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Cost analysis of lung cancer management in South Western Sydney

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Abstract

Introduction: Lung cancer is the leading cause of cancer mortality in Western nations, and associated health-care costs are escalating. The aim of this study was to describe the current pattern of resource use and direct medical costs associated in managing lung cancer in South Western Sydney, Australia.
Methods: All new cases of primary lung carcinoma discussed at the Liverpool and Macarthur Cancer Therapy Centre (CTC) Lung Cancer Multidisciplinary Team meeting or seen at CTC between 1 December 2005 and 21 December 2006 were reviewed. Staging investigations, hospitalisation, treatment and follow-up investigations were documented from first consultation to last follow-up (31 October 2008 or death). Cost estimates were based on the Australian Medicare Benefits Schedule and reported in Australian dollars. Infrastructure, staff and non-medical costs were excluded.
Results: There were 210 patients, median age 68.2 years (range 39–90) with median follow-up of 16.6 months. The pathology and stage distribution were: 3.8% limited stage small cell lung cancer (SCLC), 10.0% extensive stage SCLC, 13.4% stage I and II non-small cell lung cancer (NSCLC), 28.5% stage III NSCLC and 44.3% stage IV NSCLC. The estimated total cost for managing this patient cohort was A$2.91 million. The cost components were: staging investigations (10.1%), treatment 41.2% (2.8% surgery, 15.8% radiotherapy and 22.6% chemotherapy), hospitalisation (43.7%) and follow-up investigations (5%). The median costs for managing NSCLC and SCLC subgroups were A$10 675 (range A$669–612 789) and A$14 799 (range A$908–31 057), respectively.
Conclusion: Hospitalisation and cancer treatment, particularly chemotherapy, accounted for the major components of direct medical costs in the management of lung cancer.

Key words: costs; cost analysis; lung cancer.

Introduction

Cancers cost $2.9 billion and accounts for 5.7% of direct health system costs in Australia.[1] The expenditure for lung cancer in 2000–2001 was $136 million, consisting of 4.7% of the total expenditure on cancers.[1] It is the fourth and fifth most expensive cancer to treat in males and females, respectively.[1] Lung cancer is the fifth most common cancer in Australia, accounting for 10.2% of all cancers in males and 7.8% in females.[1] Despite the advances in preventative care, diagnostic imaging and treatment interventions, the incidence of lung cancer continues to increase[1,2] with a poor 5-year relative survival rate of 14%.[2]

Estimating the cost of managing lung cancer is very complex as there are many components to consider. These include direct medical costs, indirect costs and humanistic costs.[3–5] Direct medical costs refer to

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resources consumed as a result of medical intervention whilst indirect costs comprise the patient's loss of productivity in the workplace, home and society, both from the illness and premature death.[4] Humanistic cost relates to the effect of treatment on the patient's quality of life and satisfaction with treatment.[4]

The direct medical costs of lung cancer include diagnostic procedures, staging investigations, treatment, clinician consultations, treatment interventions and hospitalisation. To date, there has only been one published Australian study in a small cohort of patients estimating the cost of treating small cell lung cancer (SCLC).[6] Although there have been various studies examining the costs of managing lung cancer in other high-income countries,[7–14] their results can not be easily extrapolated to the Australian context, given the differences in health-care system design and delivery, individual study focus and methodology or approach to cost analysis.

The aim of this study was thus to evaluate the patterns of resource use and direct medical costs in the management of lung cancer (non-small cell lung cancer (NSCLC) and SCLC) in a modern patient cohort.

Methods

This study was approved by the Sydney South West Local Health District Human Research Ethics Committee. The study population included all new cases of primary lung cancer presented at the Lung Cancer Multidisciplinary Team (MDT) meeting or seen at the Liverpool or Macarthur Cancer Therapy Centre (CTC) between 1 December 2005 and 31 December 2006. All cases of recurrent disease at first presentation to the MDT or CTC were excluded.

Data were obtained through retrospective review of clinical records. The review period included the time of the first consultation between 1 December 2005 and 31 December 2006, and ended with the last follow-up appointment, hospitalisation or death with a censor date of 31 October 2008.

The following data were collected: demographic details, date of diagnosis, date of first consultation at CTC, date of MDT meeting discussion, date of death, diagnostic tests, histological subtype, stage of cancer, treatment providers (surgeon, radiation oncologist and medical oncologist), treatment intent (curative or palliative), nature and date of all interventions including surgical procedures, radiotherapy, chemotherapy and duration of hospitalisation. In addition, the details of follow-up investigations, defined as radiological and/or pathological investigations performed following completion of staging investigations or primary treatment, were obtained. Staging of NSCLC was based on the fifth edition of the Union for International Cancer Control (UICC)-TNM classification (1997),[15] with staging of SCLC recorded as limited or extensive stage.[16]

Cost estimates

Costs that were incurred during the review period were divided according to diagnostic- and investigation-related costs, primary treatment and treatment of relapse, hospitalisation at any time point and follow-up investigations. Treatment modalities for primary treatment and treatment of relapse include surgery, chemotherapy and radiotherapy. The cost for each item (unit cost) for the resources used were based on the 2005 Australian Medicare Benefits Schedule (MBS),[17] the Pharmaceutical Benefits Scheme (PBS),[18] with additional data provided by the Sydney South West Local Health District Health Finance Department. All costs were reported in Australian dollars. Costs for departmental infrastructure, staff, medical equipment and other non-medical costs (such as transportation) were not included. Costs incurred out of hospital – such as general practitioner, private specialist, community-based care costs and travel costs incurred by the families – were not examined in this study as these data were not readily available.

All diagnostic- and investigation-related costs were recorded with costs based on the MBS. Pathology costs included histopathology, cytology and immunohistochemistry. Routine blood tests such as full blood count, electrolytes and liver function tests were not included. Radiology costs included plain radiology, ultrasound, CT scans and MRI. Nuclear medicine costs included the costs of whole body bone scans and 18F-fluorodeoxyglucose positron emission tomography (FDG-PET) scans. Other investigation-related costs included pulmonary function tests and echocardiography.

Hospitalisation costs included the cost of admission at any time point from diagnosis until death or the end of the follow-up period. The average daily bed cost for oncology and surgical wards, coronary care unit and intensive care units were provided by the Sydney South West Local Health District Finance Department. The costs of radiology and pathology investigations performed during admission were also included in the costs of hospitalisation.

Cardiothoracic surgeon professional fee, anaesthetic fees and surgical procedures were incorporated into the costs for surgery and based on the MBS. Anaesthetic fees included the management and administration of anaesthesia and therapeutic services performed during anaesthesia.

Details regarding the number of new and follow-up consultations with the radiation oncologist, simulation, planning, number of treatment fields and number of on-treatment verification port films were recorded. The cost of each item was based on the MBS.

Chemotherapy costs included both new and follow-up consultations with the medical oncologist, chemotherapy administration, chemotherapy drugs and premedications (such as antiemetics), drug dispensing fees and blood transfusions. Chemotherapy drugs were costed accord-

Table 1. Cost of selected items in managing lung cancer

	Australian dollars
Chest X-ray	47
Bronchoscopy	360
CT-guided fine needle aspiration biopsy	651
CT chest with intravenous contrast	400
Whole body bone scan	475
Positron emission tomography scan	953
Pulmonary function test	120
Clinician (surgeon/medical oncologist/radiation oncologist) consultation fee	37–131
Lobectomy	2489
Radiotherapy	
Simulation	210–642
Planning process	67–783
Treatment field delivery	52–216
Definitive lung radiotherapy (60 Gy in 30 fractions)	7000*
Palliative lung radiotherapy (20 Gy in five fractions)	1000*
Chemotherapy	
Administration	56–72
Price of drugs (per milligrams)	
Carboplatin	0.14
Gemcitabine	0.28
Etoposide	0.29
Cisplatin	0.30
Vinorelbine	4.75
Docetaxel	15.75
Inpatient bed in oncology ward (daily)	261

*Estimated approximate cost. All patients are costed individually.

ing to the number of cycles and the actual dose of drugs delivered in milligrams. The costs were based on the PBS, with pharmacy-related costs provided by the CTC pharmacy. The cost of intravenous fluids, syringes or other equipment and disposal of cytotoxic material were not included.

A selection of costs for staging investigations, treatment and hospitalisation are demonstrated in Table 1.

Statistical analysis

Data were analysed using the SAS v9.1 (SAS Institute Inc, Cary, NC, USA) and SPSS v15 (SPSS Inc, Chicago, IL, USA). Differences between the groups were determined using non-parametric tests. Survival outcomes were derived from the Kaplan–Meier method, with the logrank test used to compare survival curves.

Results

Patient characteristics

There were a total of 236 patients identified, with 26 patients excluded due to recurrent disease, leaving 210 patients who met the inclusion criteria. Their median age was 68.2 years (range 39–90 years) and 129 (61.4%) were male. A total of 159 out of 210 patients (75.7%) who were referred for management at the CTC were actually discussed at the lung cancer MDT meeting. The histological subtype and stage are summarised in Table 2. The median follow-up was 16.6 months.

Table 2. Patient characteristics (n = 210)

Histological subtype	n	%
NSCLC		
Adenocarcinoma	62	29.5
Large cell carcinoma	63	30.0
Squamous cell carcinoma	36	17.1
Not otherwise specified	11	5.2
SCLC	29	13.8
Presumed malignant*	9	4.3
Stage at diagnosis		
NSCLC		
Stage I	14	6.7
Stage II	14	6.7
Stage III	60	28.5
Stage IV	93	44.3
SCLC		
Limited stage	8	3.8
Extensive stage	21	10.0

*No histological confirmation of diagnosis. These cases were staged as per NSCLC. NSCLC, non-small cell lung cancer; SCLC, small cell lung cancer.

In patients where there was no histological confirmation of their lung cancer diagnosis (i.e. an imaging-only diagnosis), these cases were presumed to be malignant and were subsequently characterised into the NSCLC subgroup for the purposes of further analysis.

Cost characteristics

The total cost for managing the 210 study patients during the review period from 1 December 2005 to the censor date of 31 October 2008 was A$2 906 724.25. The components of costs are illustrated in Table 3. Hospitalisation and chemotherapy accounted for the great-

Table 3. Components of cost

	Australian dollars	%
Staging investigations	292 267	10.1
Treatment		
Surgery	80	2.8
Radiotherapy	460	15.8
Chemotherapy	655	22.6
Hospitalisation	1 271 130	43.7
Follow-up investigations*	146 795	5.0
Total	2 906 724	100.0

*Follow-up investigations were defined as radiological and/or pathological investigations performed following completion of staging investigations or primary treatment.

Table 4. Total cost by stage

	Patients (n)	Australian dollars (AUD)	%	Mean ± (SD) (AUD)	Median (AUD)
NSCLC					
Stage I	14	115 290	4.0	8 235 ± (2573)	8 026
Stage II	14	238 096	8.2	17 007 ± (10 379)	13 615
Stage III	60	820 701	28.2	13 678 ± (8250)	13 070
Stage IV	93	1 298 141	44.6	13 959 ± (11 759)	10 349
SCLC					
Limited stage	8	162 213	5.6	20 277 ± (8536)	20 826
Extensive stage	21	272 282	9.4	12 966 ± (6026)	13 874
Total	210	2 906 724	100.0		

est components of cost, constituting 44 and 22% of total costs, respectively. Only two patients received tyrosine kinase inhibitors (TKIs).

The total cost by cancer type and stage are presented in Table 4. The median total cost increased with increasing stage for NSCLC (Kruskal–Wallis test, $P = 0.048$) and SCLC (Wilcoxon's rank sums test, $P = 0.043$). The median cost per patient was highest for stage II NSCLC and limited stage SCLC. The median total costs for managing the SCLC and NSCLC subgroups were comparable \$14 799 versus \$10 674 (Wilcoxon's rank sums test, $P = 0.11$).

Table 5 highlight the total, median and mean treatment costs by stage. Treatment costs include cost of surgery, radiotherapy, chemotherapy and hospitalisation. In the NSCLC subgroup, the total treatment cost of radiotherapy, chemotherapy and hospitalisation increased with increasing stage. However, on evaluation of the total cost per person by treatment modality, the proportion of costs spent on radiotherapy for stage I to III NSCLC was comparable, between 40–54%. Less was spent on stage IV NSCLC with only 9.6% of cost spent per patient on radiotherapy. Conversely, for this same subgroup of stage IV NSCLC patients, a higher proportion was spent on chemotherapy per patient – 33%. Patients with stage IV NSCLC and extensive stage SCLC had the highest proportion of their management costs spent on hospitalisation. The median treatment costs for managing the SCLC and NSCLC subgroups were comparable, \$12 378 versus \$8747 (Wilcoxon's rank sums test, $P = 0.28$).

Hospitalisation details

The median overall length of stay in hospital was 17 days (range 0–136 days). For patients with NSCLC, the median length of hospital stay was 7 days for stage I NSCLC, 21 days for stage II, 13 days, for stage III and 18 days for stage IV. In comparison, patients with SCLC had longer periods of hospitalisation with a median 22 and 25 days for limited stage and extensive stage disease, respectively. All the exact reasons for hospitalisation could not be accurately deduced in this retrospective review of clinical records. However, departmental audits of radiation oncology patients suggest that the main reason for oncology admissions for NSCLC were for symptom control and palliative care.

Survival outcomes

The median survival for all 210 patients was 8.2 months (95% confidence interval (CI): 7.0–11.1 months). The 2-year overall survival was 16.9% (95% CI: 11.1–22.6%). The median cost per month of survival for all 210 patients was A\$1854 (range A\$41–28 650).

Discussion

This study is among the few contemporary studies addressing current direct costs in modern lung cancer management and one of the first to attempt to assess the direct costs of managing NSCLC in Australia. Estimating the costs for resources used in the Australian context is complex. This is in part due to the current structure of health-care funding, in which the Commonwealth Government as well as the States and Territories jointly fund public hospitals and community care, whilst the Commonwealth Government alone funds most out-of-hospital medical services.[19]

Use of the MBS and PBS fees, which incorporate both professional (service provider's time) and practice components (the physical costs of providing services), have been set historically and not kept pace with current practice, thereby serving to underestimate actual costs in the current study.

A detailed approach in accounting for the direct medical costs was attempted, but there were some costs that were difficult to account for and thus were excluded from this analysis. The costs for routine blood test, investigations that were not documented in the clinical or electronic records, hospital department infrastructure, staff, other non-medical costs to patients (i.e. transportation, home aids) and other costs incurred out of hospital such as general practitioner or community-based care costs were not included in cost estimations.

With these limitations in mind, the estimated direct medical costs of managing lung cancer in South Western

Table 5. Total and mean treatment cost by stage and modality

	Patients (n)	Surgery, AUD (%)	Radiotherapy, AUD (%)	Chemotherapy, AUD (%)	Hospitalisation, AUD (%)	Total treatment cost (AUD)	Mean treatment cost (AUD)
NSCLC							
Stage I	14	16 300 (19)	20 907 (25)	4 570 (5)	43 993 (51)	85 770	6 126
Stage II	14	21 491 (10)	51 144 (25)	54 918 (27)	79 612 (38)	207 165	14 798
Stage III	60	26 899 (4)	210 779 (30)	151 454 (21)	318 627 (45)	707 759	11 796
Stage IV	93	14 306 (1)	107 287 (10)	365 610 (33)	628 468 (56)	1 115 671	11 996
SCLC							
Limited stage	8	0 (0)	52 476 (39)	32 237 (24)	48 972 (37)	133 685	16 711
Extensive stage	21	1 548 (1)	17 430 (8)	47 179 (22)	151 454 (69)	217 611	10 362
Total	210	80 453	460 023	655 966	1 271 130		

Sydney (SWS) were determined. The average mean cost per patient was A$13 842 for the whole study cohort, A$13 659 for patients with NSCLC and A$14 983 for patients with SCLC. The cost of managing NSCLC and SCLC was comparable; however, the SCLC patients represented only a small subgroup and thus it is difficult to make any definite conclusions regarding this. The main cost components were due to hospitalisation followed by chemotherapy, accounting for 44 and 22% of total costs, respectively. There was a non-statistically significant trend for an increasing proportion of costs incurred from on hospitalisation with advancing stage for both NSCLC and SCLC, which may reflect the greater use of multimodality treatment, supportive and palliative care.

With regard to the use of newer systemic biologic agents, such as TKIs, only two patients in the study cohort were treated with TKIs. Although indications for these expensive systemic biological agents are continuing to evolve, current lack of reimbursement for epidermal growth factor receptor mutation testing has limited more widespread use of these agents. As a result, the data presented in this study remains relevant for the majority of lung cancer patients in current clinical practice.

Direct comparison of the results from this study and those of other countries is also difficult due to the differences in patient cohorts, approach to management of lung cancer, health-care system design, funding structures, study design and type of analysis.[20] The finding that hospitalisation accounted for the major component of total cost in the current Australian study is consistent with results from other high-income countries such as the United States,[11] Ireland,[13] Switzerland,[10] United Kingdom,[8] Canada[12] and the Netherlands[14] (Table 6). These studies have demonstrated that hospitalisation accounted for between 31 and 71% of total costs.[12,14–18] In the current study, the proportion of direct medical costs spent on hospitalisation was 44%, a result comparable to the United States[11] (49%) and the Netherlands (50%).[14] Compared with a previous Australian study estimating the costs of SCLC in only 31 patients published in 1992, the findings in this study are similar in that the main constituents of cost were also hospitalisation (42%) followed by chemotherapy (18%).[6]

As hospitalisation accounted for the main cost, it is valuable to better understand the reasons for hospitalisation. In the study cohort, the reasons varied from staging of lung cancer, administration of cancer treatments, management of therapy or disease-related complications, symptomatic disease progression, placement issues (such as nursing home placements) or terminal care. Although not statistically significant, there was a trend for longer length of hospital stay in the NSCLC subgroup with increasing stage, which may be related to the increasing need for symptom control and/or terminal care associated with managing patients with locally advanced and/or metastatic disease. Given that the major component of cost is hospitalisation, further

Table 6. Summary of lung cancer hospitalisation cost

Study	Year of publication	Year of Costing	Country	Number of patients/disease group	Percentage of total treatment cost spent on hospitalisation
Rosenthal *et al*.6	1992	1988	Australia	(*n* = 31) SCLC	42
Oliver *et al*.8	2001	1998	United Kingdom	(*n* = 109) SCLC	51
Dedes *et al*.10	2004	1999	Switzerland	(*n* = 105) NSCLC + (*n* = 13) SCLC	71
Kutikova *et al*.11	2005	2000	United States	(*n* = 2040) NSCLC + SCLC	49
Demeter *et al*.12	2007	2000–2001	Canada	(*n* = 448) NSCLC + (*n* = 105) SCLC	31
Fleming *et al*.13	2008	2004	Ireland	(*n* = 449) NSCLC (*n* = 122) SCLC + (*n* = 151) NMV	62
Pompen *et al*.14	2009	2005	The Netherlands	(*n* = 102) NSCLC	50
Kang *et al*.	2012	2005	Australia	(*n* = 181) NSCLC + (*n* = 29) SCLC	44

NMV, non-microscopically verified cancer; NSCLC, non-small cell lung cancer; SCLC, small cell lung cancer.

analysis of the reasons for hospital admission and at which timepoints along the patient's disease trajectory admission occurred, is warranted. This could also aid in the development of strategies to address reduction in the rates and/or duration of hospitalisation.

This study cohort was selected via their MDT presentation or attendance at two oncology centres in SWS. This represents approximately 60% of all patients with newly diagnosed lung cancer in the local health district. These two centres and associated public hospitals provide the only cardiothoracic surgery, all radiotherapy and most of the chemotherapy for lung cancer patients in SWS. A lung cancer pattern study performed in New South Wales (NSW) in 2001, showed that lung cancer management in SWS was similar to that in NSW overall.[21] Thus, the nature of the costs described in this study is likely to be similar to other public facilities throughout NSW. However, there is evidence that patients discussed at an MDT forum benefit from improved treatment utilisation in lung cancer.[22] Lower overall treatment utilisation in the wider lung cancer population may result in a different cost breakdown, although this may not necessarily affect hospitalisation rates. Further research into the treatment patterns and resource use at other Australian centres would provide valuable comparative data to this study.

Whilst this study has attempted to estimate the direct medical costs of care, the actual total costs of managing lung cancer are likely to be significantly higher. There are significant other proportional costs associated with managing lung cancer, which include health system expenditures, productivity costs, other financial costs, transfer costs and also non-financial costs, as illustrated on Figure 1.[20,23] Non-financial cost refers to the years of healthy life lost to cancer related to the pain and suffering from cancer.[23] In terms of the lifetime financial cost of cancer in NSW in 2005, productivity costs accounted for the main cost component of cancer (54%), followed by health system costs (29%).[23] As this study has only examined a component of health system expenditure, the true costs of lung cancer to the individual, family and society are predicted to be significantly more than that approximated here in this study.

In the future, a study utilising prospective methodology that attempts to account for direct and indirect costs should be undertaken. This should include the period from the first contact with a clinician and should include the time spent at each consultation or investigation, a record of all resources utilised and loss of productivity or income. To estimate the cost from each treatment centre, data should be collected on resources used to deliver the treatment including infrastructure, resource usage and capital overheads. Furthermore, a study incorporating selected health economic modelling of various costs, similar to that which has been performed in France and Canada,[7,9,24] but in the Australian context would be ideal.

Lung cancer management continues to evolve with increasingly sophisticated diagnostic and therapeutic options, all of which will have their associated costs. Diagnostic modalities such as FDG-PET and endobronchial ultrasound are now becoming widely available. Radiotherapy treatment now includes the more advanced technological options of stereotactic radiotherapy and image-guided treatment. Pathology testing for epidermal growth factor receptor status and other

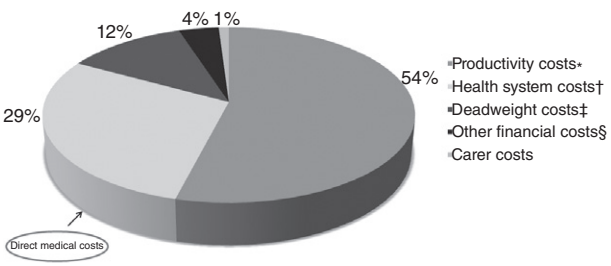

Fig. 1. Costs associated with managing lung cancer.[23] *Productivity costs incorporate the cost of loss productivity (loss of wages, caregiving and household work) due to illness and premature death. †Health system expenditure costs consists of that related to the diagnosis and treatment of lung cancer, medical and allied health services, pharmaceuticals, infrastructures and administration costs. ‡Deadweight costs are associated with government transfers such as taxation revenue forgone, welfare and disability payments. §Some of the other financial costs include respite or palliative care, home modifications and community programs.

emerging molecular markers will have an increasing role in individualisation of chemotherapy treatment. Furthermore, the escalating use of multimodality treatments, novel chemotherapy agents and emerging biological agents are also predicted to increase the direct medical costs for lung cancer in the future.

Conclusion

This study provides an estimation of the direct medical costs of the management of lung cancer in a contemporary cohort of patients. Hospitalisation and cancer treatments, particularly chemotherapy, accounted for the major components of costs.

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