Lung Cancer 91 (2016) 79–88

Contents lists available at ScienceDirect

Lung Cancer

journal homepage: www.elsevier.com/locate/lungcan

Costs of non-small cell lung cancer in the Netherlands

N. van der Linden[a,g,*,1], M.L. Bongers[b,1], V.M.H. Coupé[b], E.F. Smit[c], H.J.M. Groen[d], A. Welling[e], F.M.N.H. Schramel[f], C.A. Uyl-de Groot[a]

[a] Institute for Medical Technology Assessment, Erasmus University Rotterdam, the Netherlands
[b] Epidemiology and Biostatistics, VU University Medical Center, Amsterdam, the Netherlands
[c] Pulmonology, VU University Medical Center, Amsterdam, the Netherlands and Thoracic Oncology, Netherlands Cancer Institute, Amsterdam, the Netherlands
[d] Pulmonology, University Medical Center Groningen, the Netherlands
[e] Pulmonology, Medical Center Alkmaar, the Netherlands
[f] Pulmonology, St. Antonius Hospital, Nieuwegein, the Netherlands
[g] CHERE (Centre for Health Economics Research and Evaluation), University of Technology Sydney, Australia

ARTICLE INFO

Article history:
Received 17 March 2015
Received in revised form 24 June 2015
Accepted 12 October 2015

Keywords:
Non-small cell lung cancer
Costs
Resource use

ABSTRACT

Objectives: Real-world resource use and cost data on non-small cell lung cancer (NSCLC) are scarce. This data is needed to inform health-economic modelling to assess the impact of new diagnostic and/or treatment technologies. This study provides detailed insight into real-world medical resource use and costs of stage I-IV NSCLC in the Netherlands.
Materials and methods: A random sample of patients newly diagnosed with NSCLC (2009–2011) was selected from four Dutch hospitals. Data was retrospectively collected from patient charts. This data included patient characteristics, tumour characteristics, treatment details, adverse events, survival and resource use. Resource use was multiplied by Dutch unit costs expressed in EUR 2012. Total mean costs were corrected for censoring using the Bang and Tsiatis weighted complete-case estimator. Furthermore, costs of adverse events, costs per phase of NSCLC management and costs of second opinions are presented.
Results: Data was collected on 1067 patients. Total mean costs for NSCLC diagnosis, treatment and follow-up are €28,468 during the study period and €33,143 when corrected for censoring. Adverse events were recorded in the patient charts for 369 patients (41%) and 82 patients (9%) experienced an adverse event of grade III or higher. For these patients, adverse event-related hospital admissions cost on average €2,091. Mean total costs are €1,725 for the diagnostic period, €17,296 for first treatment line, and €13,236 for each later treatment line. Costs of providing a second opinion are €2,580 per patient.
Conclusions: Total mean hospital costs per NSCLC patient are €33,143 for the total duration of the disease. Ignoring censoring in our data underestimates these costs by 14%. Main limitations of the study relate to the short follow-up time, staging difficulties and missing data. Its main strength is that it provides highly detailed, real-world data on the costs of NSCLC.

1. Introduction

Of new cancer cases, lung cancer has the second highest incidence. Although incidence and mortality have been reduced [1,2], due to a reduction in smoking and recent developments in diagnosis and treatment, the health burden remains considerable. In addition, the economic burden of lung cancer care on society is high; in the Netherlands, costs of lung cancer were estimated to be over 400 million euro in the year 2011. The majority of these costs involve hospital care (82%) [3].

Health care spending for NSCLC has increased due to the growing number of new, expensive treatments [4]. Because of the economic burden of lung cancer, it is critical to estimate the cost-effectiveness of new developments in diagnosis and treatment. Mathematical models that estimate cost-effectiveness of new strategies using available data are commonly used to support decision making [5]. Such models synthesize evidence on health effects and costs from many different sources, including data from clinical trials, claims databases, registry data and public health statistics. To inform such health-economic models with data, it is

* Corresponding author at: CHERE, University of Technology Sydney, P.O. Box 123, Broadway NSW 2007, Australia.
E-mail address: vanderlinden@bmg.eur.nl (N. van der Linden).
[1] Both authors contributed equally to this article.

http://dx.doi.org/10.1016/j.lungcan.2015.10.015
0169-5002/

important that the best available evidence is used, and preferably data that reflects clinical practice [6]. Resulting cost-effectiveness estimates can inform hospital-, industry- and governmental policy makers on costs of NSCLC and impact of new diagnostic or treatment technologies.

The health effects of new interventions can generally be obtained from trial data or literature. Data from pooled clinical trials is considered the best available evidence for estimating clinical treatment efficacy of new interventions. However, health-economic trial data reflects the resource use and costs of the trial protocol and not the resource use and costs in "the real world" [7]. The real-world resource use and cost data that is needed for health-economic modelling of non-small cell lung cancer (NSCLC) is scarce. In general, cost estimates in the literature are not complete enough for modelling purposes. Often, costs are not separated by phase in the treatment pathway, or different types of costs are merged into one cost [8].

At present, two Dutch studies present NSCLC costs that can be used for health-economic modelling. One study from 2009 focused on late-stage disease [9], while the other study included a detailed analysis of the costs of radiotherapy in 2010 [10]. Both studies have been used in health-economic modelling [11,12].

The objective of this study is to provide insight into real-world medical resource use and costs of NSCLC in the Netherlands. We aimed to estimate costs for all cost items of hospital-based lung cancer care. These cost items include the full diagnostic work-up, cancer treatments, concomitant medication, hospital visits, and adverse events for all phases of lung cancer care. The results can be used in a decision model of lung cancer.

Table 1
Baseline characteristics.

	Study sample, 2009–2011	Dutch population, 2001–2006
	n (%)	*n* (%)
Total patients	907 (100)*	13,992 (100)
Age (years)		
<60	235 (26)	3566 (26)
60-74	450 (50)	6910 (49)
≥75	222 (25)	3516 (25)
Gender		
Male	601 (66)**	8841 (63)
Smoking status		
Non-smoker	60 (7)	NA
Smoker	295 (33)	
Former smoker (quit >1 month ago)	296 (33)	
Not reported	256 (28)	
Charlson comorbidity score		
0	383 (42)	NA
1	269 (30)	
2	145 (16)	
≥3	110 (12)	
Histology		
Adenocarcinoma	442 (49)	6222 (45)
Squamous cell carcinoma	237 (26)	4062 (29)
Large cell carcinoma	90 (10)	1884 (14)
Other histology	29 (3)	407 (3)
Unknown	107 (12)	1417 (10)
Clinical stage		
Stage <IV	561 (62)	6552 (47)
Stage = IV	321 (35)	6887 (49)
Unknown	25 (3)	553 (4)

*Initially, data was collected on 1067 patients. 1067 minus 102 (previous treatment in another hospital) minus 58 (second opinion only) = 907 patients.
**For one patient, gender was not registered.

2. Materials and methods

2.1. Study design

A retrospective outcomes study was conducted to capture medical resource use and costs in the management of all stages of NSCLC in the Netherlands. Patients newly diagnosed with stage I-IV NSCLC between January 31, 2009 and January 31, 2011 in participating hospitals (VU University Medical Center, Amsterdam; University Medical Center Groningen; Medical Center Alkmaar; St. Antonius Hospital, Nieuwegein) were eligible. Eligible patients were identified through hospital databases and were followed until study end, transfer to another hospital, or death. Last month of data collection was July 2012.

Data was collected on 1067 randomly selected patients and abstracted from patient charts by trained data assistants, using a web-based case report form (CRF). The CRF captured information about patient characteristics, tumour characteristics, treatment details, adverse events (AEs), survival and resource use. Adverse events were obtained from the patient charts, which noted the grade of the event according to the common terminology criteria for adverse events (CTC AE) version 4.03. In case grade was not registered by the clinician, it was derived by the data manager if the patient chart contained the necessary information. If the necessary information was not registered, the grade was considered missing.

Data from the Netherlands Cancer Registry (NCR) was used to validate tumour histology and disease stage collected from the patient charts. The NCR also provided population-based data on patient and tumour characteristics of all patients diagnosed with NSCLC in the Netherlands between January 2009 until January 2011, as identified through the automated pathological archive (PALGA) and the National Registry of Hospital Discharge Diagnoses. This information was used to assess the representativeness of the study sample.

This study was performed from a hospital perspective. Direct medical costs outside the hospital (such as care by a general practitioner) and indirect medical and non-medical costs were outside the scope of the study. Oral oncolytics and other specialist drugs were considered hospital care and included in the cost.

2.2. Resource use

Information was collected on all relevant resources consumed within the hospital setting, including surgeries, radiotherapy, anticancer drug therapy, laboratory tests (including pathology, microbiology, hematology, chemistry, immunology), medical imaging services, other medical diagnostics and procedures, outpatient visits, telephone consultations, day care visits, hospitalizations and intensive care stay.

Per patient, the number and types of resources used were counted. In the case of hospital admissions, it was specified whether admissions were needed for treatment of disease, for treatment of adverse events or other reasons.

2.3. Costs

Costs were estimated by linking resource use to Dutch unit costs, based on the Dutch costing manual [13] and NZa (Dutch Healthcare Authority) tariffs [14]. All costs were based on EUR 2012 unit cost data or were adjusted to 2012 prices using the general price index as published by Statistics Netherlands. Mean costs for drug use other than anti-cancer drugs, including treatments for adverse events, were determined for a subsample of VUMC patients ($n = 107$), for feasibility reasons. Mean costs for laboratory tests were obtained