population were collapsed into seven treatment decision categories representing the latent degree of aggressiveness with which the treatment addresses a patient's condition. It was clear that the least aggressive and the most aggressive treatment alternatives were no treatment and surgery respectively. The decision to rank radiotherapy treatments according to the number of fractions a patient receives was based upon professional judgement and the general relationship between fractions and treatment intensity (Coy, P., personal communication). In addition, the total number of fractions of radiotherapy that a patient receives largely determines the extent of the radiotherapy costs, and hence reflects an opportunity to detect implicit rationing.

An examination of Table 1 reveals several possible break points among the number of fractions of radiotherapy received by the sample population. A single fraction consists of treatment generally involving a higher one-time radiation dose than that associated with delivery over several fractions. The purpose of such a treatment is strictly the one-time palliation of the cancer patient's symptoms. Therefore, it comprises its own treatment category, and is assumed to be the least aggressive course of radiotherapy.

The next treatment category consists of patients receiving three to six fractions of radiotherapy. There appears to be a natural grouping around four to five fractions, with the usual goal of the therapy being palliation of symptoms. Similarly, patients receiving nine to fifteen fractions of radiotherapy comprise the next aggressive treatment decision category. In this treatment group, the majority of patients received ten fractions and the goal of the treatment was also chiefly palliative.

The remaining participants received eighteen to twenty fractions of radiotherapy. This group was divided into two categories on the basis of the number of fields over which the course of treatment was applied, as suggested by professional judgement (Coy, P., personal communication).

The use of three fields in delivering the radiation dosage, as opposed to two fields, represents a significantly more aggressive treatment strategy and a significantly larger expenditure commitment. Hence, patients receiving eighteen to twenty fractions over two fields were grouped into one class, and those receiving the same number of fractions over three fields were grouped into another. The treatment goal for all patients in the three field category was curative, whereas the majority of those receiving therapy over two fields were pursuing a palliative intent. Table 2 describes the distribution of patients

**TABLE 2 - Distribution of Patients by Treatment Choice Set**  
**(n = 138)**

Treatment Choice	Frequency
<b>No Primary Treatment</b>	17
<b>Radiotherapy</b>	
1 fraction	7
3-6 fractions	22
9-15 fractions	38
18-20 fractions	23
2 fields	
18-20 fractions	17
3 fields	
<b>Surgery</b>	14
<b>TOTAL</b>	138

by the treatment choice set and in order of increasing aggressiveness.

#### 4.3 Sample Characteristics of Study Participants: Personal Attributes

Table 3 describes the personal characteristics of the sample population which are hypothesized to implicitly affect resource rationing in the physician-patient choice of lung cancer therapy. The distribution of patients by age is virtually normal, with 44.2 percent of the participants belonging to the central age group of 66-75 years old, and a mean age of slightly greater than 70 years old. The youngest participant in the sample is 48 years old, and

**TABLE 3 - Sample Characteristics of Study Participants:**  
**Personal Attributes**  
*(n = 138)*

Characteristic	% *
<b>Age</b>	
Under-56	7.2
56 - 65	21.0
66 - 75	44.2
76 - 85	21.7
Over-85	5.8
<b>Karnofsky Index</b>	
40	3.6
50	5.1
60	9.4
70	36.2
80	26.1
90	16.7
100	2.9
<b>Gender</b>	
Female	37.0
Male	63.0
<b>Marital Status</b>	
Currently married	84.1
Never married	4.3
Divorced	7.2
Widowed	4.3

\* may not total 100% due to rounding.

the oldest is 89 years old.

The Karnofsky Index is a physician assigned rating of patient health status describing the ability to function at home, work, and the need for personal and medical care (see Appendix D). Among the sample population, 36.2 percent of the participants belong to the mean category of 70 in terms of functional status. The sample is skewed considerably to the right, with only 8.7 percent of the sample receiving a rank of 50 or less. A total of 45.7 percent of the study sample achieved a rating of 80 or greater, indicating the ability to conduct normal activities and to work without special care. The minimum rating in the sample was 40, the maximum was 100. This would imply that, in terms of the physicians' perceptions of their health status, the participants of the study group were able to function relatively well and were largely self-reliant.

Compared with the general Canadian population, females are under-represented in the study sample (Statistics Canada, 1994). However, the sample is consistent with the current two-to-one ratio of males-to-females who exhibit lung cancer in Canada (Coy, P., personal communication). Males comprise 63.0 percent of the sample population, with females totaling only

37.0 percent. Patients who are currently married constitute 84.1 percent of the sample participants, while those who never married total 4.3 percent. Divorced patients make up 7.2 percent of the sample and widowed patients comprise the remaining 4.3 percent. No indicators of race or socio-economic status were available for the sample population, although all study participants resided in the Capital Regional District of Victoria, which is predominantly a white middle class community.

#### 4.4 Sample Characteristics of Study Participants: Disease Indicators

The ViCC LCE data base contains a variety of health status indicators reflecting the extent and severity of the lung cancer among the sample population. The disease indicators employed in this study were selected on the basis of a review of the literature and the recommendations of professional expertise (Coy, P., personal communication). The distribution of patients with respect to the selected disease indicators is described in Table 4.

The stage of the cancer tumour describes its rate of growth and advancement into surrounding structures (see Appendix C). For 39.8 percent of the participants, the tumour stage was either Stage I or Stage II, indicating the disease is contained completely within the lung. On the basis of tumour stage alone, these participants are candidates for the more aggressive

**TABLE 4 - Sample Characteristics of Study Participants:**  
**Disease Indicators**  
**(n = 138)**

Characteristic	%*
<b>Tumour Stage</b>	
I	32.6
II	7.2
IIIa	31.9
IIIb	10.9
IV	17.4
<b>Tumour Size</b>	
Too small to measure	2.2
1 - 3 centimeters	20.3
4 - 6 centimeters	46.4
≥ 7 centimeters, measurable	24.6
≥ 7 centimeters, unmeasurable	6.5
<b>Feinstein Index</b>	
Asymptomatic	7.2
Long pulmonic	10.1
Short Pulmonic	21.7
Pulmono-systemic	29.0
Pulmono-ultrapulmono	28.3
Ultrapulmonic	3.6
<b>Tumour Differentiation</b>	
Could not be assessed	25.4
Well differentiated	7.2
Moderately differentiated	18.8
Poorly differentiated	31.9
Undifferentiated	16.7
<b>Weight Loss</b>	
No weight loss	52.9
Up to 5 kilograms	23.9
6 - 10 kilograms	15.2
11 - 15 kilograms	5.8
≥ 16 kilograms	2.7

\* may not total 100% due to rounding.

treatment strategies such as surgery or curative radiotherapy. Stage IIIa disease is exhibited by a total of 31.9 percent of the participants, suggesting a range of treatment protocol recommendations for this group extending from surgical procedures to palliative radiotherapy.

Patients with Stage IIIb disease totaled 10.9 percent, and those with Stage IV disease comprised 17.4 percent. Those patient's whose cancer belongs to one of these categories are generally candidates for non-surgical therapies, as the disease has progressed to extensively involve the surrounding structures.

In addition to its stage, the size of the tumour is a primary factor in determining feasible treatment alternatives. In general, patients who exhibit a small, measurable tumour are likely candidates for the primary treatment of surgery. As the tumour grows larger, it becomes less probable that the patient will receive surgery. A tumour which is too small to measure may be difficult to find and therefore not surgically excised, or may not warrant immediate treatment.

As described in Table 4, the distribution of patients by tumour size is approximately normal. A total of 46.4 percent of the participants had measurable tumours in the range of 4-6 centimeters. Patients with tumours

in the 1-3 centimeter range totaled 20.3 percent, and those whose tumour was measurable but larger than 7 centimeters comprised 24.6 percent of the sample. Only 2.2 percent of the patients had tumours too small to measure, and the remaining 6.5 percent exhibited tumours too large to measure.

The Feinstein Index, as discussed in chapter 3, is a classification of lung cancer symptoms according to the rate of growth and invasiveness of the tumour (see Appendix A). The nature of the symptoms themselves define the index categories, and not the cancer tumour *per se*. The Feinstein Index consists of six ordered categories reflecting symptoms associated with the severity of the lung cancer. Symptoms which define the lower categories are associated with less extensive cancer advancement, and those assigned to the higher categories reflect more severe cancer effects.

The distribution of the study sample was skewed slightly to the right with respect to the Feinstein Index, as seen in Table 4. This implies that the sample participants generally exhibited symptoms associated with more serious lung cancers. A total of 60.9 percent of the patients were assigned to one of the three most serious Feinstein Index categories. A total of 31.8 percent of the sample belonged to the two least serious symptom categories, and 7.2 percent exhibited no symptoms.

Tumour cell differentiation is an important indicator of the predictability of the behaviour of a patient's disease (see Appendix B). Cell differentiation is classified by four ordered categories according to the extent to which certain characteristics of the tumour cells can be distinguished. Tumour cells that are less differentiated are more unpredictable, and therefore the lung cancer is considered more dangerous. More than one-quarter of the sample participants, or 25.4 percent, displayed tumours whose cells could not be assessed for their grade of differentiation. A total of 57.9 percent of the sample had tumour cells that ranged from well to poorly differentiated. The remaining 16.7 percent of the sample were evaluated as having undifferentiated tumour cells and hence represented the most unpredictable type of cancer tumour.

The final disease indicator employed in this study is patient weight loss. Over one-half of the sample participants, or 52.9 percent, experienced no weight loss whatsoever in the time leading to their diagnosis and treatment choice. For those who did experience weight loss, a majority totalling 23.9 percent lost five kilograms or less, and 15.2 percent lost 6-10 kilograms. Those patients who lost more than 10 kilograms comprised the remaining 8.5 percent. In general, patients who experience rapid and significant weight loss

tend to be weaker, and hence are poor candidates for the more aggressive treatment alternatives.

The following chapter contains a series of cross tabulations of the treatment choice variable and the personal attributes of the patients which are hypothesized to implicitly affect treatment choice.

## 5. CROSS TABULATIONS

In order to understand the effects that a patient's age, Karnofsky Index, gender, and marital status have on treatment received, a series of cross tabulations were performed for these variables. An examination of the joint distributions may provide insight into the relationship between the explanatory variables and treatment choice.

The distribution of patients by treatment choice and age group is presented in Table 5. Visual examination does not identify any strong association between treatment choice and most of the age categories. It appears that patients in the over-85 age group tend to receive less aggressive treatment than patients in the other groups. However, there is no clear pattern in the treatment of the remaining patients, as the observations are distributed across the entire range of treatment alternatives.

A simple method of assessing how useful an independent variable is in predicting a dependent variable is the  $\lambda$  goodness-of-fit measure for modal prediction (Ott and Hildebrand, 1983, pp. 43-45). Without knowledge of the age distribution of the sample population, the modal prediction of treatment choice is 9-15 fractions of radiotherapy. This choice results in the smallest

**TABLE 5 - Distribution of Patients by Treatment Choice  
and Age Group**  
( $n = 138$ )

Treatment Choice	Age Group					TOTAL
	<u>Under-56</u>	<u>56 - 65</u>	<u>66 - 75</u>	<u>76 - 85</u>	<u>Over-85</u>	
No Treatment	2	5	5	3	2	17
Single Fraction	0	1	2	2	2	7
3 - 6 Fractions	3	4	10	3	2	22
9 - 15 Fractions	0	6	23	8	1	38
18 - 20 Fractions 2 Fields	2	7	7	7	0	23
18 - 20 Fractions 3 Fields	1	2	8	5	1	17
Surgery	2	4	6	2	0	14
<b>TOTAL</b>	10	29	61	30	8	138

$$\lambda(\text{modal prediction}) = 5.0\%$$

$$\text{Somers' } D = -0.046$$

number of prediction errors ( $138 - 38 = 100$ ). If the modal prediction is made conditional on the distribution of the age groups, the number of prediction errors is reduced to 95. The value of  $\lambda$  is calculated as  $(100 - 95)/100 = 0.05$ . Therefore, by employing the age variable in the modal prediction of

treatment choice, only 5 percent of the original prediction errors are eliminated. This suggests that the patient's age group alone is not a useful indicator in predicting their preferred therapy.

The  $\lambda$  goodness-of-fit measure provides useful information regarding the degree to which knowledge of an individual explanatory variable helps in predicting a patient's treatment choice. However, this measure is not sensitive to the ordinal nature of either the treatment choice variable or the explanatory variable under analysis. While this is not a weakness when investigating unordered categories such as gender or marital status, it does overlook important information when applied to cross tabulations of the ordered explanatory variables, such as patient age or the Karnofsky Index. Hence, Somers'  $D$  is presented as a second measure of association which explicitly accounts for the ordinal relationship between treatment choice and the ordered explanatory variables (Somers, 1962).

When both variables are hypothesized to be ordinal, or both represent continuous monotonic variables which are not directly observable, Somers'  $D$  provides an asymmetrical measure of the extent to which there is a like ordering between these two variables. The measure is based on monotonic correlation between the variables such that as one variable increases, the

other will never decrease. An attractive feature of this measure is that the cardinal rate of change is not a factor in the analysis, only the extent to which the ordered relationship is observed.

The calculation of Somers'  $D$  is based on correlating signs of differences between all possible pairs of observations in the study sample. The numerator for this measure is the difference between the number of concordant pairs ( $p$ ) and the number of discordant pairs ( $q$ ) of the sample observations, or simply  $(p-q)$ . The denominator is the total number of pairs that are not tied on the explanatory variable, regardless of their status on the treatment choice variable. This is expressed as the sum of concordant pairs, discordant pairs, and pairs tied on the dependent variable, which is denoted  $(p+q+y)$ . Somers'  $D$  is calculated as  $D = (p-q)/(p+q+y)$ , and is interpreted as the proportionate difference between concordant pairs and discordant pairs among pairs not tied on the explanatory variable. This measure is bounded by one and negative one, and the closer its value is to these extremes, the stronger the ordered association is between the two variables. The value of Somers'  $D$  regarding treatment choice and patient age is -0.046, which indicates an inverse relationship between the variables consistent with the

**TABLE 6 - Distribution of Patients by Treatment Choice  
and Karnofsky Index**  
( $n = 138$ )

Treatment Choice	Karnofsky Index							TOTAL
	<u>40</u>	<u>50</u>	<u>60</u>	<u>70</u>	<u>80</u>	<u>90</u>	<u>100</u>	
No Treatment	1	1	3	8	2	2	0	17
Single Fraction	1	0	4	2	0	0	0	7
3 - 6 Fractions	0	2	3	8	4	5	0	22
9 - 15 Fractions	2	3	1	20	10	0	2	38
18 - 20 Fractions 2 Fields	0	1	1	8	8	4	1	23
18 - 20 Fractions 3 Fields	1	0	1	3	5	6	1	17
Surgery	0	0	0	1	7	6	0	14
<b>TOTAL</b>	<b>5</b>	<b>7</b>	<b>13</b>	<b>50</b>	<b>36</b>	<b>23</b>	<b>4</b>	<b>138</b>

$\lambda(\text{modal prediction}) = 9.0\%$

Somers'  $D = 0.349$

literature review of chapter 3. However, the size of Somers'  $D$  suggests that this association is rather weak within the study sample.

Table 6 depicts the distribution of patients according to treatment choice and the Karnofsky Index assigned by their physician. Although a

preponderance of zeros in the lower-left corner and the upper-right corner suggests some relationship between treatment choice and the Karnofsky Index, the observations are in general distributed among all treatment alternatives.

The value of  $\lambda$  in this instance is 9 percent, further suggesting that the Karnofsky Index alone is a poor predictor of treatment choice. On the other hand, the value of Somers'  $D$  is 0.349, which implies a substantial positive ordinal association between these variables. It should be noted that patients who were assigned a rank of 80, 90, or 100 appear to receive considerably more aggressive treatments than patients ranked 40, 50, or 60. This finding is consistent with expectations and with Somers'  $D$ , yet the distribution of patients with a Karnofsky Index of 70 indicates no clear treatment pattern. This may be due in part to the fact that a rank of 70 represents the threshold between no special care being required, and needing a varying amount of assistance. Hence, there is a good chance that the level of prognostic uncertainty is greater among this group than within the others.

The joint distribution of treatment choice and gender is shown in Table 7. The  $\lambda$  measure for modal prediction is 0.0 percent, indicating no predictive value in making treatment choice conditional on patient gender alone. In

**TABLE 7 - Distribution of Patients by Treatment Choice  
and Gender**  
(*n* = 138)

Treatment Choice	Gender		TOTAL
	<u>Female</u>	<u>Male</u>	
No Treatment	5	12	17
Single Fraction	2	5	7
3 - 6 Fractions	10	12	22
9 - 15 Fractions	16	22	38
18 - 20 Fractions 2 Fields	8	15	23
18 - 20 Fractions 3 Fields	6	11	17
Surgery	4	10	14
<b>TOTAL</b>	<b>51</b>	<b>87</b>	<b>138</b>

$\lambda(\text{modal prediction}) = 0.0\%$

Somers' *D* = 0.029

In addition, the gender categories are intrinsically unordered, hence Somers' *D* contains no easily interpretable information. Visual inspection indicates that the observations are distributed among each of the treatment alternatives for each of the gender categories, suggesting no clear pattern of treatment choice.

However, the preponderance of observations for females in the radiotherapy categories of 3-6 fractions and 9-15 fractions may imply a preference for moderately aggressive therapies. The distribution of females indicates that the treatment extremes are generally not selected, which suggests that females prefer some treatment rather than none, but are conservative in the level of treatment aggressiveness they wish to pursue.

On the other hand, the distribution of therapies among the males is considerably more uniform across the treatment choice set. Males appear much less averse to selecting treatment extremes, such as no treatment or surgery. The relatively low incidence of males selecting mildly or moderately aggressive treatment strategies may suggest that males prefer to receive no treatment if they believe their cancer is too serious to cure. However, the large proportion of observations in the more aggressive treatment categories indicates that males may be more willing to accept aggressive treatments if they believe their cancer might be cured.

Table 8 describes the distribution of patients by treatment choice and marital status. Once again, Somers'  $D$  is not a useful measure for the unordered variable. *Prima facie*, the only treatment pattern that is clear is with respect to single patients who have never had a spouse. It appears that

**TABLE 8 - Distribution of Patients by Treatment Choice  
and Marital Status**  
(*n* = 138)

Treatment Choice	Marital Status				TOTAL
	<u>Married</u>	<u>Never Married</u>	<u>Divorced</u>	<u>Widowed</u>	
No Treatment	10	4	2	1	17
Single Fraction	7	0	0	0	7
3 - 6 Fractions	19	0	2	1	22
9 - 15 Fractions	32	1	1	4	38
18 - 20 Fractions 2 Fields	22	0	1	0	23
18 - 20 Fractions 3 Fields	16	0	1	0	17
Surgery	10	1	3	0	14
<b>TOTAL</b>	<b>116</b>	<b>6</b>	<b>10</b>	<b>6</b>	<b>138</b>

$\lambda(\text{modal prediction}) = 5.0\%$

Somers' D = -0.180

patients who never married are more likely to select no treatment than patients who have been or are currently married. This may indicate the importance of a social support network in facing a critical illness. Patients who are currently married have their spouse to offer support and

encouragement, and those who were married at some time in their life are more likely to have children to accompany them. Given the mean age of the sample, it seems reasonable that patients who never married will in general not enjoy the same opportunities for family support.

It also appears that widowed patients are less likely to prefer aggressive treatments, perhaps reflecting a greater intimacy with the prospect of death. Patients who are predeceased by a spouse may be more accepting or less afraid because of the experience of their partner's death. In this instance, the value of  $\lambda$  is 5 percent, indicating that marital status alone is not especially useful in predicting a patient's choice of treatment.

It is clear that each of the four variables which are hypothesized to implicitly affect resource rationing have very little explanatory power on their own, as indicated by the  $\lambda$  goodness-of-fit value for modal prediction and Somers'  $D$ . The possibility that the lung cancer disease indicators are of more value in explaining treatment choice is explored in Tables E1 - E5 of Appendix E. Although in each case Somers'  $D$  exhibits the expected sign, its value ranged from only -0.053 for tumour differentiation to -0.387 for tumour stage. In addition, not one of the disease indicators was able to reduce modal prediction errors by more than 9.0 percent, suggesting that no single disease

factor determines the treatment a patient will receive.

This method of analysis, however, is wholly inadequate for identifying the impact that the explanatory variables may exert as a set. Because of the interaction of these variables and their simultaneous influence on treatment choice, cross tabulation analysis that fails to control for other variables is subject to confounding. Hence, the predictive value of each variable is impossible to isolate from the influence of other factors. The relationship between treatment choice and the explanatory variables can be explored much more rigorously using multiple regression analysis. The following chapter describes the econometric technique employed in this study, and derives the estimated equation used to generate the logistic probabilities and hence cost profiles.

## 6. THE ORDERED LOGIT MODEL

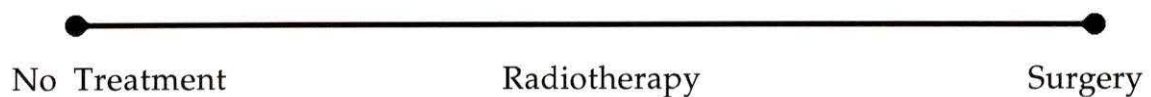
### 6.1 Ordered Logit Analysis

The complete set of alternatives from which the choice of lung cancer therapy is selected can be conceptualized as a continuum of available treatment or care. Underlying this continuum is the latent degree of aggressiveness with which each treatment addresses a patient's condition. As such, each subsequent therapy along the continuum reflects a higher degree of aggressiveness among treatment alternatives. In practice, the level of treatment aggressiveness is unobservable, and only the outcome of the treatment decision process is observed. Hence, the outcome of the physician-patient choice implicitly reflects their willingness to accept increasing levels of intensity in the treatment of the patient's condition.

In chapter 4 the choice set of lung cancer therapy alternatives in the study sample was condensed into seven discrete categories. The decision categories are ordered according to their degree of aggressiveness, and each is assumed to be a distinct interval or point on the choice set continuum. Therapies which are relatively less aggressive and intrusive, such as no treatment or a single fraction of radiotherapy, appear in the lower range of the choice set

continuum. Near the end of the continuum are therapies consisting of high numbers of fractions delivered over several fields, or removal of the tumour by surgery. Figure 2 illustrates the conceptual framework defined in this treatment choice set.

**FIGURE 2 - Treatment Choice Continuum**



The nature of this choice set excludes the application of many econometric techniques (Becker and Kennedy, 1992). To explicitly account for its ordinal properties, this study employs the ordered logit regression technique (McKelvey and Zavoina, 1975; Greene, 1990, pp. 703-707; Agresti, 1990, pp. 322-331). The ordered logit model is a non-linear maximum likelihood method of analyzing ordinal level data within a multiple regression framework.

The methodology assumes that a patient who prefers a low level of treatment aggressiveness for their condition will select a therapy near the beginning of the choice set continuum. As the physician and patient become more willing to accept aggressive treatment strategies, a threshold point will be reached at which they are assigned to a subsequently more aggressive

treatment category. Hence, patients can be assigned to a decision category which implicitly reflects a preferred level of treatment aggressiveness, as revealed through the physician-patient choice of therapy.

The conceptual framework for the ordered logit analysis in this study is as follows. It is assumed that the criteria for a patient's treatment choice can be described in terms of a linear function of  $K$  exogenous variables. Specifically, we can express this relationship in the form of equation (1).

$$T^* = \alpha + \sum_{k=1}^K \beta_k X_k + \varepsilon \quad (1)$$

In this model,  $\alpha$  is a constant term,  $\beta$  is a vector of coefficients, and the disturbance term  $\varepsilon$  is assumed to be logistically distributed across the sample observations. The  $K$  explanatory variables are the personal attributes of the study population and the selected disease indicators as described in chapter 4.

The continuous, unobservable dependant variable in equation (1),  $T^*$ , represents the latent degree of aggressiveness with which a selected treatment addresses a patient's condition. The observable counterpart to  $T^*$  is  $T$ , which is ordinal in nature, and  $T = j$  is the observed outcome when a patient chooses treatment  $j$ . It is assumed that  $T$  has a total of  $M+1$  decision categories. This relationship is expressed as equation (2).

$$T = j \Leftrightarrow \mu_{j-1} < T^* \leq \mu_j \quad (2)$$

In equation (2),  $\mu_j$  is a real number corresponding to a threshold parameter such that  $\mu_0 \leq \mu_1 \leq \dots \leq \mu_M$ . The ordered logit technique makes it possible to estimate the probability that a patient's choice of treatment belongs to the  $j$ th decision category.

Following equation (2), the  $M+1$  alternatives in the treatment choice set, beginning with no primary treatment and ending with surgery, are labelled 0 through 6. The labels do not indicate cardinal measures in any way, but serve only to illustrate the ordering of the treatment aggressiveness inherent in the choice set continuum. The dependent treatment choice variable is described explicitly by equation (3).

$$\begin{aligned} T = 0 &\Leftrightarrow T^* \leq \mu_0 \\ T = 1 &\Leftrightarrow \mu_0 < T^* \leq \mu_1 \\ &\vdots \quad \quad \quad \vdots \\ T = 6 &\Leftrightarrow \mu_{M-1} < T^* \end{aligned} \quad (3)$$

The model is estimated under the assumption that  $\mu_0 = 0$ . The ordered logit technique, using a maximum likelihood estimation procedure and the relationships defined in equations (1), (2), and (3), will therefore generate estimates of the parameters  $\mu_1, \dots, \mu_5, \beta_1, \dots, \beta_K$ , and  $\alpha$ . The parameter

estimates can be used to identify logistic probability distributions defined over the range of treatment alternatives, as illustrated below in equation (4).

$$\begin{aligned}
 Pr(T = 0) &= \frac{e^{-\alpha - \sum_{k=1}^K \beta_k X_k}}{1 + e^{-\alpha - \sum_{k=1}^K \beta_k X_k}} \\
 Pr(T = 1) &= \frac{e^{\mu_1 - \alpha - \sum_{k=1}^K \beta_k X_k}}{1 + e^{\mu_1 - \alpha - \sum_{k=1}^K \beta_k X_k}} - \frac{e^{-\alpha - \sum_{k=1}^K \beta_k X_k}}{1 + e^{-\alpha - \sum_{k=1}^K \beta_k X_k}} \\
 &: \\
 Pr(T = 6) &= 1 - \frac{e^{\mu_5 - \alpha - \sum_{k=1}^K \beta_k X_k}}{1 + e^{\mu_5 - \alpha - \sum_{k=1}^K \beta_k X_k}}
 \end{aligned} \tag{4}$$

By evaluating the estimated model at specific values of the explanatory variables, the probability that a patient will belong to any one of the treatment choice categories can be calculated. Re-evaluating the estimated model at an alternative value of an explanatory variable will indicate the effect of a change in a rationing criterion or disease indicator on treatment selection and hence treatment costs.

## 6.2 Model Specification

The ordered logit model to be estimated is given below in equation (5).

$$\begin{aligned}
T = & \alpha + \beta_1ST1 + \beta_2ST2 + \beta_3ST3a + \beta_4ST3b \\
& + \beta_5SIZE1 + \beta_6SIZE2 + \beta_7SIZE3 + \beta_8SIZE4 \\
& + \beta_9DIFF1 + \beta_{10}DIFF2 + \beta_{11}DIFF3 + \beta_{12}DIFF4 \quad (5) \\
& + \beta_{13}WT0 + \beta_{14}WT1 + \beta_{15}WT2 + \beta_{16}WT3 \\
& + \beta_{17}FI1 + \beta_{18}FI2 + \beta_{19}FI3 + \beta_{20}FI4 + \beta_{21}FI5 \\
& + \beta_{22}AGE1 + \beta_{23}AGE2 + \beta_{24}AGE3 + \beta_{25}AGE4 \\
& + \beta_{26}K50 + \beta_{27}K60 + \beta_{28}K70 \\
& + \beta_{29}K80 + \beta_{30}K90 + \beta_{31}K100 \\
& + \beta_{32}MALE + \beta_{33}SINGLE
\end{aligned}$$

The dependent treatment choice variable,  $T$ , is categorical and modelled as a function of the disease indicators and personal attributes of the sample population. Table 9 describes the abbreviations which represent the explanatory variables in equation (5). Similar to the dependant choice variable, each of the explanatory variables is categorical and therefore enters the model as a dummy variable. As such, evaluating the model requires that only a single category for each of the explanatory variables takes a value of one, and the remaining categories are assigned values of zero.

For estimation purposes, however, it is important to note that one category from each of the explanatory variables must be omitted to avoid the

**TABLE 9 - List of Explanatory Variables**

Variable	Abbreviation	Variable	Abbreviation
<b>Tumour Stage</b>		<b>Tumour Size</b>	
Stage I	ST1	Too small to measure	base category
Stage II	ST2	1 - 3 centimeters	SIZE1
Stage IIIa	ST3a	4 - 6 centimeters	SIZE2
Stage IIIb	ST3b	≥ 7 centimeters, measurable	SIZE3
Stage IV	base category	≥ 7 centimeters, unmeasurable	SIZE4
<b>Feinstein Index</b>		<b>Tumour Differentiation</b>	
Asymptomatic	FI1	Could not be assessed	base category
Long Pulmonic	FI2	Well differentiated	DIFF1
Short Pulmonic	FI3	Moderately differentiated	DIFF2
Pulmono-systemic	FI4	Poorly differentiated	DIFF3
Pulmono-ultrapul.	FI5	Undifferentiated	DIFF4
Ultrapulmonic	base category		
<b>Weight Loss</b>		<b>Patient Age</b>	
No weight loss	WT0	Under-56	AGE1
Up to 5 kilograms	WT1	56 - 65	AGE2
6 - 10 kilograms	WT2	66 - 75	AGE3
10 - 15 kilograms	WT3	76 - 85	AGE4
> 15 kilograms	base category	Over-85	base category
<b>Karnofsky Index</b>		<b>Marital Status</b>	
40	base category	Never married	SINGLE
50	K50	Otherwise	base category
60	K60		
70	K70	<b>Gender</b>	
80	K80	Female	base category
90	K90	Male	MALE
100	K100		

dummy variable trap (Greene, 1990, p. 241). For each disease indicator, the category associated with the least aggressive treatment strategy has been omitted from the estimated equation. Hence, the estimated coefficients for the remaining categories indicate how improvements relating to the extent and severity of the disease affect the probability distribution across the set of treatment alternatives.

For the variable representing the age of the patient, the over-85 group is the omitted or base category in the estimated equation. This is justified on the basis that this group receives the least aggressive treatment of all the age categories. The estimated coefficients of the remaining age groups are expected to be positive, and their magnitudes will indicate the extent to which age influences the probability of receiving more aggressive therapies.

Similarly, the Karnofsky Index category representing an assigned rank of 40 was omitted, leaving six progressively healthier states for this variable. It is hypothesized that each of the coefficients for the remaining Karnofsky Index groups will be positive. The size of the coefficients should provide insight into the effect that a physician's perception of greater functional status has on the probability distribution across treatment alternatives. A larger estimated

coefficient for a higher Karnofsky Index group would indicate healthier patients are more likely to receive aggressive therapies.

The patient gender variable enters the equation as a male specific indicator. Females are included in the base category on the assumption that males tend to prefer more aggressive treatment strategies. This was indicated generally in the cross tabulation analysis, and has also been the convention in former treatment choice studies. Hence, it is hypothesized that the coefficient indicating a male patient will be positive in the estimated equation.

The final variable to be examined in the ordered logit model is the patient's marital status. Due to the low number of observations in each non-married category and on the basis of cross tabulation analysis, this variable was condensed into two categories. Patients who had never been married were assigned to the SINGLE category, and all remaining patients comprised the omitted group. Because of the large proportion of patients who were either currently married or had been in the past, it seems reasonable to include these patients as the base group. It is expected, therefore, that patients who never married will receive less aggressive treatment strategies and the estimated coefficient for this variable will be negative.

In the following chapter, the empirical results of the estimated model are

presented and several measures of goodness-of-fit are reported.

## 7. EMPIRICAL RESULTS

### 7.1 The Estimated Model

Table 10 presents the estimation results for the ordered logit model derived in the previous chapter. In addition, several goodness-of-fit measures are reported, since there is no single measure of the ordered logit model equivalent to the  $R^2$  of least squares regression analysis (Greene, 1990, p. 682). Two measures presented are the  $\lambda$  test for modal prediction and the Somers'  $D$  statistic, as discussed in chapter 5. The value of Somers'  $D$  for the estimated model is 0.667, indicating a strong ordinal association between the treatment choice variable and predictions of the estimated model. Alternatively, modal prediction results in a total of 100 prediction errors without the use of the model. If the modal prediction is made conditional on the estimated model, prediction errors are reduced to 80 and the value of  $\lambda$  is 20 percent. This is a considerable improvement over the results of the cross tabulation analysis, but still indicates a substantial random disturbance term in the estimated model. However, given the complex decision-making process and variety of interests associated with the choice of medical treatment, it should not be surprising that appreciable differences in the

**TABLE 10 - Ordered Logit Analysis of Lung Cancer Treatment Choice**  
**(Preliminary Model)**

Variable	Estimated Coefficient	t-ratio	Significance Level
Constant	-9.0168	-3.27	0.001
ST1	3.1958	4.49	0.000
ST2	3.9757	3.78	0.000
ST3a	2.1289	3.20	0.001
ST3b	2.5515	3.11	0.002
SIZE1	5.3264	4.69	0.000
SIZE2	4.7296	3.32	0.000
SIZE3	4.5605	3.94	0.000
SIZE4	3.4878	2.74	0.006
DIFF1	0.7345	0.88	0.378
DIFF2	0.9017	1.44	0.151
DIFF3	0.1491	0.25	0.804
DIFF4	-0.9556	-1.31	0.190
WT0	2.7616	1.58	0.115
WT1	2.0829	1.14	0.256
WT2	2.4924	1.38	0.167
WT3	2.1326	1.11	0.266
FI1	0.5647	0.39	0.698
FI2	0.1055	0.08	0.936
FI3	0.0094	0.01	0.995
FI4	-0.3745	-0.28	0.784
FI5	-0.4219	-0.33	0.743
AGE1	3.4387	2.70	0.007
AGE2	2.7549	2.90	0.004
AGE3	2.4096	2.69	0.007
AGE4	2.1747	2.49	0.013
K50	0.4687	0.33	0.743
K60	-0.8954	-0.67	0.504
K70	0.2452	0.21	0.837

**TABLE 10 (cont'd) - Ordered Logit Analysis of Lung Cancer Treatment Choice  
(Preliminary Model)**

Variable	Estimated Coefficient	<i>t</i> -ratio	Significance Level
K80	1.2035	0.98	0.328
K90	1.6634	1.36	0.175
K100	2.1872	1.31	0.189
MALE	0.2773	0.63	0.529
SINGLE	-2.4783	-2.62	0.009
$\mu_1$	0.6100	2.52	0.012
$\mu_2$	2.1445	5.82	0.000
$\mu_3$	4.2088	8.42	0.000
$\mu_4$	5.5342	9.82	0.000
$\mu_5$	6.8985	10.04	0.000

Summary Statistics:

Number of Observations = 138

$\lambda$ (modal prediction) = 20%

Somers' *D* = 0.667

$\chi^2$  (degrees of freedom) = 114.638 (33)

Percent Correctly Classified = 42%

*LRI* = 0.2250

decision outcome still remain.

Goodness-of-fit can also be assessed by how well the model classifies the patients based on the estimated probabilities. The results suggest that the overall ability of the model to yield correct predictions regarding the physician-patient treatment choice was 42 percent. Although this value appears relatively low, it is not unreasonable given the large number of treatment alternatives. Fewer elements in the choice set will result in a

greater number of correct predictions, but such gains are made at the expense of analytical detail and have no theoretical foundation.

A third measure of goodness-of-fit is the likelihood ratio index (*LRI*). This measure is intuitively similar to the  $R^2$  of a least squares regression model and is bounded by zero and one (Greene, 1990, p. 682). A zero value of the *LRI* indicates that the model has no explanatory power whatsoever. However, it is impossible to make the  $LRI = 1$  in a properly specified model, therefore caution must be exercised when interpreting this measure of goodness-of-fit. The *LRI* for the estimated model is 0.2250, which suggests an appreciable degree of random disturbance and supports the indications of the previous measures.

Despite the results of the measures of goodness-of-fit, the Chi-squared test for joint significance of all the slope parameter estimates indicates a strong relationship between treatment choice and the explanatory variables. The null hypothesis that the estimated coefficients are jointly equal to zero is strongly rejected ( $\chi^2 = 114.638$  with 33 degrees of freedom), suggesting the model does in fact have reasonable explanatory power.

Many of the estimated coefficients are statistically significantly different from zero at the 0.01 level. A series of *t*-ratio tests reveal that the stage and

the size of a lung cancer tumour exert strong influences on the probability of selecting an aggressive treatment alternative. The positive sign for these coefficients and their relative magnitudes support the hypothesis that their base categories warrant the least aggressive treatment strategies.

Estimated coefficients for the other disease indicators reflecting tumour cell differentiation, patient weight loss, and the Feinstein Index were generally not statistically significant. The results concerning the Feinstein Index were particularly interesting, since other research has found symptom information contained within this index to be of considerable value in determining treatment choice (Coy *et al.*, 1981). There are several explanations which may account for these results.

If similar information is contained within each of the three disease indicator variables, it is possible that the model has a multicollinearity problem. If this is true, tests of significance based on the *t*-ratios will not be reliable. Alternatively, it may be the case that each of the variables are statistically independent of treatment choice, and in no way affect the probability of selecting a particular treatment. In this instance, the appropriate course of action would be to omit all of these variables from the equation and

re-estimate the model. However, on the basis of the theoretical foundations of lung cancer treatment, it is highly unlikely that all of these indicators are irrelevant. Hence, it was hypothesized that the composite nature of the Feinstein Index may be deleteriously affecting the estimation of the model's parameters.

To investigate this theory, the initial course of action was to test the joint statistical significance of the set of dummy variables relating to the categories of the Feinstein Index. To accomplish this end, a Wald Chi-squared test was conducted of the relevant parameters (Kennedy, 1987, p. 58). The null hypothesis that the estimated coefficients for the Feinstein Index variable are jointly equal to zero could not be rejected ( $\chi^2 = 2.04$  with 5 degrees of freedom).

On the basis of the Wald Chi-squared test, it was decided to omit the Feinstein Index from the original specification and re-estimate the model for the remaining explanatory variables. However, professional judgement suggests that a symptom indicator of some type should be included in the treatment choice model (Coy, P., personal communication). Hence, an extensive examination of data relating to the individual symptoms represented by the Feinstein Index led to the definition of two new variables

as proxy for the composite index. The original model was redefined to include a dummy variable indicating whether a patient experienced sputum production, and an additional dummy variable indicating whether a patient suffered from excessive fatigue. In the revised model, these variables are labelled SPUTUM and FATIGUE respectively, and each is assigned a value of one if the symptom is present, and zero otherwise.

It seems reasonable to assume that a patient suffering from either of these lung cancer symptoms is more ill than a patient exhibiting neither symptom. Hence, the coefficients of the new symptom variables are both expected to have a negative sign. The estimation results of the redefined model are presented in Table 11.

It is important to note that the new model is not a sub-model of the original presented in Table 10. Therefore, direct comparisons of the two models should be interpreted with caution. A Chi-squared test of the new model strongly rejects the null hypothesis that all of the slope parameters are jointly equal to zero ( $\chi^2 = 123.701$  with 30 degrees of freedom). In addition, the *LRI* of the new model is slightly higher at 0.2428, although it still implies a substantial degree of random disturbance.

The value of  $\lambda$  for modal prediction is identical to the earlier model's

**TABLE 11 - Ordered Logit Analysis of Lung Cancer Treatment Choice  
(Unrestricted Model)**

Variable	Estimated Coefficient	t-ratio	Significance Level
Constant	-9.6612	-3.47	0.001
ST1	3.7606	5.22	0.000
ST2	4.1369	3.58	0.000
ST3a	2.4635	3.79	0.000
ST3b	3.1264	3.81	0.000
SIZE1	4.9484	4.15	0.000
SIZE2	4.2940	3.61	0.000
SIZE3	4.1346	3.41	0.001
SIZE4	3.1015	2.41	0.016
DIFF1	0.8852	1.15	0.249
DIFF2	1.0385	1.64	0.101
DIFF3	0.3315	0.59	0.552
DIFF4	-0.9306	-1.45	0.148
WT0	2.6639	1.53	0.127
WT1	1.7603	0.99	0.324
WT2	2.0699	1.19	0.233
WT3	2.1058	1.04	0.298
SPUTUM	-1.1177	-2.58	0.010
FATIGUE	0.8759	1.62	0.105
AGE1	3.8607	3.24	0.001
AGE2	2.7986	2.97	0.003
AGE3	2.4905	3.01	0.003
AGE4	1.9786	2.36	0.019
K50	0.9403	0.58	0.564
K60	0.1249	0.09	0.932
K70	0.8055	0.61	0.543
K80	2.0942	1.52	0.129
K90	2.4839	1.74	0.081

**TABLE 11 (cont'd) - Ordered Logit Analysis of Lung Cancer Treatment Choice  
(Unrestricted Model)**

Variable	Estimated Coefficient	<i>t</i> -ratio	Significance Level
K100	2.4292	1.35	0.178
MALE	0.3922	0.96	0.335
SINGLE	- 2.2533	- 2.48	0.013
$\mu_1$	0.6064	2.56	0.010
$\mu_2$	2.1262	5.64	0.000
$\mu_3$	4.3012	7.84	0.000
$\mu_4$	5.6877	9.56	0.000
$\mu_5$	7.0937	9.57	0.000
Summary Statistics:			
Number of Observations = 138			
$\lambda$ (modal prediction) = 20%		Percent Correctly Classified = 41%	
Somers' <i>D</i> = 0.674		<i>LRI</i> = 0.2428	
$\chi^2$ (degrees of freedom) = 123.701 (30)			

measure of 20 percent, indicating that replacement of the Feinstein Index by the two symptom variables does not affect the number of prediction errors. The value of Somers' *D* is 0.674, which shows a modest improvement over the first model, although the ability of the new model to correctly classify patients declines slightly from 42 percent to 41 percent. It is concluded that, in general, the new model fits the data set as well as the original model, yet does so with fewer explanatory variables.

The coefficients of the symptom variables SPUTUM and FATIGUE are

both statistically significant. As suggested earlier, it seems reasonable that patients with excessive sputum production may be more ill than otherwise, hence the negative coefficient estimate implies a greater probability of receiving less aggressive treatment. However, the positive coefficient regarding the fatigue symptom was not expected, and indicates that greater fatigue leads to more aggressive cancer treatments. This result is counter to the hypothesized relation between fatigue and treatment aggressiveness. A possible explanation, however, is that fatigue is acting as a proxy for several other symptoms which are not otherwise identified.

Replacing the Feinstein Index with the symptom variables had little effect on the estimated coefficients of tumour stage and tumour size. The relative order and magnitude of each variable coefficient remained consistent with the original model. Similarly, a series of *t*-ratio tests result in rejection of the null hypothesis that any one of the coefficients representing tumour stage or tumour size is equal to zero.

It was hoped that the statistical significance of the coefficients for the individual weight loss categories and the tumour differentiation categories would appreciably improve over their original model counterparts. However, this is generally not the case. Hence, the null hypothesis that the coefficients

of the tumour differentiation variable are jointly equal to zero was tested. Similarly, this test was repeated for the coefficients relating to the weight loss variable. The Wald test regarding tumour differentiation indicates the coefficients are not statistically significantly different from zero as a set ( $\chi^2 = 9.33$  with 4 degrees of freedom). Likewise, the null hypothesis that the coefficients are jointly equal to zero can not be rejected for the weight loss variable ( $\chi^2 = 5.08$  with 4 degrees of freedom). However, rather than drop these variables from the estimated equation, it was decided to combine several of the dummy variable categories before re-estimating the model.

The base dummy for the tumour differentiation indicator was redefined as all differentiation classes other than DIFF4, or undifferentiated. This was decided on the basis of professional judgement and the sign of the DIFF4 coefficient (Coy, P., personal communication). Similarly, the variable indicating patient weight loss was collapsed into two discrete categories. All patients who experienced weight loss due to their disease were assigned to the base group, and patients who lost no weight remained in WT0.

The coefficients for the patient age categories were all highly statistically significant and exhibited the correct positive signs. In addition, the coefficient

of the marital status variable was statistically significant at the 0.01 level. The hypothesized negative relationship between the probability of a patient receiving more aggressive treatment and never having been married was therefore supported in the estimated results.

Of the remaining patient attributes, the only coefficient to prove statistically significantly different from zero was K90. A Wald Chi-squared test was performed to explore the null hypothesis that the coefficients of the dummy variables representing the Karnofsky Index are jointly equal to zero. The null hypothesis was rejected ( $\chi^2 = 13.06$  with 6 degrees of freedom). It was decided to collapse the range of Karnofsky Index variables into three categories. The base dummy was redefined as patients assigned a Karnofsky Index of 70 or less, K80 remains as in the original model, and K910 represents a Karnofsky rank of 90 or 100.

The null hypothesis that the coefficient of the variable MALE is equal to zero can not be rejected. Hence, patient gender does not appear to influence the probability of selecting a more aggressive treatment alternative. This result was not expected, based on the indications of the cross tabulation analysis in chapter 5, and hence received further investigation.

A variety of interaction terms were defined to adjust for possible

confounding in the estimation of the gender coefficient. The model was re-estimated to test a series of coefficients relating to male-tumour stage, male-tumour size, male-age, and male-Karnofsky Index interaction variables. It was found that none proved statistically significant or appreciably affected the estimate of the original gender coefficient. It was therefore decided to omit the gender variable from the re-estimated model.

The final model is a restricted sub-model of the one presented in Table 11. The ordered logit results for the restricted model are presented in Table 12. The validity of the new model specification was tested by employing the likelihood ratio (*LR*) test (Kennedy, 1987, pp. 58-66). If the restrictions on the parameters of the new model are legitimate, the maximized value of the log-likelihood function should not be significantly less than the maximized value of the original unrestricted model. The *LR* test indicates that the difference between the restricted and the unrestricted log-likelihood functions is not statistically significant ( $\chi^2 = 5.83$  with 11 degrees of freedom). Hence, the specification of the new model appears to be reasonable.

The re-estimated model seems to fit the data slightly better than its unrestricted counterpart. According to the  $\lambda$  test for modal prediction, 24 percent of the modal prediction errors are eliminated by employing the new

**TABLE 12 - Ordered Logit Analysis of Lung Cancer Treatment Choice  
(Restricted Model)**

Variable	Estimated Coefficient	<i>t</i> -ratio	Significance Level
Constant	- 7.0858	- 5.96	0.000
ST1	3.6944	5.84	0.000
ST2	4.1292	3.93	0.000
ST3a	2.3502	3.84	0.000
ST3b	3.0244	4.21	0.000
SIZE1	4.9655	4.68	0.000
SIZE2	4.4527	4.17	0.000
SIZE3	4.1293	3.79	0.000
SIZE4	3.2973	2.82	0.005
DIFF4	- 1.3145	- 2.74	0.006
WT0	0.8483	2.00	0.045
SPUTUM	- 1.0007	- 2.42	0.016
FATIGUE	1.0209	2.12	0.034
AGE1	4.1244	4.22	0.000
AGE2	2.9482	3.60	0.000
AGE3	2.7996	3.65	0.000
AGE4	2.2958	2.90	0.004
K80	1.3969	2.71	0.007
K910	1.7261	2.98	0.003
SINGLE	- 2.1759	- 3.03	0.002
$\mu_1$	0.5689	2.58	0.010
$\mu_2$	1.9792	5.70	0.000
$\mu_3$	4.0143	8.54	0.000
$\mu_4$	5.3700	9.93	0.000
$\mu_5$	6.7280	10.26	0.000

Summary Statistics:

Number of Observations = 138

$\lambda$ (modal prediction) = 24%

Somers' D = 0.662

$\chi^2$  (degrees of freedom) = 112.038 (19)

Percent Correctly Classified = 45%

LRI = 0.2199

model. This is slightly higher than the unrestricted specification. Moreover, the restricted model correctly classifies 45 percent of the patients, which once again is an improvement over the unrestricted model. However, the value of Somers'  $D$  is 0.662, indicating a slight reduction due to the restriction on the model's parameters. The Chi-squared test for joint significance of all the slope estimates strongly rejects the null hypothesis that the estimated coefficients are jointly equal to zero ( $\chi^2 = 112.038$  with 19 degrees of freedom). Hence, the model has satisfactory explanatory power and fits the data reasonably well.

Each one of the estimated coefficients is statistically significant at the 0.01 level except for WT0, SPUTUM, and FATIGUE, which are statistically significant at the 0.05 level. The signs of the estimated coefficients are as expected, except for the positive sign of the FATIGUE coefficient as noted earlier.

With respect to tumour stage, the estimated coefficients for all of the categories are positive as expected. However, their relative magnitudes are not ordered according to the expected pattern, although each is highly statistically significant. The results suggest that an advanced tumour stage does not necessarily indicate less aggressive treatment strategies. I can offer no

explanation for the relative sizes of the tumour stage coefficients. It does appear, however, that patients with Stage II disease are the likeliest to receive more aggressive treatment alternatives.

The model also identifies tumour size as having a significant impact on the probability of receiving more aggressive treatment strategies. Unlike the tumour stage variable, there is a clear ranking in the tumour size coefficients and their relative influence on the treatment choice probabilities. Although all have a positive sign, the largest coefficient belongs to measurable tumours in the 1-3 centimeter range, with the magnitude of the subsequent coefficients declining as tumour size increases. Hence, a smaller tumour shifts the probability distribution further to the right, towards the more aggressive treatments of the choice set continuum.

The model suggests that the probability that a patient will receive a more aggressive treatment declines if the cancer tumour cells are found to be undifferentiated. This is consistent with expectations, as the other grades of cell differentiation are all considered less severe. The model also indicates patients who have experienced zero weight loss due to their cancer are more likely to receive aggressive therapies than patients who have lost some weight. The size of the weight loss coefficient is comparatively small,

however, so the impact on the probability distribution will be relatively modest.

Among the personal attributes investigated in the model, patient age was found to have the largest impact on the probability of receiving more aggressive cancer treatment. The signs of each of the coefficients representing the age categories are positive, hence patients in the base over-85 category are less likely to receive aggressive therapies than those in any other group. The relative size of the age coefficients indicate that progressively younger patients are increasingly likely to receive more aggressive treatment for their condition, which is consistent with the findings of Mor *et al.* (1985), Samet *et al.* (1986), and Greenberg *et al.* (1988). By far the largest reductions are associated with a movement from the age group 76-85 to the over-85 group, yet the first drop from the under-56 group to the 56-65 group also exerts a substantial impact on the probability distribution.

The model clearly indicates that the Karnofsky Index rankings in this study can be combined into three distinct groups. The assignment of a Karnofsky rank of 100 or 90 suggests a greater probability of receiving a more aggressive treatment strategy. A Karnofsky Index of 80 has a moderately smaller positive impact on the probability distribution, and a ranking of 70 or

less significantly reduces the likelihood of receiving more aggressive treatments.

With respect to marital status, the results suggest a definite relationship between having never married and the probability of selecting a less aggressive treatment alternative. The favourable consequence of having married at some time appears in the form of a substantial increase in the likelihood of receiving aggressive cancer therapy. In fact, the impact on the probability distribution is greater for a change in marital status than for a gain in youth of twenty years, based on the difference between the coefficients of the 76-85 age group and the under-56 group. The result of this age-marital status comparison is consistent with the research of Goodwin *et al.* (1987) and Greenberg *et al.* (1988).

A number of inferences can be drawn from the results of the ordered logit analysis. The estimated model suggests that, in general, the disease indicators of tumour size and tumour stage are the most important factors in determining the level of aggressiveness of lung cancer therapy. The difference between the most ill category and the first improvement in either disease indicator have a substantial positive impact on the probability distribution.

Subsequent improvements in stage or tumour size imply more modest influences across the choice set continuum. This is reasonable since it may be easier for physicians to distinguish those patients who are most ill from the others. As patient health status improves, it may become more difficult to discriminate among states of disease, or there may be more treatment alternatives available to address a patient's condition. Hence, a movement from a less severe tumour state to another may not have as large an impact on the probability of receiving aggressive treatment.

Among the non-disease factors investigated in the model, a patient's age group is the most responsible for shifting the probability distribution across treatment alternatives. Patients who are younger than 86 years old are significantly more likely to receive aggressive therapies, with those under 56 enjoying the greatest positive impact on the probability distribution. The difference between the three central groups is modest, yet the leftward shift in the probability distribution towards less aggressive treatments represents a steady decline attributable to age.

A comparison of the absolute values of the Karnofsky Index coefficients implies a modest leftward shift in the probability distribution corresponding to a deterioration of health status from a rank of 100 or 90 down to 80. The

decline is comparable to the impact associated with an increase in tumour size from 1-3 centimeters to 4-6 centimeters. Hence, a physician's perception of patient health status may have as large an impact on the odds of receiving aggressive treatment as more objective quantifiable factors.

Finally, the ordered logit analysis clearly indicates that patients who are widowed, divorced, or currently married enjoy a considerably higher probability of receiving more aggressive cancer treatments than those who have never been wed. This result may indicate the importance of family and social support when facing a critical illness, or possibly the influence of physician bias in treatment recommendations (Geller *et al.*, 1993; Labrecque *et al.*, 1991). In terms of impact on the probability distribution, the implicit value of having married at some time is greater than that of a reduction in tumour size from 7 centimeters to 1-3 centimeters.

Therefore, it appears from the results of the ordered logit analysis that aggressive treatment is implicitly rationed according to non-disease criteria such as patient age, functional status, and marital status. The rationing of aggressive treatment, however, is not necessarily the same as the rationing of scarce health care resources. The following section illustrates the method employed to simulate the estimated model in order to generate probability

distributions across the treatment alternatives. The estimated logistic probabilities can then be linked to treatment costs to identify the degree of implicit rationing in the physician-patient choice of treatment.

### 7.2 Calculation of Logistic Probabilities

For the ordered logit model, the estimated coefficients should be interpreted in the sense that they affect the probability that a patient will select a specific treatment alternative (Greene, 1990, pp. 704-705). For cardinal values of explanatory variables, it is possible to calculate marginal impacts by computing the probability derivatives of the model. The ordered logit model in this study, however, is defined for explanatory variables which are strictly categorical in nature. The probability derivatives for binary variables such as this do not exist, hence the model must be evaluated at specific zero-one values of the explanatory variables in order to identify logistic probability distributions.

For notational simplicity, I have defined

$$\widehat{P}_{ij}(\mathbf{x}) = \widehat{Pr} [T_i = j | \mathbf{X} = \mathbf{x}]. \quad (6)$$

In other words, for the  $i$ th patient exhibiting characteristics  $\mathbf{x} \equiv (x_1, \dots, x_K)$ , the probability of receiving treatment  $j$  is  $\widehat{P}_{ij}(\mathbf{x})$ . The vector  $\mathbf{x}$  represents

specific zero-one values of the  $K$  exogenous variables as defined in the estimated model. Therefore, this vector can be tailored to reflect the characteristics of any patient profile corresponding to the patient attributes and disease indicators included in the estimated model.

The probability that the  $i$ th patient belonging to the profile described by vector  $x$  will select a particular treatment category can be calculated by simulating the model for the values of vector  $x$ . The model can then be re-evaluated for a change in a single explanatory variable in order to identify the effect of a rationing criterion on the probability of receiving a more aggressive treatment. The base characteristics of the illustrative patient profile, or the base vector  $x$ , are described in Table 13.

**TABLE 13 - Illustrative Patient Profile**

Disease Characteristics	Personal Attributes
Stage I tumour disease	55 years old or less
Tumour size 1-3 cm	Karnofsky Index of 90
Tumour cells are not undifferentiated	or 100
No weight loss	Currently married, divorced, or widowed
No sputum production	
No fatigue symptoms	

All of the coefficients for the variables assigned a value of zero will drop out of the model, leaving equation (7) as the basis for the logistic probability estimates of the model in Table 12.

$$T = - 7.0858 + 3.6944ST1 + 4.9655SIZE1 + 4.1244AGE1 \quad (7)$$

$$+ 1.7261K910 + 0.8483WT0$$

Assigning a value of one to each explanatory variable in equation (7) reduces the right hand side of the model to a constant term with a value of 8.27286. From the results in Table 12, the five estimated threshold parameters relating to the treatment decision categories are  $\mu_1 = 0.5689$ ,  $\mu_2 = 1.9792$ ,  $\mu_3 = 4.0143$ ,  $\mu_4 = 5.3700$ , and  $\mu_5 = 6.7280$ . These are not explanatory variables *per se*, hence they do not enter equation (7) in the same manner as the other estimated coefficients. The threshold parameters serve to partition the probability distribution across the treatment choice continuum as described in equation (4) of chapter 6. The various probabilities relating to the treatment alternatives for a patient described by Table 13 are calculated in Table 14.

It is clear from the estimated probabilities listed in Table 14 that a patient belonging to this profile would likely receive very aggressive treatment for their lung cancer. The probability of this type of patient receiving surgery is approximately 82 percent, which is unequivocally much greater than the

**TABLE 14 - The Estimated Probability that a Patient Belonging to the Illustrative Patient Profile will Receive a Specific Treatment**

$$\widehat{P}_{i0}(x) = \frac{e^{-8.27286}}{1 + e^{-8.27286}} = 0.00026$$

$$\widehat{P}_{i1}(x) = \frac{e^{0.56892-8.27286}}{1 + e^{0.56892-8.27286}} - \frac{e^{-8.27286}}{1 + e^{-8.27286}} = 0.00045 - 0.00026 = 0.00019$$

$$\widehat{P}_{i2}(x) = \frac{e^{1.9792-8.27286}}{1 + e^{1.9792-8.27286}} - \frac{e^{0.56892-8.27286}}{1 + e^{0.56892-8.27286}} = 0.00184 - 0.00045 = 0.00139$$

$$\widehat{P}_{i3}(x) = \frac{e^{4.0413-8.27286}}{1 + e^{4.0413-8.27286}} - \frac{e^{1.9792-8.27286}}{1 + e^{1.9792-8.27286}} = 0.01395 - 0.00184 = 0.01211$$

$$\widehat{P}_{i4}(x) = \frac{e^{5.3700-8.27286}}{1 + e^{5.3700-8.27286}} - \frac{e^{4.0413-8.27286}}{1 + e^{4.0413-8.27286}} = 0.05201 - 0.01395 = 0.03806$$

$$\widehat{P}_{i5}(x) = \frac{e^{6.7280-8.27286}}{1 + e^{6.7280-8.27286}} - \frac{e^{5.3700-8.27286}}{1 + e^{5.3700-8.27286}} = 0.17583 - 0.05201 = 0.12382$$

$$\widehat{P}_{i6}(x) = 1 - \frac{e^{6.7280-8.27286}}{1 + e^{6.7280-8.27286}} = 1 - 0.17583 = 0.82417$$

probability of receiving any of the other treatment alternatives. In fact, the two most aggressive treatment strategies, 18-20 fractions over three fields or

surgery, are responsible for almost 95 percent of the probability mass along the entire choice set continuum. This is to be expected, since the profile is defined to reflect a relatively healthy lung cancer patient. The tumour is small and measurable, the disease is in the mildest category of Stage I, and the patient has lost no weight and has no symptoms. In addition, the physician assigned Karnofsky Index is either 100 or 90, the patient is relatively young and is assumed to have a family support network by virtue of the marital status variable.

In the following chapter, implicit rationing is examined using the estimated logistic probabilities to link expenditures on treatment to patient characteristics.

## 8. THE EXPECTED COST PROFILE

### 8.1 Definition of Treatment Costs

The treatment cost data used in this study are from the Victoria Cancer Clinic as presented in Coy *et al.*, 1992. The cost of each treatment in the choice set of the estimated model, with the exception of no primary treatment, is depicted in Table 15. It was assumed that the decision to decline primary treatment resulted in no direct expenditures, and hence was assigned a cost of zero.

The costs of the remaining treatment alternatives were based on a weighted average of the sample frequency percentages and the individual unit costs. Only the direct costs of treatment were included in the calculations, hence expenditures relating to patient assessment, follow-up, and ancillary care are not presented in this study.

### 8.2 Calculation of Expected Cost Profiles

It is hypothesized that the level of treatment expenditures dedicated to lung cancer patients will vary according to a patient's age, Karnofsky Index, and marital status. In the previous chapter, the calculation of estimated logistic probabilities was demonstrated for an illustrative patient profile. As

**TABLE 15 - Treatment Costs (Excluding Follow-up) in  
1989 Dollars**

Treatment	Frequency <sup>a</sup>	Fields	Planning <sup>b</sup>	Shielding <sup>c</sup>	Unit Cost <sup>d</sup>	Average Cost <sup>e</sup>
Single Fraction	3	1	No	No	219.39	261.37
	4	2	No	No	292.86	
3 - 6 Fractions	3	1	No	No	549.55	803.39
	15	2	No	No	697.98	
	4	2	No	Yes	1389.05	
9 - 15 Fractions	1	1	No	No	962.25	1452.61
	23	2	No	No	1204.38	
	14	2	No	Yes	1895.45	
18 - 20 Fractions	10	2	No	No	2217.18	2509.02
	4	2	Yes	No	2340.35	
	9	2	No	Yes	2908.25	
18 - 20 Fractions	17	3	Yes	No	3912.22	3912.22
Surgery	14				7279.20 <sup>f</sup>	7279.20

a Number of patients in treatment category

b Additional planning beyond basic requirement

c Custom shielding employed

d Source: Coy *et al.* (1992), Discussion Paper 92-13

Table 3, p. 17. Cost of Shielding: 1005.82 - 314.75 = 691.07

Tables 4a and 4b, pp. 18-19. Average of Linac and Cobalt machines

Unit Cost = Number of Fractions (1, 5, 10, or 20) x Cost per Fraction + Planning Cost +  
Shielding Cost

e Weighted Average = Unit Cost x Frequency Percentage

f Source: Coy, P., personal correspondence, surgical costs based on average of four cases

discussed earlier, the model can be re-evaluated for a change in a single explanatory variable in order to identify the effect of an hypothesized rationing criterion on the estimated probabilities. Once logistic probability estimates of the model are calculated for each of the categories relating to patient age, Karnofsky Index, and marital status, the expected ration dedicated to a patient's treatment can be computed.

The average cost of treatment  $j$  is defined as  $C_j$ . The expected ration of health care resources dedicated to the  $i$ th patient,  $E[R_i]$ , is calculated as follows. The cost of each  $j$  treatment is weighted by the estimated logistic probability that the  $i$ th patient will receive that treatment. The sum of these products yields a measure of the expected ration, or expected cost, of treating the  $i$ th patient belonging to that patient profile. The calculation of  $E[R_i]$  is depicted in equation (8) below.

$$E[R_i] = \sum_{j=0}^M \widehat{P}_{ij}(\mathbf{x}) C_j \quad (8)$$

This might also be thought of as the expected outlay, or willingness to spend for treatment of the  $i$ th patient, and differences in  $E[R]$  based on a patient's personal attributes suggests the presence of implicit rationing. By linking the values of  $E[R]$  together for the alternative age variable categories,

a variety of expected cost-age profiles can be created to illustrate differences in the expected outlay for treatment.

Similar methodologies have been employed in attempts to quantify the value of human life (Blomquist, 1979; Carlin and Sandy, 1991; Mooney, 1977). While the present study is not dedicated to that end, it may be argued that differences in  $E[R]$  represent an implicit ranking of the value of human lives, based on personal attributes of a patient. Although this is an interesting interpretation of  $E[R]$ , the implications of this interpretation are beyond the immediate scope of this study.

Calculation of the expected ration for a patient belonging to the illustrative patient profile is demonstrated in Table 16. The cost of each treatment alternative, as defined in Table 15, is weighted by its corresponding probability estimate from Table 14. The products are summed to create a measure of the expected cost of treatment of a patient from the illustrative patient profile.

The expected cost of treating a patient with the indicated characteristics is approximately \$6598 dollars. The vast majority of that expenditure, almost \$6000, can be traced to the high cost of surgery and the large probability of this patient receiving that therapy. The cost of each remaining alternative is

**TABLE 16 - Calculation of Expected Ration for a Patient  
Belonging to the Illustrative Patient Profile (1989 Dollars)**

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$$E[C_0] = 0.00 \times 0.00026 = 0.000$$

$$E[C_1] = 261.37 \times 0.00019 = 0.050$$

$$E[C_2] = 803.39 \times 0.00139 = 1.117$$

$$E[C_3] = 1452.61 \times 0.01211 = 17.591$$

$$E[C_4] = 2509.02 \times 0.03806 = 95.493$$

$$E[C_5] = 3912.22 \times 0.12382 = 484.411$$

$$E[C_6] = 7279.20 \times 0.82417 = 5999.298$$

$$E[R] = 6597.96$$


---

considerably less than treatment by surgery.

The expected ration of \$6598 dollars for this hypothetical patient is the first point of the expected cost-age profile relating to the base patient profile. The next point is found by evaluating the model once again at identical values except for patient age. In this case, all of the age variable categories are assigned a value of zero, except for the AGE2 variable which is set equal to one. Hence, the resulting measure of  $E[R]$  will reflect the expected ration dedicated to an identical patient in the 56-65 age group. By repeating this procedure, expected rations are computed over the range of age categories and an expected cost-age profile is derived. This profile is shown as the first line in Table 17 relating to the patient attribute "Married". The second line of Table

17 shows the expected cost-age profile for "Never Married" patients who are, in all other respects, identical to the base profile.

This procedure is repeated for each alternative category of the Karnofsky Index. To ensure a *ceteris paribus* framework for the analysis, all other variables in the model are held constant at the values described in the patient profile of Table 13. Table 18 shows the expected ration of treatment expenditures by Karnofsky Index for the illustrative patient profile.

In the following chapter, the information contained in Table 17 and Table 18 is presented graphically in the form of expected cost-age profiles, followed by a discussion of several direct comparisons of the profiles.

**TABLE 17 - Expected Ration of Treatment Expenditures by  
Marital Status and Age Group (1989 Dollars)**

Patient Attribute	Age Group				
	<u>Under-56</u>	<u>56 - 65</u>	<u>66 - 75</u>	<u>76 - 85</u>	<u>Over-85</u>
Married*	6597.96	5639.48	5480.92	4906.43	2487.59
Never Married	4494.05	3184.98	3039.41	2586.24	1183.63

\* base profile

**TABLE 18 - Expected Ration of Treatment Expenditures by  
Karnofsky Index and Age Group (1989 Dollars)**

Patient Attribute	Age Group				
	<u>Under-56</u>	<u>56 - 65</u>	<u>66 - 75</u>	<u>76 - 85</u>	<u>Over-85</u>
Karnofsky 90 or 100*	6597.96	5639.48	5480.92	4906.43	2487.59
Karnofsky 80	6387.29	5280.71	5110.59	4515.58	2234.33
Karnofsky $\leq$ 70	5029.16	3657.24	3497.33	2987.36	1396.22

\* base profile

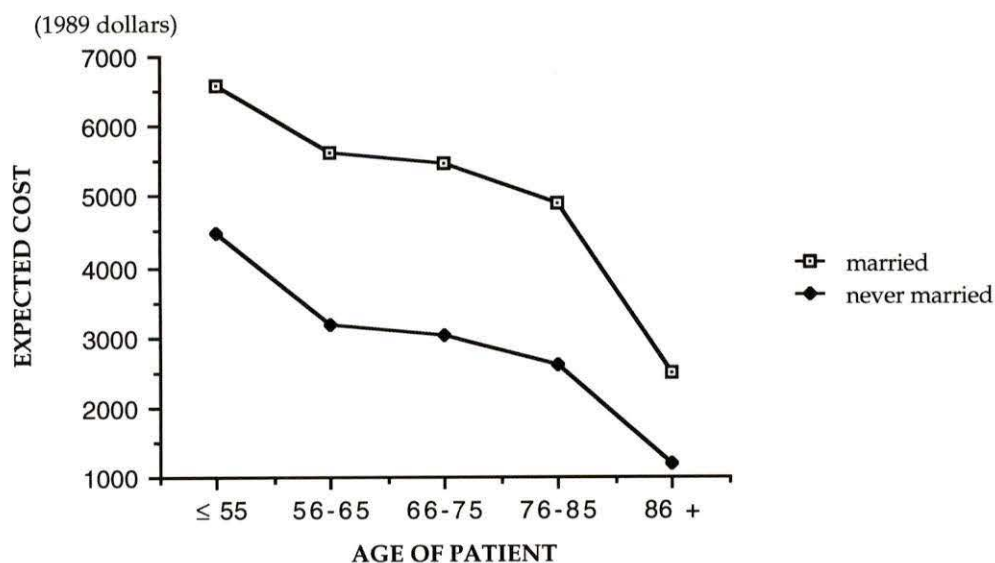
## 9. DISCUSSION

The expected cost-age profiles in Table 17 for “Married” and “Never Married” patients who are otherwise identical, as measured by the other variables in the treatment choice model, are presented graphically in Figure 3. Each profile clearly indicates that the expected cost of treatment for identical patients declines as age increases. The expected cost-age profiles show three distinct levels of expenditures with respect to the five age groups.

The first sharp decline in expected cost occurs when patients move out of the youngest category (under-56) to the next age category (56-65), as indicated by a decrease from approximately \$6598 to \$5639 for a patient belonging to the “Married” profile. In other words, the expected per patient outlay on the latter group is only 85 percent of the per patient outlay for the former group, *ceteris paribus*.

The expected cost-age profile becomes relatively flat over the middle age categories of 56-65, 66-75, and 76-85 respectively. The profile shows a decline of slightly more than 10 percent in the expected cost of treatment for a patient 56-65 years old relative to a patient 76-85 years old, from approximately \$5639 to \$4906. The most significant drop in expected cost occurs for patients over 85

**FIGURE 3 - Expected Cost-Age Profiles  
by Marital Status (1989 Dollars)**



years old. On a per patient basis, the expected cost of treatment for these patients is approximately \$2488, representing only 38 percent of the expected cost of the youngest group, all other things remaining equal.

Hence, the results imply that treatment for non-small cell lung cancer is implicitly rationed on the basis of patient age. Research indicating that elderly patients receive more costly treatment relative to younger patients (Blume, 1992) is not supported by the cost-age profile in Figure 3. It can be argued that results of such studies are a consequence of the physician reimbursement mechanism. A patient who is able to directly purchase medical care may insist upon more treatment for their condition than they would otherwise receive.

In such a case, treatment is explicitly rationed on the basis of ability to pay, hence it is not surprising that treatment and cost patterns would differ from those observed in the Canadian health care system. Similarly, physician self-interest may be influenced by direct reimbursements, resulting in a greater number of recommendations for expensive therapies. The role of physician self-interest in the decision process is probably minimal in the case of the Victoria Clinic, since oncologists are reimbursed on the basis of a salary.

Two additional explanations are offered for the shape of the expected cost-age profile. Busschbach (1993) found that health status is considered twice as valuable in the early periods of life than in the last decade of life. If this is true, relatively young patients may be more willing to pursue aggressive treatment strategies than are elderly patients. This would result in fewer older patients selecting aggressive or expensive cancer treatment, as indicated by the expected cost-age profile. Hence, the shape of the expected cost-age profile may be a result of differences in the utility of greater health status across the age categories.

A second interpretation is based on the professional agency relationship and two earlier findings discussed in the literature review. It is conceivable

that age *per se* is not responsible for the rationing effect observed. We may accept the premise that elderly patients are more willing to defer the responsibility of treatment choice to their physician (Blanchard *et al.*, 1988). We may also accept the premise that physicians are more averse to aggressive treatment alternatives than are patients (Mackillop *et al.*, 1987). If both premises are true, the conservative treatment preferences of physicians will dominate the decision making process for older patients relative to younger patients. Hence, the effect observed in the expected cost-age profile will appear as if treatment is rationed according to age, when in fact, it is actually a consequence of revealed preferences and the professional agency relationship.

The vertical distance between the expected cost-age profiles suggests the marital status of a patient has a powerful influence on the level of expenditures dedicated to treat that patient's condition. Patients represented by the profile "Never Married" are expected to receive less in treatment costs for all age categories relative to "Married" patients. For example, a "Never Married" patient in the under-56 age group will receive approximately \$4494 in expected costs, compared to \$6798 for the identical "Married" patient.

It should be noted, however, that the difference in expected treatment cost for the profile "Married" relative to "Never Married" is greater for the three

middle age groups than for the two extremes. Due to the intrinsically non-linear nature of the ordered logit model, the profiles do not need to be an equal distance from each other across the age groups (Kmenta, 1986, p. 513). Visual inspection of the vertical distance between the expected cost-age profiles might suggest that rationing on the basis of marital status declines as patient age increases. However, the relative difference between the profiles "Never Married" and "Married", when expressed in terms of percentage, does not support this conclusion.

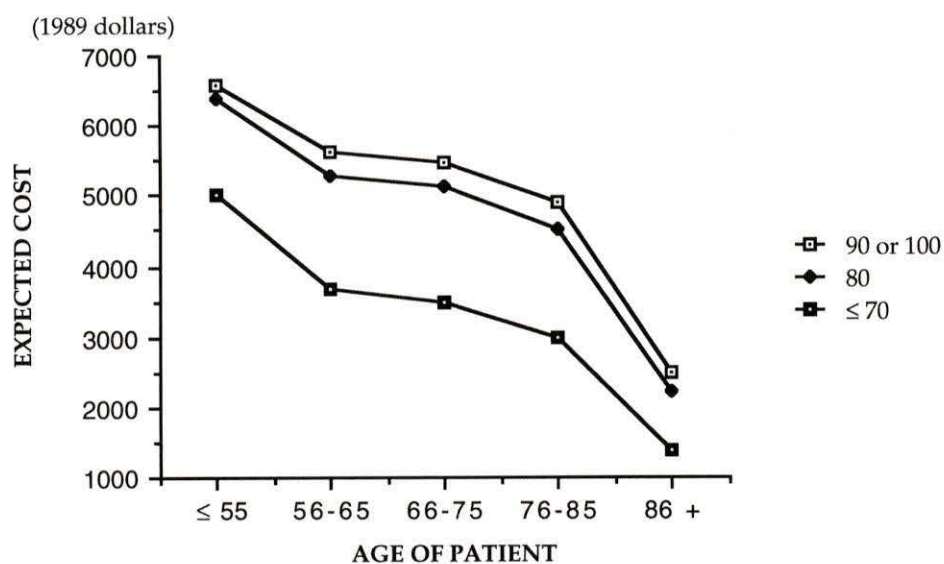
A "Never Married" patient in the under-56 age group is expected to receive 68 percent of the treatment cost of an identical "Married" patient. Similar comparisons for the age groups 56-65, 66-75, 76-85, and over-85 show that "Never Married" patients will receive 56 percent, 55 percent, 52 percent, and 48 percent respectively of the expected cost of their "Married" counterparts. Hence, it can be argued that older "Never Married" patients are subject to greater implicit rationing than are younger "Never Married" patients. The steady decline suggests that implicit rationing on the basis of marital status actually increases with patient age.

The importance of social support in facing a critical illness was indicated in the literature review, hence it is reasonable that married patients will

receive more aggressive and expensive therapies (Goodwin *et al.*, 1987; Labrecque *et al.*, 1991; Wu, 1990-1). On the other hand, the literature also indicates a possible physician bias towards less aggressive treatment for patients without close social support (Geller *et al.*, 1993). Therefore, it may be the case that a combination of effects is responsible for the variation in expected cost assigned to marital status, particularly with respect to older "Never Married" patients. Conservative treatment preferences of physicians may dominate for more elderly patients, and physician bias may exist regarding patients without close social support. This might result in the observed decline in percentage of treatment cost for progressively older "Never Married" groups relative to their "Married" counterparts.

The expected age-cost profiles relating to the Karnofsky Index shown in Table 17 are presented graphically in Figure 4. The results clearly indicate differences in expected cost among the three categories of the Karnofsky Index over the range of age groups, although the results suggest this difference is quite small for patients assigned a rank of 90 or 100 relative to a rank of 80. The expected cost for a patient in the under-56 age group assigned a rank of 90 or 100 is approximately \$6598. For the identical patient assigned rank of 80, an expected cost of approximately \$6387 is indicated. Hence, a decline in

**FIGURE 4 - Expected Cost-Age Profiles  
by Karnofsky Index (1989 Dollars)**



functional status from 90 or 100 to 80 is associated with a decrease of three percent in expected treatment cost.

However, a decline from the “80” group to the “≤ 70” group is associated with a considerably larger reduction in the level of expected costs. A patient who is identical to that above, except for a Karnofsky Index of 70 or less, is assigned an expected cost of approximately \$5029. This represents a decrease of 21 percent relative to patients in the “80” group, and a decrease of 24 percent relative to patients in the “90 or 100” group.

Similar to the “Married” and “Never Married” expected cost-age profiles, the vertical distance between the Karnofsky Index profiles does not remain

constant. The largest vertical distance between each profile is observed over the three middle age categories. For example, the vertical distance between group "80" relative to " $\leq 70$ " for the 56-65 age category is close to twice that of the corresponding over-85 age category, when measured in terms of dollars.

However, when the results of the "80" and " $\leq 70$ " groups are expressed as percentages of "90 or 100" expected costs, the findings indicate a trend similar to that of the marital status profiles. Patients in the "80" group receive 97 percent, 94 percent, 93 percent, 92 percent, and 90 percent of the expected cost of the "90 or 100" group, for the age categories under-56, 56-65, 66-75, 76-85, and over-85 respectively. The decline is even more pronounced for the " $\leq 70$ " group when compared to its "90 or 100" counterpart. The former group receives 76 percent, 65 percent, 63 percent, 61 percent, and 56 percent of the expected cost of the latter, for the age categories under-56, 56-65, 66-75, 76-85, and over-85 respectively. Hence, an increasing degree of implicit rationing is associated with the Karnofsky Index as patients move to progressively older age categories.

It was proposed that a patient's Karnofsky Index ranking may influence the level of treatment expenditure dedicated to address that patient's lung

cancer, and the data supports this hypothesis. The expected cost-age profiles corroborate the results of other studies indicating treatment is rationed on the basis of functional status (Scitovsky, 1988). The effect of the Karnofsky Index on expected costs can be as great as a gain in twenty years of youth, based on the difference between "90 or 100" and " $\leq 70$ " for patients 76-85 years old relative to those under 56 years old. Clearly, a physician's perception of health status is critical in determining expenditures directed toward lung cancer treatment.

Appendix F and Appendix G illustrate the expected cost-age profiles associated with various degrees of disease severity, as indicated by tumour stage and tumour size respectively. The shape of the expected cost-age profiles for the two disease indicators is very similar to that of Figure 3 and Figure 4. The results indicate a steady decline in the level of expected cost as patients move to progressively older age groups. In addition, this decline in expected cost is clearly indicated for all categories of tumour stage and tumour size. Hence, the implicit rationing of lung cancer treatment on the basis of age is pervasive regardless of the extent or severity of the disease.

The following chapter presents a summary of the results obtained in this study, and offers several concluding remarks.

## **10. SUMMARY AND CONCLUSIONS**

This study investigated whether non-small cell lung cancer treatment at the Victoria Cancer Clinic is implicitly rationed through the physician-patient choice of cancer therapy. The analysis employed an ordered logit regression technique to generate probability distributions over a range of treatment alternatives, based on a variety of disease indicators and personal attributes. The probability distributions were used with available treatment cost data to compute expected cost-age profiles for a variety of patient groupings. When these expected cost-age profiles are compared with each other within a *ceteris paribus* framework, there is evidence of implicit rationing. Cancer treatment appears to be implicitly rationed on the basis of patient age, Karnofsky Index, and marital status. A number of conclusions may be drawn from the analysis.

First, the findings clearly indicate that substantially higher levels of treatment expenditures are expected for patients under 56 years old. A movement from the under-56 group to the 56-65 group results in a drop of 15 percent in expected treatment costs. Expected costs continue to fall modestly over the next two age groups (66-75, 76-85), then decline sharply when a patient reaches 86 years old. Patients in the over-85 group can expect to

receive only 38 percent of the treatment expenditures that patients in the under-56 group receive. Such findings may reflect a degree of agism in our society, or perhaps a patient's acceptance of the completion of a natural lifespan. It is also possible this effect is due to differences in treatment preferences between physicians and patients in the professional agency relationship.

Second, the importance of family or social support when facing a critical illness is indicated by the greater level of expected treatment expenditures associated with divorced, widowed, or currently married patients. Those who have never married are likely to have less family support, and hence appear to select less aggressive and less expensive treatment strategies. An alternative explanation is that physician biases are contributing to the lower level of expenditures on patients without close social support.

Third, if the patient is perceived by the physician to have a high functional status as measured by the Karnofsky Index, a significantly greater amount of expenditures is likely to be directed to treat their cancer. This is true across all age categories, suggesting that active elderly patients are treated more aggressively than more frail elderly patients. Hence, it can be argued that chronological age alone does not exclude patients from greater treatment

expenditures. Age appears to have a greater impact on expenditures than patient functional status, but both play a role.

Overall, it appears that high cost lung cancer treatments may already be rationed implicitly to a much greater degree than is generally assumed. However, the professional agency relationship inherent in the choice of lung cancer treatment makes the exact source of implicit rationing difficult to detect. Although criteria are revealed through the expected cost-age profiles, it is not clear to what extent they reflect patient attitudes toward health status and treatment, or reflect implicit physician biases. The ethical implications are far less serious if differences in expected costs are truly a reflection of the preferences of unique groups of patients.

Further study regarding the professional agency relationship and patients of various age groups and social support networks would be valuable. In particular, research should be directed at the treatment preferences of younger patients relative to older patients, physicians relative to patients, and patients relative to their social support network. Such research may add to our understanding of the physician-patient choice of cancer treatment, and hence expected costs.

Moreover, the presence of implicit rationing raises important questions

concerning the impact of alternative treatment protocols on the health status of cancer patients. Do patients who receive more aggressive, and more expensive, therapies experience subsequent improvements in quality of life, or in survival time? Further study of the marginal benefits of alternative cancer therapies, measured in terms of health status, and their corresponding marginal costs is required if we are to identify the optimal level of expenditures dedicated to a lung cancer patient's condition.

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### APPENDIX A - Feinstein Index Classification

Value	Time	Description
1. Asymptomatic	0	Diagnosed by screening or chance.
2. Long Pulmonic	≥ 6 months	Pulmonic symptoms (cough, fever, haemoptysis, dyspnea, chest pain) with no metastatic or systemic symptoms.
3. Short Pulmonic	< 6 months	Pulmonic symptoms (cough, fever, haemoptysis, dyspnea, chest pain) with no metastatic or systemic symptoms.
4. Pulmono-systemic	Any	One or more systemic symptoms with one or more pulmonic symptoms (cough, fever, haemoptysis, dyspnea, chest pain) with no metastatic symptoms.
5. Pulmono-ultrapulmono	Any	One or more metastatic symptoms with one or more pulmonic symptoms (cough, fever, haemoptysis, dyspnea, chest pain).
6. Ultrapulmonic	Any	Metastatic symptoms (distant pain, neurological, hoarseness, dysphagia) with no other symptoms.

From Feinstein, A.R. (1964), "Symptomatic Patterns, Biologic Behavior, and Prognosis in Cancer of the Lung: Practical Application of Boolean Algebra and Clinical Taxonomy," *Annals of Internal Medicine*, Vol. 61 No. 1, 27-43.

Source: Victoria Cancer Clinic (1991), *Lung Cancer Cost Effectiveness Study Data Dictionary*, V1.0, pp. 3-4.

### APPENDIX B - Tumour Differentiation Classification

Description	Classification
<p>Differentiation describes the extent to which certain characteristics (eg. malignancy, growth) of the tumour's cells can be distinguished. Poorly differentiated cells (as opposed to well differentiated cells) are more unpredictable and hence more dangerous in terms of the malignancy.</p>	<p>0. Grade of differentiation can not be assessed.</p> <p>1. Well differentiated.</p> <p>2. Moderately differentiated.</p> <p>3. Poorly differentiated.</p> <p>4. Undifferentiated.</p>

Source: Victoria Cancer Clinic (1991), *Lung Cancer Cost Effectiveness Study Data Dictionary*, V1.0, p. 27.

### APPENDIX C - Tumour Stage Classification

Classification	Description
Stage I	Patients with best prognosis. Disease is completely contained within the lung; no evidence of lymph node or other metastases. Optimum candidates for definitive surgery.
Stage II	Disease is completely contained within the lung; tumour has progressed to involve the intrapulmonary lymph nodes, by either metastasis or direct extension.
Stage IIIa	Limited, circumscribed extrapulmonary extension of the primary tumour and metastases confined to the ipsilateral mediastinal and subcarinal lymph nodes. May be candidates for definitive surgery; candidates for radiotherapy.
Stage IIIb	More extensive involvement of mediastinal structures than Stage IIIa; metastases to contralateral mediastinal, contralateral hilar and ipsilateral, or contralateral supraclavicular/scalene lymph nodes. Generally candidates for non-surgical therapies.
Stage IV	All patients with evidence of distant metastases.

From Mountain, C.F. (1986), "A New International Staging System for Lung Cancer," *Chest*, Vol. 89, 225S-233S.

Source: *Surgical Clinics of North America* (1987), Volume 67, Number 5. pp. 931-935.

### APPENDIX D - Karnofsky Performance Index

Definition	Value	Description
Able to carry on normal activity and to work. No special care is needed.	100	Normal; no complaints; no evidence of disease.
	90	Able to carry on normal activity; minor signs or symptoms of disease.
	80	Normal activity with effort; some signs or symptoms of disease.
Unable to work. Able to live at home, care for most personal needs. A varying amount of assistance is needed.	70	Cares for self. Unable to carry on normal activity or active work
	60	Requires occasional assistance, but is able to care for most needs.
	50	Requires considerable assistance and frequent medical care.
Unable to care for self. Requires equivalent of institutional or hospital care. Disease may be progressing rapidly.	40	Disabled; requires special care and assistance.
	30	Severely disabled; hospitalization is indicated although death not imminent.
	20	Very sick; hospitalization necessary; active supportive treatment necessary.
	10	Moribund; fatal processes progressing rapidly.
	0	Death

From Karnofsky, D.A., Abelmann, W.H., Craver, L.F., Burchenal, J.H.: The use of the nitrogen mustards in the palliative treatment of carcinoma. *Cancer* 1, 634-656, 1948.

Source: Schaafsma, J. (1992) *"The Karnofsky Index as a Proxy for the Lung Cancer Patient's Quality of Life: A Quantitative Assessment,"* University of Victoria, B.C., Canada. p. 16.

## APPENDIX E

**CROSS TABULATION ANALYSIS OF TREATMENT CHOICE  
AND DISEASE INDICATORS**

**TABLE E1 - Distribution of Patients by Treatment Choice  
and Tumour Stage**  
(n = 138)

Treatment Choice	Tumour Stage					TOTAL
	<u>Stage I</u>	<u>Stage II</u>	<u>Stage IIIa</u>	<u>Stage IIIb</u>	<u>Stage IV</u>	
No Treatment	7	0	3	1	6	17
Single Fraction	3	0	1	0	3	7
3 - 6 Fractions	1	0	8	4	9	22
9 - 15 Fractions	5	3	20	5	5	38
18 - 20 Fractions 2 Fields	9	2	7	4	1	23
18 - 20 Fractions 3 Fields	10	3	3	1	0	17
Surgery	10	2	2	0	0	14
<b>TOTAL</b>	<b>45</b>	<b>10</b>	<b>44</b>	<b>15</b>	<b>24</b>	<b>138</b>

 $\lambda(\text{modal prediction}) = 9.0\%$ 

Somers' D = -0.387

**TABLE E2 - Distribution of Patients by Treatment Choice  
and Tumour Size**  
(n = 138)

Treatment Choice	Tumour Size					TOTAL
	<u>Smallest</u> *	<u>1 - 3 cm</u>	<u>4 - 6 cm</u>	<u>≥ 7 cm</u>	<u>Largest</u> ‡	
No Treatment	2	2	6	4	3	17
Single Fraction	0	0	7	0	0	7
3 - 6 Fractions	1	4	9	6	2	22
9 - 15 Fractions	0	6	16	14	2	38
18 - 20 Fractions 2 Fields	0	3	12	6	2	23
18 - 20 Fractions 3 Fields	0	8	8	1	0	17
Surgery	0	5	6	3	0	14
<b>TOTAL</b>	<b>3</b>	<b>28</b>	<b>64</b>	<b>34</b>	<b>9</b>	<b>138</b>

$\lambda(\text{modal prediction}) = 5.0\%$

Somers' D = -0.149

\* too small to measure

‡ ≥ 7 centimeters, unmeasurable

**TABLE E3 - Distribution of Patients by Treatment Choice  
and Tumour Differentiation**  
(*n* = 138)

Treatment Choice	Tumour Differentiation					TOTAL
	<u>NOS</u> *	<u>Well</u>	<u>Moderate</u>	<u>Poor</u>	<u>Undiff.</u>	
No Treatment	8	0	1	3	5	17
Single Fraction	3	1	0	2	1	7
3 - 6 Fractions	3	1	2	9	7	22
9 - 15 Fractions	9	2	9	15	3	38
18 - 20 Fractions 2 Fields	7	1	7	5	3	23
18 - 20 Fractions 3 Fields	2	3	5	4	3	17
Surgery	3	2	2	6	1	14
<b>TOTAL</b>	<b>35</b>	<b>10</b>	<b>26</b>	<b>44</b>	<b>23</b>	<b>138</b>

$\lambda(\text{modal prediction}) = 5.0\%$

Somers' D = -0.053

\* could not be assessed

**TABLE E4 - Distribution of Patients by Treatment Choice  
and Weight Loss**  
(*n* = 138)

Treatment Choice	Weight Loss					TOTAL
	<u>No Loss</u>	<u>≤ 5 kg</u>	<u>6 - 10 kg</u>	<u>11 - 15 kg</u>	<u>≥ 16 kg</u>	
No Treatment	8	4	1	3	1	17
Single Fraction	1	3	3	0	0	7
3 - 6 Fractions	10	5	6	0	1	22
9 - 15 Fractions	18	13	4	3	0	38
18 - 20 Fractions 2 Fields	14	5	2	2	0	23
18 - 20 Fractions 3 Fields	12	2	2	0	1	17
Surgery	10	1	3	0	0	14
<b>TOTAL</b>	<b>73</b>	<b>33</b>	<b>21</b>	<b>8</b>	<b>3</b>	<b>138</b>

$\lambda(\text{modal prediction}) = 3.0\%$

Somers' D = -0.209

**TABLE E5 - Distribution of Patients by Treatment Choice  
and Feinstein Index**  
(n = 138)

Treatment Choice	Feinstein Index *						TOTAL
	I	II	III	IV	V	VI	
No Treatment	0	1	4	2	8	2	17
Single Fraction	1	0	0	2	3	1	7
3 - 6 Fractions	1	2	4	7	6	2	22
9 - 15 Fractions	1	2	8	14	13	0	38
18 - 20 Fractions 2 Fields	3	4	3	9	4	0	23
18 - 20 Fractions 3 Fields	1	2	5	5	4	0	17
Surgery	3	3	6	1	1	0	14
<b>TOTAL</b>	<b>10</b>	<b>14</b>	<b>30</b>	<b>40</b>	<b>39</b>	<b>5</b>	<b>138</b>

$\lambda(\text{modal prediction}) = 6.0\%$

Somers' D = -0.303

\* I Asymptomatic

II Long Pulmonic

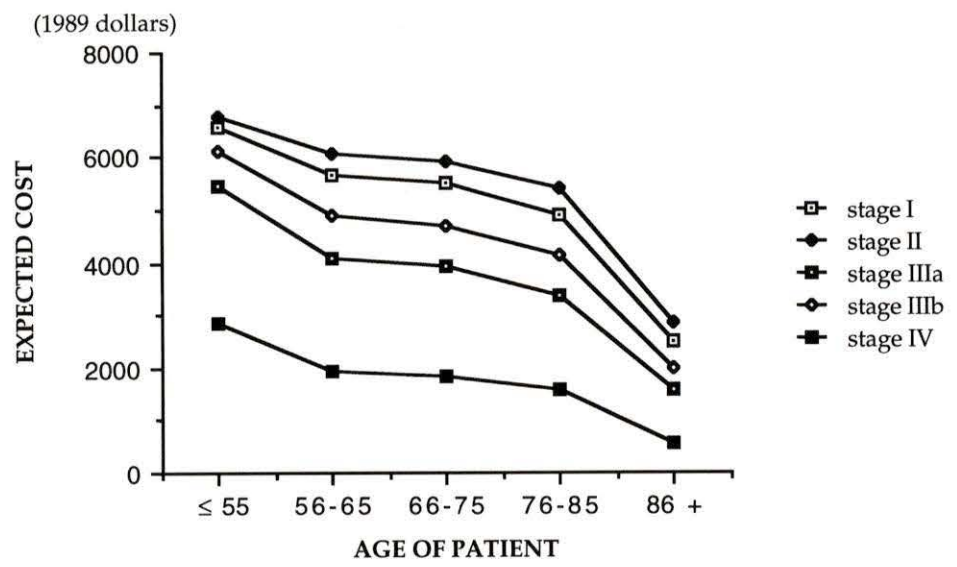
III Short Pulmonic

IV Pulmono-systemic

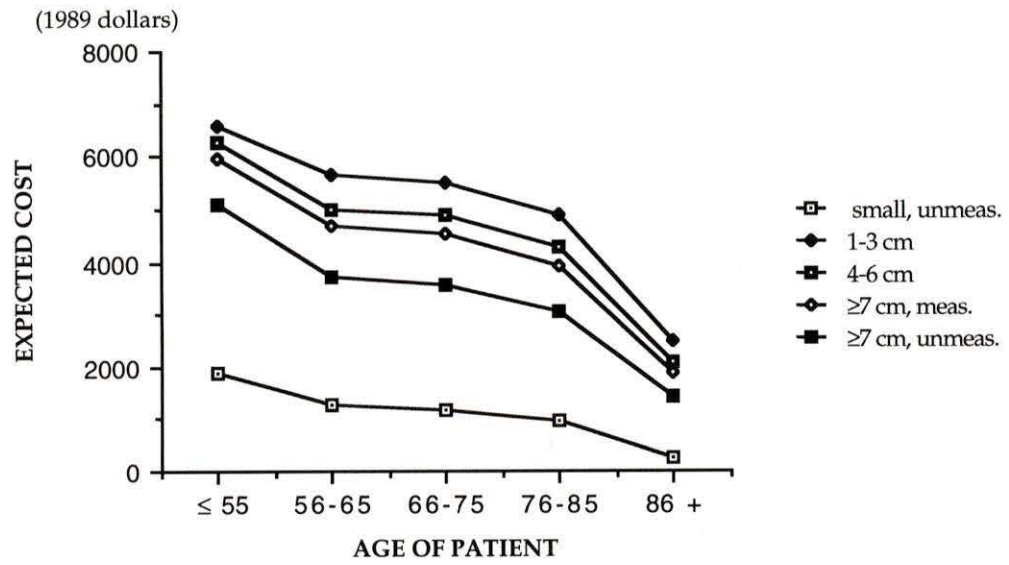
V Pulmono-ultrapulmono

VI Ultrapulmonic

**APPENDIX F - Expected Cost-Age Profiles  
by Tumour Stage (1989 Dollars)**



**APPENDIX G - Expected Cost-Age Profiles  
by Tumour Size (1989 Dollars)**



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Author: —



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22 APRIL 1994