RESEARCH ARTICLE

The cost of lost productivity due to premature lung cancer-related mortality: results from Spain over a 10-year period

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Abstract

Background: Cancer mortality is one of the major causes of productivity loss; and within all cancer sites, malignant neoplasms of the lung continue to be the principal cancer-related cause of death in Spain, with a survival rate of only 10.7%. Thus its effects in labour productivity are a major concern and represent a great social impact. The objective of this study was to evaluate the productivity losses that occur as a result of premature deaths due to lung cancer in Spain.

Methods: The human capital approach was used to calculate the costs derived from the premature mortality due to lung cancer, via the extraction of data on mortality, reference salaries and unemployment rates.

Results: Deaths due to lung cancer represented the 28.90% and the 10.83% of all cancer-related deaths in 2017 in males and females respectively, with an increasing tendency in this last group. In addition, the YPPLL count increased in the study period among females. Lung cancer was responsible annually for 60,846 YPPLL, and productivity losses summed €13.1 billion over the 10 year period.

Conclusions: The assessment of productivity losses due to lung cancer provides new information that may assist decision makers in the allocation of resources, reducing the burden it supposes in working-age individuals.

Keywords: Lung cancer, Years of potential productive life lost, Productivity costs, Human capital approach

Background

Lung cancer is the fourth most prevalent cancer among males in Spain, the ninth in women, and the leading cancer-related cause of death in males [1]. Worldwide, tracheal, bronchus and lung cancers were the leading cancer-related cause of death for both males and females in 2013 [2], indeed, in Spain, the 5 year survival rate is only 10.7% [3].

Lung cancer mortality peaks in individuals aged 75 to 79 years in developed countries as the United Kingdom [4]; however, worldwide, the highest rates are observed in males between 60 and 75 years of age [5]. Altogether, deaths prior 65 years of age have a notorious impact on economic productivity, in which cancer plays a great role [6]. In males, cancers of the trachea, bronchus and lung together were the leading cause of disability-adjusted life-years (DALYs), which combine health loss with premature mortality, accounting for 34.7 million DALYs in 2013, 62% of those in developing countries and 38% in developed countries [2].

Estimations of productivity loss provide valuable data for informed resource allocation. Distinct approaches are used to estimate lost productivity. The human capital approach is the majority method, based on the assumption that individuals have a potential productivity to their retirement age that is reduced due to illness or death, leading to losses that can be quantified [7]. Secondarily, the friction cost approach is centred on the losses that take place in the time it takes to replace a worker; this method aims to provide a more realistic calculation, however, it requires the use of a standard measurement of replacement time [8]. Finally, other methods exist focusing on different variables, for instance the willingness to pay approach values immaterial costs as pain and distress [9].
Altogether, predictions of cancer mortality-related productivity loss have been projected for various countries [10, 11]. In Spain, the estimated losses due to cancer temporary disability were €248.6 million in 2005 [12], added to the €2.5 billion in losses due to premature mortality estimated in 2009 [13]. The scale of such costs demonstrates the extent of the burden of cancer and the possible economic gains that could be reached by the implementation of informed policies that reduce the incidence of the cancers causing the most expenses.

The present study aimed to evaluate the losses in terms of productivity that occur as a result of premature deaths due to lung cancer in Spain.

Materials and methods

Study design

This study was developed based on the human capital approach to calculate the costs derived from premature mortality due to lung cancer, considering the income and contribution to the nation productivity of an individual that are prevented when a premature death occurs. This method was selected taking into account previous studies in the country, and looking to provide a calculation from the worker’s perspective.

Mortality data and reference salaries per age group were obtained from the Spanish National Statistics Institute (INE) [14, 15]. The years of potential productive life lost (YPPLLs) due to premature mortality from lung cancer were estimated by multiplying the number of lung cancer-specific deaths for a given age group by the expected productive years remaining for each group. Retirement age was fixed at 65 years.

To obtain an estimation of costs of premature mortality, age- and sex-specific annual wages from death age to age of retirement were used. YPPLL was corrected per age- and gender-specific unemployment rates [16] and an annual discount rate of 3% was applied to future income values. A sensitivity analysis was conducted considering two alternative discount rates (0 and 6%).

Results

In total, 212,632 people died of lung cancer in Spain between 2008 and 2017, 69,225 during working age. Deaths due to lung cancer represented 28.90% of all cancer-related deaths in 2017 in males and 10.83% in females, with an increasing tendency in this last case (Table 1). The year 2008 displayed the highest number of YPPLLs for males, 49,654, while the highest number in females was observed the last year of the study period, 23,035 measured in 2016. Altogether, the average annual YPPLL count was 60,846.

The year 2017 was considered the reference year in the analysis of the age distribution of YPPLL. Premature mortality in the age period between 50 and 59 years accounted for the highest values of YPPLL (Fig. 1).

Productivity losses derived from total cancer-related mortality were calculated in order to assess this data in context. Lung cancer accounted for 22.33% of the losses

| Year  | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|-------|------|------|------|------|------|------|------|------|------|------|
| Number of deaths        |      |      |      |      |      |      |      |      |      |      |
| males                  | 17,150 | 17,279 | 17,285 | 17,479 | 17,661 | 17,559 | 17,194 | 17,239 | 17,598 | 17,241 |
| females                | 3049  | 3122  | 3447  | 3579  | 3826  | 4105  | 4057  | 4357  | 4557  | 4848  |
| Deaths at working age  |      |      |      |      |      |      |      |      |      |      |
| males                  | 5613  | 5564  | 5520  | 5468  | 5535  | 5252  | 5064  | 5015  | 5004  | 4697  |
| females                | 1290  | 1321  | 1495  | 1497  | 1657  | 1736  | 1680  | 1902  | 1918  | 1997  |
| % of lung cancer related deaths |      |      |      |      |      |      |      |      |      |      |
| males                  | 28.43 | 26.61 | 27.94 | 33.61 | 26.95 | 27.59 | 34.38 | 25.46 | 25.65 | 28.90 |
| females                | 7.68  | 8.29  | 8.39  | 10.54 | 9.37  | 9.75  | 10.22 | 9.98  | 10.91 | 10.83 |
| YPPLL                  |      |      |      |      |      |      |      |      |      |      |
| males                  | 49,654 | 47,097 | 46,225 | 46,239 | 46,455 | 43,281 | 40,852 | 40,065 | 38,757 | 36,246 |
| females                | 15,210 | 15,368 | 16,430 | 16,126 | 17,491 | 17,708 | 16,390 | 18,076 | 17,754 | 23,035 |
in 2017, and lost productivity derived from lung cancer peaked the year 2010 when it represented 32.72% of losses (Fig. 2).

**Discussion**

Cancer mortality has been pointed out as one of the major causes of productivity loss [12]. Hence, the increasing interest on measuring and quantifying its economic and social impact.

In general calculations, the productivity loss linked to tumors has been estimated to rise up to hundreds of billions of dollars. The year 2000, the productivity losses associated with cancer only in the United States summed $116 billion and were projected to increase to $148 billion in 2020 [6]. Conversely, in Australia, estimations lower this sum to around $4.2 billion, and 88,000 YPPLLs, presumably an effect of the smaller population [11]. The same study remarked lung cancer as one of the malignancies accounting for the highest portion of costs, in line with former findings in health loss and premature mortality [2]. Lung cancer is, in many countries, the most prevalent cancer type among males, and the principal cancer-related cause of death [17–19]. A study developed in 30 European countries, cancer was appointed responsible for losses of €75 billion, with lung cancer representing 23% of total costs [18], while another study centred in the EU measured €126 billion in losses, with lung cancer representing 15% of the total [19]. In the present study, losses attributable to lung cancer represented 22.33% of all cancer-related losses in 2017.

Similarly, a revision of data in Spain linked cancer to 43.5% of deaths at working age, accounting for 298,753 YPPLL in 2009 and €2.5 billion in losses [10]. Herein, lung cancer alone represented 36,246 YPPLL for males and 23,035 for females in 2017; and its costs summed €1.4 billion that year, €13.1 billion over a ten year period. The differences observed in the number of YPPLL between males and females, as well as the opposed tendencies are presumably

| Year | Premature mortality costs (baseline) Males | Premature mortality costs (0%) Males | Premature mortality costs (6%) Males | Premature mortality costs (baseline) Females | Premature mortality costs (0%) Females | Premature mortality costs (6%) Females |
|------|------------------------------------------|-------------------------------------|-------------------------------------|--------------------------------------------|---------------------------------------|---------------------------------------|
| 2008 | 1245                                     | 1278                                | 1214                                | 319                                        | 327                                   | 310                                   |
| 2009 | 1182                                     | 1213                                | 1153                                | 244                                        | 251                                   | 237                                   |
| 2010 | 1159                                     | 1190                                | 1130                                | 228                                        | 234                                   | 222                                   |
| 2011 | 1140                                     | 1170                                | 1112                                | 219                                        | 225                                   | 213                                   |
| 2012 | 1158                                     | 1189                                | 1129                                | 174                                        | 178                                   | 169                                   |
| 2013 | 1078                                     | 1107                                | 1052                                | 170                                        | 174                                   | 164                                   |
| 2014 | 1019                                     | 1045                                | 993                                 | 164                                        | 169                                   | 161                                   |
| 2015 | 998                                      | 1024                                | 974                                 | 225                                        | 231                                   | 218                                   |
| 2016 | 963                                      | 988                                 | 939                                 | 254                                        | 261                                   | 247                                   |
| 2017 | 899                                      | 923                                 | 877                                 | 284                                        | 291                                   | 277                                   |
| Total| 10,841                                   | 11,126                              | 10,573                              | 2281                                       | 2342                                  | 2218                                  |
derived from the difference in smoking habits and other trends that promote an increasing incidence among women [20]. However, in the calculation of losses, the significantly different wages for males and females in Spain play an important role and distort any interpretation of mortality trends [16].

Interestingly, €2.1 billion in productivity losses were estimated for women with breast cancer in Spain in 2014 [21], an elevated figure presumably due to the prevalence of this cancer type in females. It must be considered that the human capital approach allows an estimation of losses that provides a general vision of disease burden, but comparisons among different studies can become a limitation. In addition, it attributes a greater weight to deaths affecting young working males, versus groups with lower employment rates or income, and thus leading to underestimates and overestimates [16]; its use is nonetheless generalised in the recent literature given its efficacy [22].

On the other hand, further considerations including a calculation of DALYs could be of interest to estimate the social impact of lung cancer, since early onsets of the disease may lead primarily to an incapacity for work.

It is interesting to highlight the increasing incidence of lung cancer-related deaths in females during the study period, a tendency that has been observed at a global scale [23] and continues to pose a challenge for researchers. Nonetheless, a global decreasing tendency of cancer-related deaths has been described, yet important variations are observed per cancer typeology [24]. Such trends must be taken into consideration for an adjusted distribution of resources. Equally, the increased years of potential productive life that are lost by the premature death of workers with ages between 50 and 59 years are noteworthy in order to develop adjusted programs.

Conclusions

The assessment of total productivity losses due to lung cancer provides new information that may assist decision makers in the allocation of resources. Lung cancer supposes a significant burden in Spain, with an increasing tendency in women that is reflected in the increasing number of YPPLL. The promotion of programs aiming to reduce the incidence of lung cancer in working-age individuals will presumably yield substantial reductions in productivity loss counts.

Abbreviations

DALYs: Disability-adjusted life-years; INE: Spanish national statistics institute (Instituto Nacional de Estadística); YPPLL: Years of potential productive life lost

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Authors’ contributions

JD contributed to the investigation by interpreting the economic situation of lung cancer in Spain and was a major contribution in the intellectual content revision. AM analysed lung cancer situation in Spain, analysed and interpreted the statistical data, and was a major contributor in writing the manuscript. Both authors have read and approved the final manuscript.

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Availability of data and materials

The data that support the findings of this study are available from the Spanish national statistics institute at http://www.ine.es.

Ethics approval and consent to participate

Ethics committee approval and patient consent were not required for this study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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