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Abstract

Context : Lung cancer has been the leading cause of cancer deaths in Canadian males for many years, and since 1994, this has been the case for Canadian females as well. It is therefore important to evaluate the resources required for its diagnosis and treatment. This article presents an estimate of the direct medical costs associated with the diagnosis and treatment of lung cancer calculated through the use of a micro-simulation model. For disease incidence, 1992 was chosen as the reference year, whereas costs are evaluated according to the rates that prevailed in 1993.

Methods : A model for lung cancer has been incorporated into the Population Health Model (POHEM). The parameters of the model were drawn in part from Statistics Canada's Canadian Cancer Registry (CCR), which provides information on the incidence and histological classification of lung cancer cases in Canada. The distribution of cancer stage at diagnosis was estimated by using information from two provincial cancer registries. A team of oncologists derived "typical" treatment approaches reflective of current practice, and the associated direct costs were calculated for these approaches. Once this information and the appropriate survival curves were incorporated into the POHEM model, overall costs of treatment were estimated by means of a Monte Carlo simulation.

Results: It is estimated that overall, the direct medical costs of lung cancer diagnosis and treatment were just over $528 million. The cost per year of life gained as a result of treatment of the disease was approximately $19,450. For the first time in Canada, it was possible to estimate the five year costs following diagnosis, by stage of the disease at the time of diagnosis. It was possible to estimate the cost per year of additional life gained for three alternative treatments of non small-cell lung cancer (NSCLC). Sensitivity analyses showed that these costs varied between $1,870 and $6,860 per year of additional life gained, which compares favourably with the costs that the treatment of other diseases may involve.

Conclusions: Contrary to widespread perceptions, it appears that the treatment of lung cancer is effective from an economic standpoint. In addition, the use of a micro-simulation model such as POHEM not only makes it possible to incorporate information from various sources in a coherent manner but also offers the possibility of estimating the effect of alternative medical procedures from the standpoint of financial pressures on the health care system.

Keywords: Lung cancer, treatment algorithm, risk factors, cost, economic efficiency

Introduction

Lung cancer has been the leading cause of cancer deaths in Canadian males for many years, and since 1994, this has been the case for Canadian females as well. In 1996, it is estimated that 17,000 Canadians will die of lung cancer[1], accounting for more than 27% of cancer deaths. In that same year, some 20,000 Canadians will be diagnosed with this disease.[1] Since lung cancer is a major health problem in Canada, it was important to be able to create a conceptual model which simulates the "standard" or "typical" diagnostic approaches and management practices currently in use in Canada to treat lung cancer.

The objective of such an exercise is to model the incidence and progression of lung cancer, as well as the associated treatment options and outcomes. For this purpose, it was necessary to acquire data on the prevalence of risk factors associated with lung cancer and the impact of these risk factors on incidence. Reliable information had to be obtained on how the disease is likely to progress after it has been diagnosed, as well as on possible therapeutic options, their consequences and costs.

When the lung cancer model was completed, it was incorporated into an analytical framework called the Population Health Model (POHEM). The incorporation of the lung cancer model into POHEM allows cost components of care delivery to be calculated, providing current estimates of health care costs to governments in addition to the cost effectiveness of current treatments. Finally, once the baseline scenario for lung cancer has been established, new approaches and procedures can be evaluated. Thus, not only can a realistic estimate be developed of the financial burden that lung cancer represents for the Canadian population, but hypothetical scenarios can be analysed.

1. Methodology and Sources

To develop a reliable and realistic model, a very wide range of information is required. The following paragraphs describe the information sources and methods used in developing the lung cancer management model.

1(a) Canadian Incidence Data

Information on the incidence of a disease in Canadian society is the inevitable point of departure for modeling it. Canadian data on lung cancer incidence are collected by the Canadian Cancer Registry (CCR), which is operated and maintained by Statistics Canada's Health Statistics Division. Provincial and territorial cancer registries annually report information to the CCR on all new cancer cases, including, among other variables, age at diagnosis, sex, site and location of the carcinoma, and histological type.[2] Combining the information from the CCR with population estimates from Statistics Canada's Demography Division,[3,4] we were able to calculate incidence rates for modeling purposes. Figure 1 provides a graph of incidence rates by age and sex, based on 17,139 Canadians diagnosed with lung cancer in 1992.

1(b) Risk Factor Information

The remarkable difference in the incidence of cancer in males and females is primarily explained by the fact that historically, a larger proportion of males have been smokers.[5] Indeed, smoking is the main reason for the rising number of deaths from lung cancer throughout the twentieth century[6,7], contributing to an estimated 90% of lung cancer deaths in North America. The consumption of cigarettes is therefore a major risk factor, the relative distributions of which, for modeling purposes, were drawn from the 1978-79 Canada Health Survey [8].

Whether or not a person smokes, it appears that age is an important known risk factor for developing lung cancer. Nearly 87% of Canadians in whom this disease was diagnosed were 55 years of age or over.[1] The impact of age was taken into account in the model by using age-specific incidence rates. Another major factor identified is cumulative exposure to radon over the ten years prior to diagnosis. Radon is a radioactive gas, exposure to which depends on a variety of factors: geographic, structural (materials used in housing construction, water systems, ventilation) and even environmental (temperature, winds, snow quantity).

These variables were chosen because they are measurable and because Canadian data are available on these major risk factors. The combined impact of smoking and exposure to radon on the probability of developing lung cancer is reflected in the model by the Whittemore-McMillan risk function[9], adjusted for Canadian information sources.

1(c) Stage at Diagnosis

In current medical practice, therapeutic decisions for patients with lung cancer are based primarily on histological type and extent of disease at presentation (tumour stage). Unfortunately, no such information is available at the national level. However, Statistics Canada's Health Analysis and Modeling Group entered into an agreement with two provincial cancer registries to have such information coded manually through retrospective chart reviews. A sample of 1,000 cases from the Ontario records for 1984 and 1985 (stratified by age and sex), and all the cases in the Alberta records for 1984 were thus reviewed.

The first level of classification (histological type) is determined by the morphological nature of the cancer cells identified. Without enumerating the specific carcinomas that distinguish non small-cell lung cancer (NSCLC) from small-cell lung cancer (SCLC), two major distinctions should be noted. First, NSCLC patients are generally treated with surgery and radiation therapy. If diagnosed very early, this form of cancer is even considered curable, since significant improvement in the patient's health status can be observed following treatment. SCLC, on the other hand, is generally considered to be incurable and is treated by systemic chemotherapy.

For the analysis of NSCLC, an internationally recognized cancer staging system - the TNM (Tumour, Node, Metastasis) system - was used[10]. It consists of four stages defined by the size and extent of the primary tumour (T), the involvement of the lymph nodes (N) and the presence or absence of metastasis (M). Since its development, this system has been used in numerous clinical trials.

For SCLC, the Veterans Administration Lung Group classification system[11] is the one most commonly used. It defines two stages (limited and extensive), according to whether the disease is confined to one hemithorax and/or to the regional lymph nodes.

The staging data from Alberta and Ontario were used in order to estimate the probability that lung cancer that has just been diagnosed according to a specific histological type has reached a given stage at the time of diagnosis. When combined with incidence by age group and sex, these probabilities served to derive the number of cases by stage, age group and sex for Canada. Incidence rates by stage and age were calculated by dividing these numbers of cases by the corresponding population figures.

1(d) Standard Diagnostic Procedures, Treatment Options and Survival

As may be seen in Figure 2, (obtained from the Alberta and Ontario registries), lung cancer is a disease which, once diagnosed, progresses very quickly. Twelve months after diagnosis, only the Stage I and II NSCLC cases show a survival rate greater than 50%. After 36 months, none of the SCLC and none of the advanced NSCLC (Stages III and IV) exhibit a survival rate greater than 15%. As a result, only patients diagnosed with Stages I or II NSCLC are considered curable. To some extent, these findings justify the differences in the treatments provided to patients with lung cancer.

To reflect this reality as well as current medical practice, the therapeutic approaches incorporated into the model corresponded with "standard" or "typical" algorithms, according to the stage of the disease at the time of diagnosis. Wherever possible, actual utilization data from provincial cancer registries (such as for length of hospital stay) were used. The practice guidelines of the American National Cancer Institute's Patient Data Query database, (PDQ)[12] were used as a reference, but were modified for Canadian practice. The validity of the therapeutic approaches was evaluated by reviewing the medical literature and responses to a questionnaire developed by the authors. The questionnaire was completed by 73 Canadian physicians representing all of the thoracic surgeons and 30% of Canada's radiation oncologists.

Through this process, diagnostic and therapeutic decision trees or algorithms were established for the lung cancer model. The decision trees were comprised of self-contained modules which included: initial diagnostic tests,

assuming an "ideal" investigation; treatment upon diagnosis; follow-up patterns and investigations; and relapse management. The four NSCLC algorithms are shown in Figures 3a, 3b, 3c and 3d.

Each branch of the model thus corresponds to a different treatment. To reflect reality, this would automatically imply different survival curves. Based on a review of the relevant literature and the expertise of the project's medical team, the necessary survival parameters were derived in order to complete the model. Generally, a Weibull distribution were used to model the observed survival rates.

2. Cost Determination

All the costs incorporated into the current model are expressed in Canadian dollars and based on 1993 rates. Costs were assigned to each branch of the diagnostic and therapeutic decision trees. Direct medical costs were established by reviewing clinical trials, and from special costing studies and fee schedules for the province of Ontario (OHIP). Figures 3c and 3d, in addition to showing the therapeutic algorithms, contain information on costs for each major treatment stage. To provide a clear picture of the effort and level of detail involved in the costing process, Table 4 describes the components of the "Diagnostic Tests" box in Figures 3 a) through d). Detailed descriptions of the treatment algorithms, the sources of the survival parameters and the costs of treating lung cancer are available in documents published by the authors.[13,14,15]

3. POHEM

The lung cancer model is then incorporated into the POHEM framework, a comprehensive micro-simulation model designed by Statistics Canada's Health Analysis and Modeling Group to simulate the health status of the Canadian population. It incorporates and reconciles data on risk factors, disease onset and progression, health care resource utilization, direct medical care costs and health outcomes.[16,17] POHEM currently models lung cancer, coronary disease, arthritis and dementia, and soon it will include breast cancer.

POHEM creates synthetic populations at birth and provides them with demographic and labour force characteristics, such as age at marriage, number of children, employment income, divorce and remarriage. By the use of computer simulation techniques, POHEM ages these individuals while exposing them to risk factors and diseases. It reproduces individual characteristics for a population and generates longitudinal data (demographic, economic and medical) for a representative sample of a generation.

The POHEM framework can be used to evaluate the impact of risk factors, to assess diagnostic and therapeutic options for lung cancer and to evaluate the costs of care for this disease. Cost effectiveness, cost per year of life gained, cost per health-adjusted year of life gained and the impact on incidence and survival can also be determined within the framework. In addition, disease-specific survival curves and costs of care for co-morbidities can easily be established. The integrated and validated information can be used to infer the impact of diseases and risk factors on the health of the Canadian population

4. Additional Assumptions

Since any model is an approximation of reality, different assumptions must be developed either to compensate for missing information or to provide a synthesis of the situations observed. One assumption we made was that clinicians' responses to questionnaires regarding current treatments conformed to actual medical practice when, in reality, it is not known if this is the case. As a result, and to compensate for the lack of reliable and accessible data on the percentage of patients undergoing surgery at each stage, averages of the percentages indicated by experts responding to questionnaires were used.

From a medical standpoint, it was assumed that treatments did not lead to complications. Hence, the side effects of some therapies are excluded from the model, in the sense that they are not explicitly described. However, the costs of some side effects are indirectly or implicitly taken into account through the use of average length of hospital stay. In addition, a patient still alive five years after diagnosis was considered to be cured, which significantly influenced the length of that patient's survival.

The model assumed that all patients had equal access to diagnostic and therapeutic procedures and received treatment, if they so desired. In addition, it was assumed that the only tests prescribed were those required for diagnosis and evaluation of the stage of the disease, and that all patients were hospitalized for confirmation of the diagnosis prior to the initial treatment. Lastly, it was assumed that any radiation therapy treatment would be administered solely on an out-patient basis. While these assumptions appear to have little or no effect on the evaluation of patients' survival, their impact on costing seemed substantial.

5. Results

In 1992, there were 17,139 cases of lung cancer in Canada (Table 5). These cases were divided between SCLC (17.7%) and NSCLC (82.3%) with close to 70% diagnosed at advanced stages[@] of the disease.

Table 5 summarizes the costs of diagnosis, treatment and relapse by histological type for the five years following diagnosis. On the basis of 1992 incidence figures, these costs are estimated at just over $528 million. Considering the high mortality rate in the twelve months following diagnosis (Figure 2) and the hospitalization costs generated by palliative care and diagnostic work-up, it is not surprising to note that nearly 82% of expenses are incurred in the first year.

For NSCLC, our analysis enables us to present (Table 6) an estimate of costs by stage at diagnosis. A brief analysis reveals that all stages but Stage I are comparable, averaging approximately $30,000 per case. Stage I patients show the lowest average cost per case. The relatively high 5 year survival rate is part of the explanation of this situation since lung cancer costs are only calculated for five years following diagnosis. The average cost for the treatment of Stage IV patients is the second lowest at $28,201 per case, but it should be kept in mind that the treatments involved here are not curative and that basically this figure represents the costs of diagnosis and palliative care, while other stages include "curative" treatment.

To evaluate the economic effectiveness of treatments, it is not enough to know the gross costs; these must be linked to the number of years of life gained as a result of the medical intervention. The indicator currently used in epidemiology is the cost per year of life gained. Even though the survival of some NSCLC Stage III and IV patients was extended as a result of the treatments received, we adopted the conservative hypothesis that only Stage I and II patients who were medically operable and were treated with radiotherapy actually showed a gain in survival. Faced with the difficulty of identifying a control group (that is, a group of persons "untreated"), we used the average survival of groups of patients who did not achieve a complete response to radiotherapy[18] in calculating the life years gained. The survival of such patients is likely a good approximation of the survival of those who receive no treatment. These results were then compared to an alternative method of calculation, which used the results of the POHEM simulation for medically inoperable Stage I and II patients.

The total number of life years gained varied from 21,044 to 24,763, depending on the method used; this resulted in a cost per life year gained which varied from $19,456 to $16,534. Studies[19] have shown that a cost of $40,000 per year of life gained is considered to be reasonable by the public. Our results compare favourably to this standard.

@ Stages III and IV of NSCLC and all cases of SCLC.

6. Interventions

Once the basic scenario is validated, the micro-simulation model offers the advantage of an integrated conceptual framework in which various parameters can be changed and the effects evaluated. It was thus possible to use the results of clinical studies[@] to estimate the economic efficiency of various therapeutic interventions. Table 7 summarizes the results of simulations of three interventions to NSCLC Stage III. The box below summarizes the simulated treatments:

Stage IIIa
Intervention 1. Chemotherapy (MVP) and surgery
Intervention 2. Chemotherapy (MVP), radiotherapy and surgery
Stage IIIb
Intervention 3. Chemotherapy (Vinblastine and Cisplatin) and radical radiotherapy

All the steps necessary for the development of standard diagnostic procedures, treatment options, survival curves and costs are repeated for each intervention. Obviously, an increase in length of hospital stay or the addition of surgery or chemotherapy treatments results in an increase in costs per patient treated. Table 8 shows the difference in costs when intervention 1 is compared to the standard treatment.

The information on the survival gain likely to be obtained by applying these interventions is taken from clinical studies[@]. The survival gains identified are incorporated into POHEM, making it possible to evaluate the cost per life year gained compared to standard practice. The results obtained indicate that the increase in costs is offset by an appreciable gain in survival. Thus, the cost per life year gained is lower than the initial treatment cost. For Interventions 1, 2 and 3, the estimated costs are $3,909, $6,859 and $1,867 per life year gained, respectively.

In light of the importance that our conclusions may have for lung cancer management and for health policy issues, we conducted a sensitivity analysis to assess the robustness of some of our assumptions. Table 9 shows the results of that analysis, in which hospitalization costs were increased by 30% and the survival gain was increased or decreased by 25% in relation to the reference clinical study. It may be concluded that even in the case of the most drastic scenario (highest hospital costs and lowest survival rate), the cost per life year gained is still substantially below the generally accepted standard of $40,000.

7. Discussion

The development of the lung cancer model has identified the need to create a multidisciplinary environment and have access to a large quantity of existing data, so as to develop a credible and realistic working tool. Statistics Canada's Health Analysis and Modeling Group formed a team of analysts, oncologists, researchers and cancer registry personnel to gather information on:

- risk factor prevalence by age and sex;
- disease incidence by age group and sex;
- disease incidence by cancer cell type for a population;
- stage at diagnosis of lung cancer for a population;
- diagnostic and therapeutic approaches by stage;
- survival and costs by histological type, stage and therapeutic approach; and
- actual utilization data by therapeutic procedure.

Any model is limited by the availability of information sources and by its underlying assumptions. With regard to the assumption concerning equality of access, previous studies[20,21,22] have shown that elderly cancer patients are less likely to receive appropriate care than younger patients. Similarly, persons living in geographically remote areas are likely to have more limited access to specialized equipment and personnel. With regard to the assumption

@ The references for these clinical studies are available on request.

that there are no treatment-related complications, we know that radiation therapy and chemotherapy sometimes cause complications such as nausea or neutropenia, and while the medications for treating such complications may be relatively inexpensive, hospitalization may be necessary, making it difficult to evaluate costs. Lastly, although the use of the fee schedules of only one province to evaluate costs for Canada as a whole could introduce a bias, it would be surprising to observe major differences in a context of public financing.

Concerns have been expressed regarding an imbalance between data on inputs (number of beds, number of physicians, amount of equipment, budget envelopes, etc.) to the health care system in relation to the outputs by which to evaluate whether investments in this sphere improve the health of Canadians. Our model should be interpreted as an attempt to correct this imbalance, since it can be used to evaluate the economic efficiency, not only of current practice, but also, of future actions. The coherent structure of a tool such as POHEM not only offers the possibility of determining the impact of new diagnostic and therapeutic approaches on health policies, but it also makes it possible to estimate cost-effectiveness. Such models enable us to answer "what if" questions, such as "what would the impact on lung cancer be, if cigarette consumption were reduced to zero in the next five years?" or "what would the effect be of introducing a disease detection program for a given age group?".

The creation of similar models integrated into the POHEM framework has resulted in the development of an analytical tool that can be used to evaluate the interplay of risk factors, pathological conditions and the associated costs. As a result of the interest aroused by the lung cancer module, a breast cancer module[23] is currently being developed and will be added to the existing POHEM framework.

Tables and Figures

Figure 1. Lung cancer incidence by age and gender, 1992 (per 100,000)

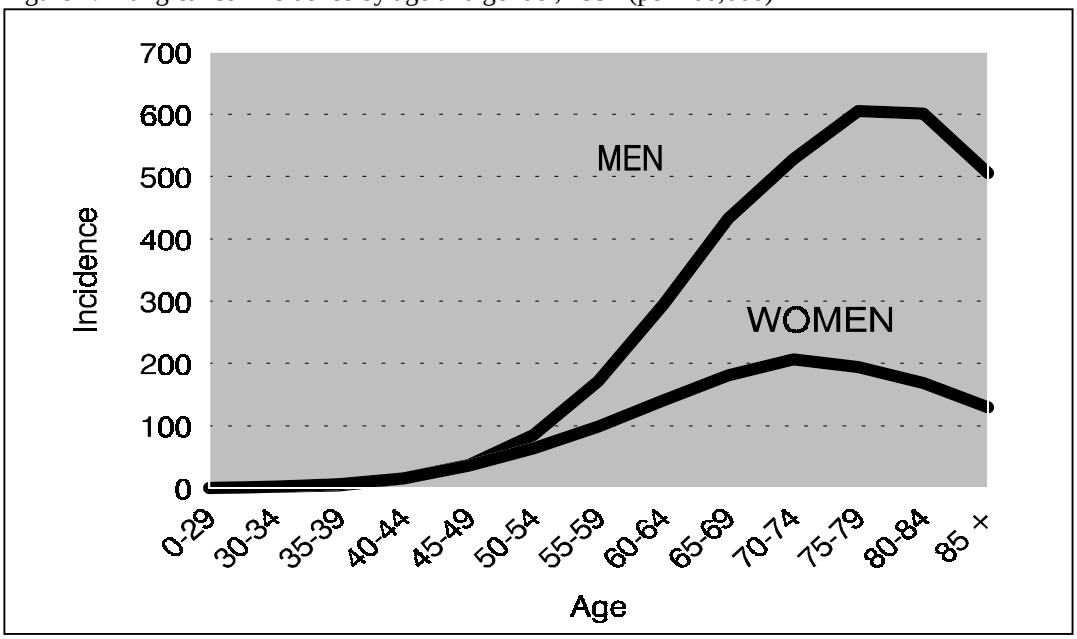
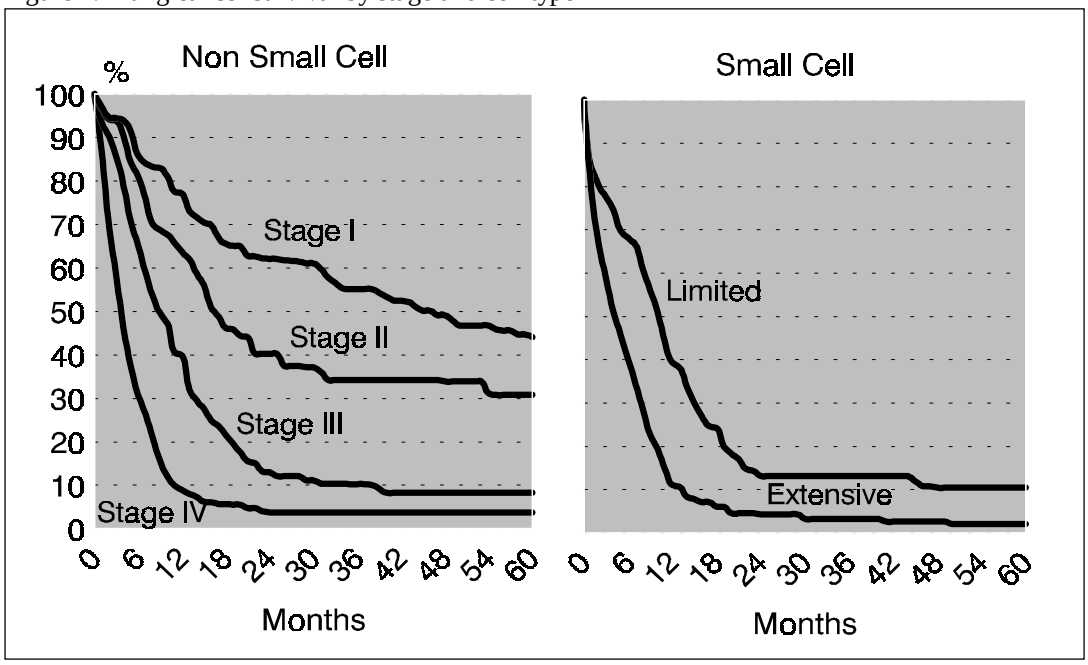


Figure 2. Lung cancer survival by stage and cell type



Cases with complete information for Ontario and Alberta, 1984-85.

Figure 3a. Therapeutic algorithm, NSCLC, Stage I

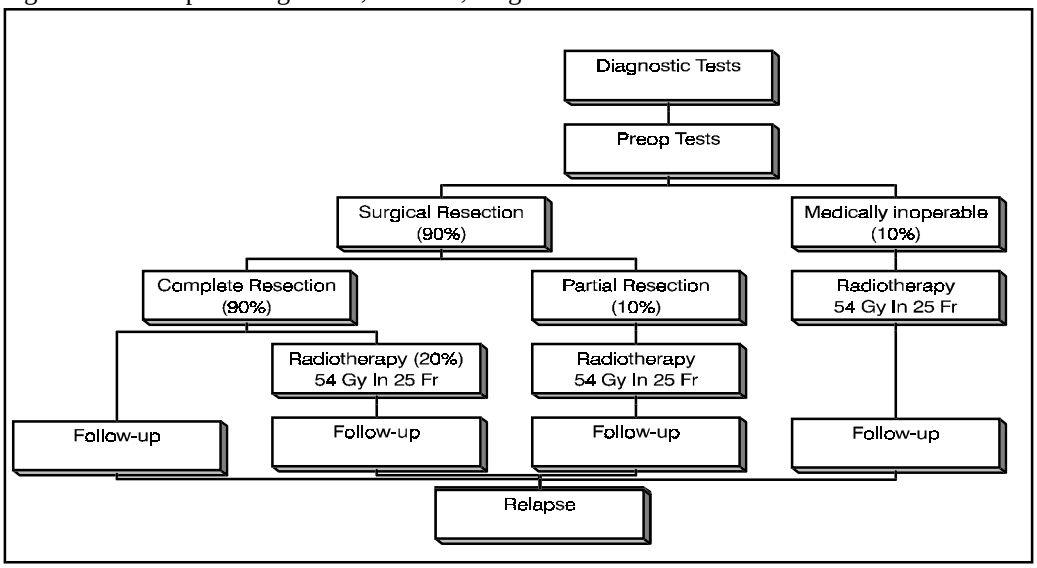


Figure 3b. Therapeutic algorithm, NSCLC, Stage II

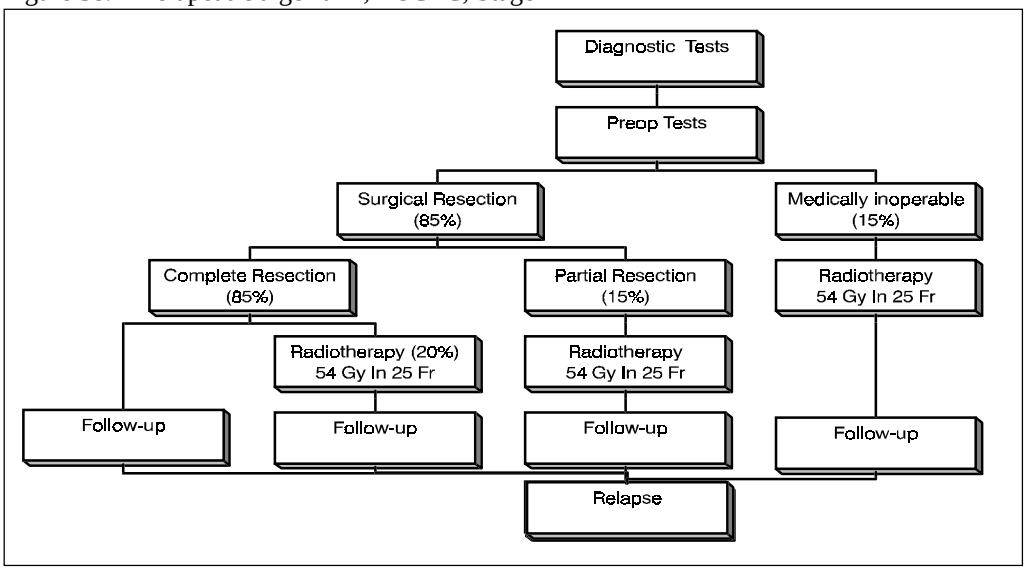


Figure 3c. Therapeutic algorithm, NSCLC, Stage III

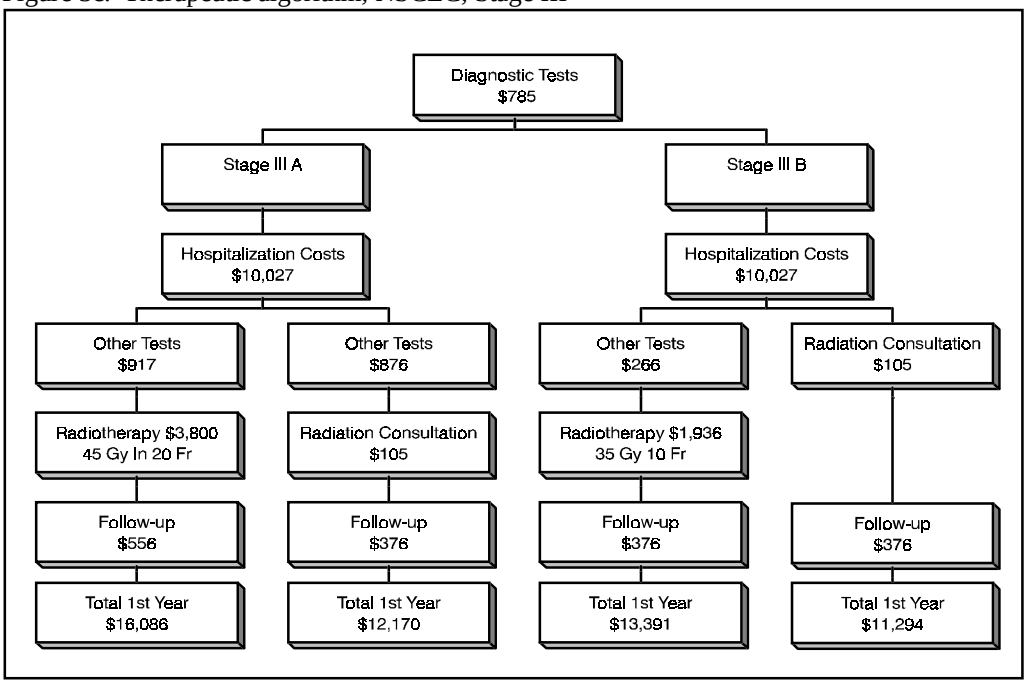


Figure 3d. Therapeutic algorithm, NSCLC, Stage IV

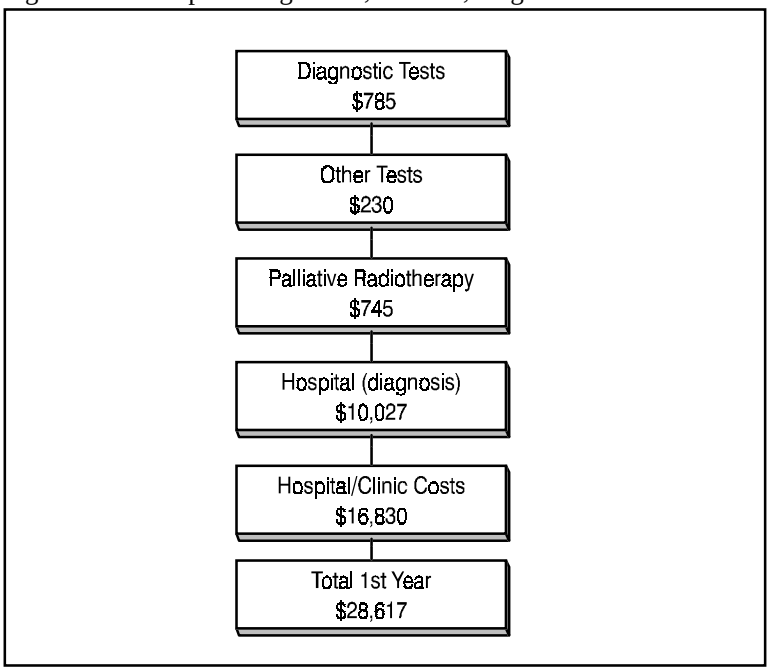


Table 4. Components of "Diagnostic Tests" Box

Initial Medical Contact	Family physician consultation Blood work (CBC, AST, electrolytes, bun, creatinine, glucose) Urinalysis Sputum cytology X 2 Chest X-ray Follow-up visit
Diagnostic Tests	Specialist consultation Chest X-ray X 2 Hematology/chemistry Pulmonary function tests Sputum cytology X 2
Bronchoscopy & Biopsy	
	$ 785

Table 5. Five-year Costs of Lung Cancer Diagnosis and Treatment, 1992

	NSCLC	SCLC	Total
Number of Cases	14,110	3,029	17,139
Costs by Year	($000,000)	($000,000)	($000,000)
Year 1	340	93	433
Year 2	40	18	58
Year 3	12	5	17
Year 4	9	2	11
Year 5	8	1	9
Total	409	119	528

Table 6. NSCLC Costs by Stage, 1992

	Number of Cases	Costs 1st Year ($000)	Costs for Five Years ($000)	Cost per Case ($)
Stage I	3,852	79,883	102,496	26,608
Stage II	1,438	33,439	44,999	31,293
Stage IIIa	2,032	52,711	66,534	32,743
Stage IIIb	1,802	42,642	54,807	30,415
Stage IV	4,986	131,808	140,610	28,201
Total	14,110	340,483	409,446	29,018

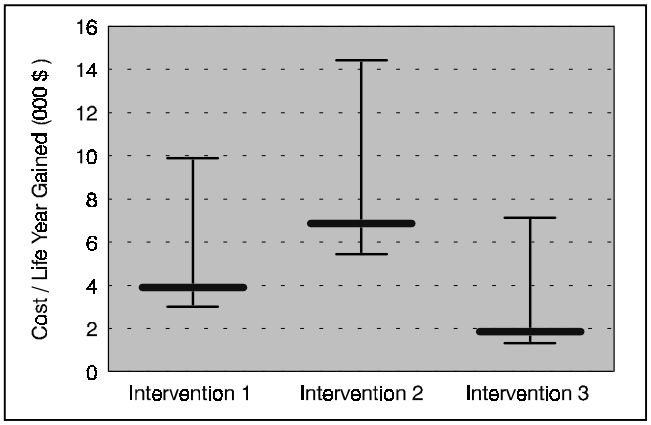
Table 7. Results of Stage III NSCLC Interventions

	Interv. 1	Interv. 2	Interv. 3
Cost Increase ($000)	16,194	28,416	4,227
Survival Increase (years)	2.399	2.399	1.57
Number of Cases	1,727	1,727	1,442
Total Life Year Gained	4,143	4,143	2,264
Cost per Life Year Gained	$ 3,909	$ 6,859	$ 1,867

Table 8. Costs of Intervention Compared to Standard Treatment.

Diagnostic/ Treatment	Radiotherapy only ($)	Intervention ($)
Diagnostic Tests	785	785
Pre-op. Tests	917	917
Radiotherapy	3,800	-----
Hospitalization		
- Diagnosis	10,027	10,027
- Treatment		12,696
Surgery(To 70 %)		1,188
Chemotherapy		6,008
Follow-up	556	397
Total	$16,086	$32,018
Increase		**$ 15, 932**

Table 9. Sensitivity Analysis of Costs (NSCLC).



Hospital costs increased by 30%
Survival gains varied upward or downward by 25%

References

[1] National Cancer Institute of Canada. *Canadian Cancer Statistics 1996*, Toronto, Canada, 1996.

[2] Band PR, Gaudette LA, Hill GB, et al. *The Making of the Canadian Cancer Registry: cancer incidence in Canada and its regions, 1969 to 1988.* Ottawa : Department of Supply and Services Canada, 1993.

[3] Statistics Canada. *Annual Demographic Statistics* (Catalogue No. 91-213) Ottawa: Department of Supply and Services Canada, 1994.

[4] Statistics Canada. *Population Estimates 1971 - today*. CANSIM matrices 6367, tables C892268-C892582, Ottawa : Statistics Canada.

[5] Beckett WS, Epidemiology and Etiology of Lung Cancer, *Clinics in Chest Medicine* 1993; 14(1): 1-15.

[6] Kessler LG, Lung and Bronchus (Section XV). In: Miller BA, Ries L, Hankey BF et al., editors. *Cancer Statistics Review: 1973-1979.* National Cancer Institute, NIH # 92-2789, 1992.

[7] Minna JD, Pass H, Glatstein E, Ihde DC, Cancer of the lung (Chapter 22). In: De Vita VT Jr, Hellman S, Rosenberg SA, editors. *Cancer: Principles and Practice of Oncology* Vol. 1, 3rd edition, 1989: 591-705.

[8] Health and Welfare Canada and Statistics Canada. *Health of Canadians: Report of the Canada Health Survey* (Catalogue No. 82-538E.) Ottawa: Department of Supply and Services, Canada, 1981.

[9] Whittemore AS, McMillan A. Lung Cancer Mortality Among US Uranium Miners : A Reappraisal. *J. National Cancer Institute* 1983; 71: 489-499.

[10] Mountain CF. A new international staging system for lung cancer. *Chest* 1986: Suppl.4: S223-S225.

[11] American Joint Committee on Cancer. Lung. In: Beahrs OH, Henson DE, Hutter RVP, Myers MH, editors. *Manual for staging of cancer.* 3rd edition, Philadelphia: J.B. Lippincott, 1988: 115-121.

[12] National Cancer Institute. *Physician Data Query System.* Bethesda, Maryland. 1994 ; Updated monthly.

[13] Evans WK, Will BP, et al., Diagnostic and Therapeutic Approaches to Lung Cancer in Canada and Their Costs, British Journal of Cancer; 72 : 1270-1277, 1995

[14] Evans WK, Will BP, et al., Estimating the Cost of Lung Cancer Diagnosis and Treatment in Canada: The POHEM Model, *The Canadian Journal of Oncology*; 5(4):408-419, 1995

[15] Evans WK, Will BP, et al., The Economics of Lung Cancer Management in Canada. *Lung Cancer*;14:19-29, 1996.

[16] Wolfson, MC. *POHEM* - A Framework for understanding and modeling the health of human populations. *Analytical Studies Branch Research Paper Series # 44*, Statistics Canada, 1992.

[17] Berthelot J-M., L'analyse de la santé au Canada : un modèle de micro-simulation. *Recueil des communications du 62ième congrès de l'ACFAS : Colloque des méthodes et applications de la statistique*, 1994.

[18] Roswit B, Patno ME, Rapp R, et al. The survival of patients with inoperable lung cancer: a large-scale randomized trial of radiation therapy versus placebo. *Radiology* 1968; 90: 688-697.

[19] Laupacis A, Feeney D, Tugwell P, et al. How attractive does a new technology have to be to warrant adoption and utilization? Tentative guidelines for using clinical and economic evaluations. *Canadian Medical Association Journal* 1992; 146: 473-481.

[20] Samet J, Hunt WC, Key C et al. Choice of cancer treatment varies with the age of the patient. *JAMA* 1986; 255: 3385-3390.

[21] Chu J, Diehr P, Feigel P, et al. The effect of age on the care of women with breast cancer in community hospitals, *J Gerontol*. 1987; 42: 185-190.

[22] Silliman R, Guadagnoli E, Weitberg A, Mor V. Age as a predictor of diagnostic and initial treatment intensity in newly diagnosed breast cancer patients. *J Gerontol*. 1989; 44: M46-M50.

[23] Will BP, Berthelot J-M, Houle C, et al., A Model for Estimating the Costs and Burdens of Breast Cancer Diagnosis and Treatment in Canada, *Health Reports* (Statistics Canada, Catalogue No. 82-003) 1993; 5: 399-408.