Lung cancer prevalence in New South Wales (Australia): Analysis of past trends and projection of future estimates

(Short title: Lung cancer prevalence in Australia)

Xue Qin Yu,1,2 Clare Kahn,1 Qingwei Luo,1,2 Freddy Sitas,1,2,3 Dianne L O’Connell,1,2,3,4

Affiliations:
1. Cancer Research Division, Cancer Council New South Wales, Sydney, Australia
2. Sydney School of Public Health, University of Sydney, Sydney, Australia
3. School of Public Health and Community Medicine, University of NSW, Sydney, Australia
4. School of Medicine and Public Health, University of Newcastle, Newcastle, Australia

Email address for each author:
Clare Kahn clarek@nswcc.org.au
Qingwei Luo qingweil@nswcc.org.au
Freddy Sitas freddy.sitas@gmail.com
Dianne L O’Connell dianneo@nswcc.org.au

Corresponding author and address:
Dr Xue Qin Yu
Cancer Research Division
Cancer Council NSW
P.O. Box 572
Kings Cross NSW 1340
Australia

Fax: +61 2 8302 3550
Email: xueqiny@nswcc.org.au
Abstract

Background To provide a temporal analysis of lung cancer prevalence over two decades in New South Wales (NSW), Australia and projections of future lung cancer prevalence up to 2017.

Methods Data for lung cancer cases diagnosed in 1983-2007 with survival follow-up to the end of 2007 were extracted from the population-based NSW Central Cancer Registry. Five-year prevalence was calculated by the counting method at five time points (1987, 1992, 1997, 2002, and 2007) for which data were available, then historical prevalence trends (1987-2007) were extrapolated into 2008-2017.

Results For men, 5-year prevalence of lung cancer in NSW increased slowly in number from 1748 in 1987 to 2151 in 2007, although there was a 15% reduction in prevalence rates over the same time period. For women, there was a greater increase both in number (2.55 times) and rates (88%) between 1987 and 2007. Despite the narrowing gap in lung cancer prevalence between men and women, in 2007 the 5-year prevalence for men was still higher than that for women. However, if the past trends continue, it is expected that in 2017 the 5-year lung cancer prevalence for women in NSW will surpass that for men.

Conclusions Our projections suggest that by 2017 the prevalence of lung cancer for women will be greater than that of men in NSW Australia. Further strengthening the current tobacco control measures should be considered a high priority in Australia, particularly for adolescents and women.

Keywords: Lung cancer, prevalence, temporal trends, tobacco
1. Introduction

Cancer incidence and mortality are the primary measures of cancer burden, and are regularly reported in many developed countries. Cancer prevalence, meanwhile, is not routinely available, despite being an important supplementary indicator of a population’s healthcare requirements. Cancer prevalence is defined as the number or proportion of cancer patients in a population at a given time, with total prevalence and limited duration prevalence being the most widely used specific measures. Total prevalence is a very broad measure of health service needs for cancer patients, as it covers all stages of cancer care, while limited duration prevalence, the number of patients diagnosed within a fixed time in the past and alive at an index date, provides a more precise measure of health service needs for more fatal cancers.

Lung cancer is one of the most common cancers diagnosed and the leading cause of cancer death in Australia. As the prognosis for lung cancer patients is generally poor, measures of short-term prevalence are more relevant for lung cancer than for cancers with higher rates of survival, and are more likely to include a group of patients with similar cancer care requirements. Five-year prevalence estimates for lung cancer would primarily include patients who were receiving initial intensive treatment, receiving ongoing post-treatment follow-up care, or who were receiving care associated with the last year of life. Information regarding the prevalence of lung cancer patients requiring these intensive levels of health care is important for future cancer care planning. However, while there are some Australian estimates of limited duration prevalence available, these estimates provide no information on temporal trends or future projections.
In this study we used population-based data to examine temporal trends in the 5-year prevalence of lung cancer between 1987 and 2007, and projected future prevalence up to 2017. We aimed to understand the patterns according to changes in factors that influence lung cancer prevalence, and hope that this will provide a timely assessment of the resources and infrastructure needed to meet future demands for preventive and medical services.

2. Methods

2.1 Data

Incidence data for first primary lung cancer cases (ICD-O3 C33-C34)\textsuperscript{9} diagnosed in 1983-2007 were extracted from the New South Wales (NSW) Central Cancer Registry database. Notification of cancer diagnosis to the registry is a statutory requirement in NSW. The registry covers a population of 7.2 million people, approximately one-third of the total population of Australia, and maintains a record of all cases of cancer diagnosed in NSW residents since 1972.\textsuperscript{10} The registry generally has high standards of data completeness and quality, and the data are accepted by the International Agency for Research on Cancer for publication in Cancer Incidence in Five Continents.\textsuperscript{11, 12} We excluded 1959 cases that were reported to the registry through death certificate only or who were first identified post-mortem, and 82 cases who were aged over 95 years at diagnosis.

Cases were followed up for survival status to 31 December 2007 (the most recent data available) through record linkage of cases in the cancer registry with death records from the NSW Register of Births, Deaths and Marriages and the National Death Index. Although mortality information was obtained by matching against the
National Death Index, it remains possible that a small number of deaths were missed. To reduce the impact of such ‘immortal’ cases, we used a short-term prevalence measure in this study and imposed a maximum possible attainable age of 95 years for prevalent cases.

2.2 Ethics statement

This study was approved by the NSW Population and Health Services Research Ethics Committee (reference number: 2009/03/139).

2.3 Statistical analysis

Five-year prevalence was estimated by counting the number of cases diagnosed in the previous 5 years and still alive at a given index date. For example, 5-year prevalence for 2007 was estimated by counting the number of cases diagnosed between 2003 and 2007 who were still alive at the end of 2007. We first calculated 5-year prevalence at five time points for which data were available (1987, 1992, 1997, 2002 and 2007). To assess the temporal trend in prevalence, we calculated the age-standardised prevalence rate (per 100,000) overall and age-specific rate (<55, 55-64, 65-74 and 75-94 years) for each of these time points using the 2001 Australian standard population.

We then used a log-linear extrapolation (considered appropriate for short-term projections\(^5\)) of existing prevalence rate trends for 1987-2007 into 2008-2017. These projections were run with two different assumptions: (1) the dynamic assumption that past (1987-2007) prevalence trends would continue in 2008-2017; (2) the constant assumption that prevalence rates for 2008-2017 would remain constant as at the
most recent year (2007) for which data were available. All analyses were performed separately for men and women, as incidence patterns are markedly different between the sexes.

Annual age-standardised incidence rates (1983-2007) were calculated to assist in the interpretation of prevalence trends and the factors that influence estimated prevalence. Age-specific incidence rates were also estimated, as trends in older generations can be used as an indication of the trajectory of the tobacco epidemic, while trends in younger generations reflect more recent changes in smoking consumption. Survival relative to the general population was also calculated using the period method for each of the corresponding periods (1987, 1992, 1997, 2002, and 2007).

Trend analyses and projections were conducted using the SAS procedure GENMOD (version 9.3, SAS Institute Inc., Cary NC, USA), while survival analyses were performed using strs in Stata (version 13.1, StataCorp LP, College Station TX, USA).

3. Results

Between 1983 and 2007 there were 56,762 people aged 18-94 diagnosed with first primary lung cancer in NSW, with a male:female ratio of 2.2. The number of new cases by period of diagnosis and age at diagnosis for men and women are shown in Table 1. The number of new cases in men was stable over the 20 year period, while the corresponding numbers for women increased steadily over the same period, with
approximately a 4% increase in each time period. Across both sexes, lung cancer was more often diagnosed in people aged 65 years and over.

Changes in 5-year lung cancer prevalence (number and rate) stratified by sex and age group from 1987 to 2007 are presented in Table 2. For men, over this period the age-specific prevalence rates fell for all age groups except for the oldest, while for women an upward trend was seen in all age groups. For the youngest age group (<55 years) the prevalence rate in 2007 was higher for women than for men, and for the two middle age groups the gap in prevalence rates between men and women narrowed over time.

Trends in the age-standardised 5-year prevalence rates between 1987 and 2007 were noticeably different between men and women: decreased by 15% (from 77.5 per 100,000 in 1987 to 65.6 per 100,000 in 2007) for men, and increased by 88% for women (from 21.8 to 41.0 per 100,000) over the same period (Figure 1). As a result of these differing trends, the sex differential in lung cancer prevalence became smaller over time, although the rates for men were still higher in the most recent year for which data were available.

Projections of 5-year prevalence are shown in Table 3. The number of prevalent cases for men shows a small increase, while a marked increase is seen for women. This difference is more apparent when trends in 5-year prevalence rates are projected to 2017 (Figure 1). If the past trends continue (dynamic assumption), the 5-year prevalence for women will surpass that of men in 2017 (Table 3).
A decreasing overall incidence trend was observed among men, while a continued increasing trend was seen for women (Figure 2). Trends in age, sex-specific incidence rates over time are shown in Supplementary Figure S1. For men, from 1983 to 2007 downward trends were observed for all four age groups, while for women an upward trend was observed for the two older age groups and a relatively stable trend observed for the two younger age groups.

There was a statistically significant improvement in relative survival for lung cancer from 1987 to 2007, although the improvement was generally limited in magnitude (Figure 3). Women tended to have slightly but significantly better survival than men.

4. Discussion

In this study we used lung cancer data from a well-established, long-standing population-based cancer registry to examine lung cancer prevalence over two decades in NSW, Australia. We found that the prevalence of lung cancer declined during the last two decades for men, while in contrast an increasing trend in prevalence was observed for women. As a result of these differing trends, and if these trends continue into the near future, the prevalence of lung cancer for women will exceed that for men by 2017. These projections are dependent on changes in future lung cancer incidence and survival, but as changes in incidence and survival may take some time to occur, for lung cancer in particular, these projections are likely to be reasonable.

While there have been some Australian studies that have estimated limited duration prevalence of lung cancer, to our knowledge no previous studies have assessed
temporal trends in lung cancer prevalence in Australia. We believe our study helps to extend this previous research by providing background data to interpret the current lung cancer prevalence (with 2007 being the most recent data available), looking at temporal trends, and exploring possible future directions. Our 5-year prevalence estimates for 2007 were consistent with those reported by the Cancer Institute NSW\textsuperscript{6} and the Australian Institute of Health and Welfare.\textsuperscript{7} However, in addition to providing the most recent update for lung cancer prevalence, we also looked at temporal trends in 5-year prevalence and estimated future prevalence. Our estimates of future prevalence seem reasonable as they are comparable with results from a similar study in the UK\textsuperscript{17} that indicate that the number of male lung cancer survivors is likely to remain roughly constant.

Unlike for cancers with excellent survival, short-term prevalence is a relevant measure for lung cancer.\textsuperscript{4,5} Survival from lung cancer has remained low for the past three decades, and only a small proportion of patients are still alive after 5 years.\textsuperscript{5,10,18} This means that 5-year prevalence estimates would include the majority of lung cancer patients, who would either be receiving initial intensive treatment, ongoing post-treatment follow-up care or terminal care in the last year of life. Therefore, while the health care system is expected to face rising numbers of cancer survivors in the future,\textsuperscript{19-21} this will not be the case for lung cancer because of its poor prognosis and an overall downward trend in incidence.

There are some limitations to the data used that could have an impact on our results. Primarily, as the survival status of cases was determined by linking registry data with death records, a small percentage of cases are never matched, resulting in an over-
estimate of the prevalence. Fortunately however, we believe this over-estimate is likely to be very small, as a previous study of cancer survival in NSW found that loss to follow-up was uniform from 1980 to 1993, and that the resulting overestimation of relative survival was a maximum of 2%.\textsuperscript{22} Furthermore, to minimize the potential impact of such ‘immortal cases’ we censored cancer survivors at the age of 95 years.

Trends in cancer prevalence can be interpreted in terms of different patterns of cancer incidence and survival. As only marginal improvements in lung cancer survival were observed in the past 20 to 30 years in NSW,\textsuperscript{10,18} it is temporal trends in lung cancer incidence that are the predominant factor affecting lung cancer prevalence. Indeed, the prevalence trend patterns are closely mirrored by the incidence patterns, as seen in Figures 1 and 2. The downward prevalence trend for men reflects the fall in incidence and some limited improvement in survival, while the upward trend for women is likely to be mainly due to increasing incidence over time, although marginally better survival over time may also partly contribute.

There is a strong relationship between lung cancer incidence and tobacco use.\textsuperscript{23,24} Lung cancer incidence trends closely follow patterns of tobacco smoking, with a 20-30 year lag between population smoking patterns and subsequent lung cancer incidence.\textsuperscript{25} In Australia, the lung cancer incidence trend for men reflects this pattern closely, with declining incidence apparent from the early 1980s following a drop in smoking prevalence among men around the middle of the last century.\textsuperscript{26} As this reduction in smoking prevalence occurred much later (around the mid 1980s) for women,\textsuperscript{26} if an equivalent time lag also occurs for women, then it would be expected that the increase in lung cancer incidence would reach its peak around the mid-
2010s. However, the most recent incidence data (2009) show little sign that the incidence for women has or will soon reach a peak. Our results for the recent generation (aged <55 years), a reflection of more recent changes in tobacco smoking and a good indicator of future lung cancer incidence, showed no apparent sign of decline in lung cancer incidence in recent years. This leads us to believe that the time lag between tobacco smoking and subsequent lung cancer diagnosis may be longer for women (25-40 years). Possible explanations for this may include that the attribution of tobacco smoking to lung cancer is lower for women than for men (65% vs 90%), so that factors other than smoking may contribute to the aetiology of lung cancer in women, or that the rate of decline in smoking prevalence has been slower for women. If this is the case, then we can expect a drop in lung cancer incidence for women to occur around 2020, which is beyond our projections (2017).

Since a vast majority of lung cancer cases are attributable to cigarette smoking, further strengthening current tobacco control measures (increasing cessation rates and reducing initiation rates) is critical to reducing the prevalence of lung cancer in Australia, particularly for women. Our results suggest that if the prevalence rate for women remained the same in the future as it was in 2007, more than 700 prevalent lung cancers in women would be avoided in 2017. Early diagnosis is also important because the majority of lung cancer patients are diagnosed with advanced disease, and thus survival for lung cancer remains very poor. Recent published results suggested that lung cancer screening with CT scans can be cost-effective and save lives. However, as screening should be targeted to a very specific set of long-term smokers (individuals aged between 55 and 74 years, with a smoking history of at
least 30 pack-years), even if it was implemented in Australia now it would have little impact on our predictions.

In conclusion, the prevalence of lung cancer declined over the last two decades for men, while for women an increasing trend was still continuing. Our projections suggest that by 2017 the lung cancer prevalence for women will surpass that for men. The main factor contributing to the differing trends is lung cancer incidence. Thus, further strengthening current tobacco control measures should be considered a high priority in Australia, particularly for adolescents and women.
Acknowledgements

Xue Qin Yu was supported by an Australian NHMRC Early Career Fellowship (550002). We thank the NSW Central Cancer Registry for providing the data for the study.

References


Acknowledgements and references


Acknowledgements and references


## Tables

### Table 1 Number of new cases of lung cancer diagnosed in New South Wales, Australia by period of diagnosis, age group and sex during 1983 to 2007

<table>
<thead>
<tr>
<th>Period of diagnosis</th>
<th>Men</th>
<th>Women</th>
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<tbody>
<tr>
<td></td>
<td>Number of new cases (% of the total)</td>
<td></td>
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<tr>
<td>1983-1987</td>
<td>7892 (20.1)</td>
<td>2217 (12.6)</td>
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<tr>
<td>1988-1992</td>
<td>7804 (19.9)</td>
<td>2899 (16.5)</td>
</tr>
<tr>
<td>1993-1997</td>
<td>7817 (19.9)</td>
<td>3601 (20.5)</td>
</tr>
<tr>
<td>1998-2002</td>
<td>7852 (20.0)</td>
<td>4042 (23.0)</td>
</tr>
<tr>
<td>2003-2007</td>
<td>7842 (20.0)</td>
<td>4796 (27.3)</td>
</tr>
<tr>
<td><strong>Age at diagnosis (years)</strong></td>
<td><strong>Men</strong></td>
<td><strong>Women</strong></td>
</tr>
<tr>
<td>&lt;55</td>
<td>3911 (10.0)</td>
<td>2474 (14.1)</td>
</tr>
<tr>
<td>55-64</td>
<td>9564 (24.4)</td>
<td>3906 (22.3)</td>
</tr>
<tr>
<td>65-74</td>
<td>14,850 (37.9)</td>
<td>5829 (33.2)</td>
</tr>
<tr>
<td>75-94</td>
<td>10,882 (27.8)</td>
<td>5346 (30.5)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>39,207</strong></td>
<td><strong>17,555</strong></td>
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Table 2 Five-year prevalence and rate (per 100,000) for lung cancer over the period 1987 to 2007 by age group and sex, New South Wales, Australia

<table>
<thead>
<tr>
<th>Age</th>
<th>5-year prevalence (rate per 100,000)</th>
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<tr>
<td>Men</td>
<td></td>
</tr>
<tr>
<td>&lt;55</td>
<td>217 (9.6)</td>
</tr>
<tr>
<td>55-64</td>
<td>566 (214.3)</td>
</tr>
<tr>
<td>65-74</td>
<td>681 (382.7)</td>
</tr>
<tr>
<td>75-94</td>
<td>284 (335.3)</td>
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<tr>
<td>Total</td>
<td>1748 (62.5)</td>
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<tr>
<td>Women</td>
<td></td>
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<tr>
<td>&lt;55</td>
<td>107 (4.9)</td>
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<tr>
<td>55-64</td>
<td>182 (68.2)</td>
</tr>
<tr>
<td>65-74</td>
<td>213 (99.9)</td>
</tr>
<tr>
<td>75-94</td>
<td>96 (63.6)</td>
</tr>
<tr>
<td>Total</td>
<td>598 (21.2)</td>
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Table 3 Projection of five-year lung cancer prevalence up to 2017 based on two different assumptions in New South Wales, Australia

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<th>Assumption</th>
<th>5-year prevalence (number)</th>
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<th>2013</th>
<th>2015</th>
<th>2017</th>
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<td>2246</td>
<td>2309</td>
<td>2374</td>
<td>2441</td>
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<tr>
<td><strong>Women</strong></td>
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<td></td>
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</tr>
<tr>
<td>Constant*</td>
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<td>1859</td>
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<td>1910</td>
<td>2110</td>
<td>2340</td>
<td>2598</td>
</tr>
</tbody>
</table>

* the prevalence rates for 2008-2017 would remain constant as the most recent year (2007)

Figure legends

Figure 1 Age-standardised 5-year prevalence rate* of lung cancer by sex, New South Wales, Australia 1987-2007 and projections to 2017
* based on the dynamic assumption: the past trends in 1987-2007 would continue into 2008-2017

Figure 2 Aged-standardised lung cancer incidence rates by sex, New South Wales, Australia 1983-2007

Figure 3 Relative survival for lung cancer by period and sex, New South Wales, Australia 1987-2007

Supplementary information

Figure S1. Trends in age-standardised lung cancer incidence rates by sex and age group, New South Wales, Australia 1983-2007
Figure 1

The figure shows a trend over time for rates per 100,000 population. The x-axis represents years from 1987 to 2017, and the y-axis represents the rate per 100,000. Two lines are depicted: one for men (solid blue line) with data points for observed values and another for estimated values, showing a decline over time. Another line represents women (dashed red line) showing an increasing trend. A vertical line indicates the year 2007 where data availability changes.
Tables and figure legends

Figure 2

Figure 3
Figure S1

[Diagram showing trends in disease rates per 100,000 population over years for men and women across different age groups: 18 to 54 years, 55 to 64 years, 65 to 74 years, and 75 to 94 years. The data indicates a general decrease in rates for men and a slight increase for women.]