HSE

Health and Safety Executive

Costs to Britain of Work-Related Cancer

Prepared by the Health and Safety Executive

RR1074

Research Report

Prepared 2015
First published 2016

Understanding the economic and wider impacts of work-related cancer is important to inform HSE's regulatory decision making and engagement with stakeholders on the case for proportionate risk management in the workplace. Monetised estimates are used by HSE in Regulatory Impact Assessments and other evaluations and economic analyses.

This report presents new research which estimates in monetary terms the total annual economic burden of new cases of work-related cancer in Great Britain (GB) in 2010. It is the first attempt at such an estimate and provides the most comprehensive indicator of the overall burden on society available. The analysis accounts for a broad range of impacts from work-related cancer and how the costs fall to different groups: individuals, employers, government, and society as a whole. Costs are estimated for the 24 work-related cancer types identified in the HSE Cancer Burden Study, which was published in 2010, based on both the known and the probable carcinogens classified by the International Agency for Research on Cancer.

The results suggest that the total economic costs of new cases of work-related cancer in GB in 2010, arising from past working conditions, were around £12.3 billion. Individuals bear the vast majority of the costs of work-related cancer.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

HSE Books

Costs to Britain of Work-Related Cancer

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Acknowledgements
The authors would like to thank the following: Alan Spence, Maria Ottati, Stavros Georgiou, Heidi Edwards and Yiqun Chen at HSE for the guidance and internal review at various stages of the project; Lesley Rushton and Sally Hutchings at Imperial College London for their advice and input; and Richard Dubourg at The Economics Interface Ltd for undertaking an external peer review of an earlier version of the report.

Key Messages

- Understanding the economic and wider impacts of work-related cancer is important to inform HSE's regulatory decision making and engagement with stakeholders on the case for proportionate risk management in the workplace. Monetised estimates are used by HSE in Regulatory Impact Assessments and other evaluations and economic analyses.

- New research has been carried out to estimate in monetary terms the total annual economic burden of new cases of work-related cancer in Great Britain. Costs are estimated for the 24 work-related cancer types identified in the HSE Cancer Burden Study, which was published in 2010, based on both the known and the probable carcinogens classified by the International Agency for Research on Cancer.

- The costs are categorised into five main groups. Four costs groups are financial impacts: productivity costs incurred due to the effects of cancer on an individual's ability to work; health and rehabilitation costs; employers' liability insurance costs; and administration and legal costs. Additionally, the research included a methodology to value the 'human costs' of cancer, over and above financial impacts, in terms of the effects on quality of life, and loss of life in the case of fatal cancers. The research provides estimates of the total costs to society as a whole, as well as the costs to individuals, employers, and government.

- The results suggest that the total economic costs to society of new cases of work-related cancer in GB in 2010, arising from past working conditions, were around £12.3 billion. The largest overall costs arise from lung cancer (£6.8 billion), mesothelioma (£3.0 billion), and breast cancer (£1.1 billion). Individuals bear the vast majority of the costs of work-related cancer: around £12.0 billion, or 98% of total costs to society, due largely to human costs (£11.4 billion).

- An assessment of the potential net cost savings from reducing exposures to carcinogens in the workplace would need to consider the costs of measures to control these risks.

- The estimates are subject to considerable uncertainty, due to both uncertainties in the number of cases of cancer attributable to work, and in the value of impacts arising from these cases, particularly human costs.

Executive Summary

This report presents new research which estimates in monetary terms the total economic burden of work-related cancer in Great Britain (GB). It is the first attempt at such an estimate in GB and, to our knowledge, it provides the most comprehensive indicator of the overall burden on society available in the literature.

HSE's annual estimates of the costs of new cases of workplace injury and work-related ill health, which do not include work-related cancer or other long-latency diseases, estimate costs of some £14.3 billion in 2013/14. The HSE Cancer Burden Study estimated that in 2005, 8,000 cancer deaths and 13,600 new cases of cancer were attributable to occupational risk factors (Rushton *et al.* 2010). This suggested that economic costs of work-related cancer were an important gap in the evidence base, which this research seeks to address.

Having reliable evidence on the economic impacts of work-related cancer will assist HSE in making the case to stakeholders for proportionate risk management, as well as ensuring that the costs are fully accounted for in regulatory decision-making. More generally, we anticipate this work will also contribute to the body of evidence around the costs of occupational risk, on which impacts give rise to the greatest economic costs, and on how the costs fall on different parties.

The cost model provides a means of adding together very different cost components from a range of work-related cancers so that they can be presented in a single summary measure. There is interest in such a measure from a wide range of stakeholders: Government; the media; private sector organisations; employer organisations; trade unions; academics and the public. It is important that this overall measure is robust, transparent and based on sound evidence: the methodology has involved extensive internal peer review with HSE analysts and scientists, as well as external expert peer review.

Research aims

The primary aims of this research are to provide a credible, evidence-based estimate of: i) the total costs of new cases of work-related cancer in GB, which can be used in making the economic case for health and safety to HSE's stakeholders; and ii) the costs per case of cancer that can be applied in HSE Regulatory Impact Assessments (IAs), evaluations and other economic analyses, to ensure they provide a robust basis for decision-making and continue to stand up to external scrutiny.

Methodology

The research builds upon the established modelling framework employed to produce HSE's annual estimates of the costs to Britain of workplace injuries and new cases of work-related ill health arising from current working conditions (hereafter referred to as 'Costs to Britain'), with important developments to capture the particular characteristics of work-related cancer. The research includes a methodology to value the 'human costs' of cancer, in terms of the effects on quality of life, and loss of life in the case of fatal cancers.

A key input is the HSE Cancer Burden study, as the best available estimate of the proportion of general population cancers attributable to occupational risk factors (attributable fractions) and the basis of HSE's official cancer burden estimates. We derive estimates for all 24 cancer types identified in that study, accounting for differences in costs arising from cancers that become fatal ('fatal cancers') and cancers that are not fatal ('non-fatal cancers').

The attributable fractions are applied to data on new cases of work-related cancer diagnosed in 2010 (cancer registrations). Because of the latency of work-related cancer (between exposure to carcinogens and possible development of the disease), the cases and costs derived in this report reflect ***past working conditions***.

The costs are categorised into five main groups as follows:

- **Productivity costs:** Costs incurred due to the effects of cancer on an individual's ability to work, such as loss of potential output, costs to firms of responding to a worker absence, etc.

- **Health and Rehabilitation costs:** The costs to Government (i.e. the National Health Service) of medical treatments for cancer sufferers, and any "out of pocket" expenses for individuals.

- **Employers' Liability Insurance costs:** The overhead cost of Employers' Liability Insurance, a compulsory insurance for all employers (except the state).

- **Administration and Legal costs:** The costs of administrative activities (to individuals, employers and the Government) associated with sick pay and benefit payments, compensation and insurance claims, etc., plus costs associated with investigations and enforcement action.

- **'Human' costs:** A monetary valuation of the effects of cancer on quality of life, and loss of life in the event of fatal cancers, over and above financial impacts.

Work-related cancer imposes costs on different groups in society. The model distinguishes broadly between three in our analysis: individuals, employers, and government. In addition, it estimates net costs to society as a whole by accounting for transfers between these stakeholder groups.

This research does not account for impacts associated with conditions preceding the onset of cancer, for example in cases where silicosis occurs prior to lung cancer due to exposure to respirable crystalline silica.

Main findings

Total Annual Costs

As shown in Table E1, the research estimates that the total annual economic costs to society of work-related cancer were £12.3 billion in 2010. This represents the present value lifetime costs of all newly registered cases of cancer in 2010 that can be attributed to exposure to carcinogens at work in the past (due to latency), based on attributable fractions.

'Human costs' account for around £11.4 billion per year, or just over 93% of total costs. This demonstrates the importance of estimating this impact in monetary terms; however, readers should note the challenges in doing so and the degree of uncertainty around this estimate in particular, which is discussed further in the main report.

Financial costs account for 7% of the total economic costs of work-related cancer. This is a much smaller proportion of overall costs than in the *Costs to Britain* model (where in 2013/14 they accounted for around 44% of overall costs, including workplace injuries and work-related ill health). The difference is driven mainly by the age profile of work-related cancers; the majority of individuals are beyond retirement age at the time they are diagnosed with cancer, so their illness does not result in a loss of output from work.

Table E1: Total annual costs of new cases of work-related cancer by cost component

	Estimated costs (£ millions)		
	Fatal cancer	Non-fatal cancer	Total
Human costs	£11,104	£297	£11,401
Productivity Costs	£524	£15	£539
Health and Rehabilitation costs	£133	£41	£174
Employers' Liability Insurance	£168	£0	£168
Admin and Legal costs	£11	£8	£18
Total costs	**£11,939**	**£360**	**£12,300**

Note: Totals may not sum due to rounding

The model also produces a breakdown of costs by cancer type. The largest overall costs to society arise from lung cancer (£6.8 billion), mesothelioma (£3.0 billion), and breast cancer (£1.1 billion).

Costs per average case of cancer ('appraisal values')

As shown in Table E2, the average cost per case of a work-related cancer is estimated at £759,100. This increases to over £1 million if non-melanoma skin cancers are excluded, as these typically incur low costs. See main report for average costs by cancer type.

The average cost of a fatal workplace cancer is estimated to be around £1.3 million, compared with £53,100 for a non-fatal case. The disparity between the two is largely due to the valuation placed on the loss of life associated with fatal cancers ('human costs').

Table E2: Costs per average case of cancer ('appraisal values')

	Human Costs (£, rounded)	Financial Costs (£, rounded)	Total Costs (£, rounded)
Average case of cancer	£703,600	£55,500	£759,100
Average fatal cancer	£1,180,000	£88,300	£1,268,000
Average non-fatal cancer	£43,700	£9,400	£53,100

Note: The model also produces unit costs by cancer type, which are provided in the main report.

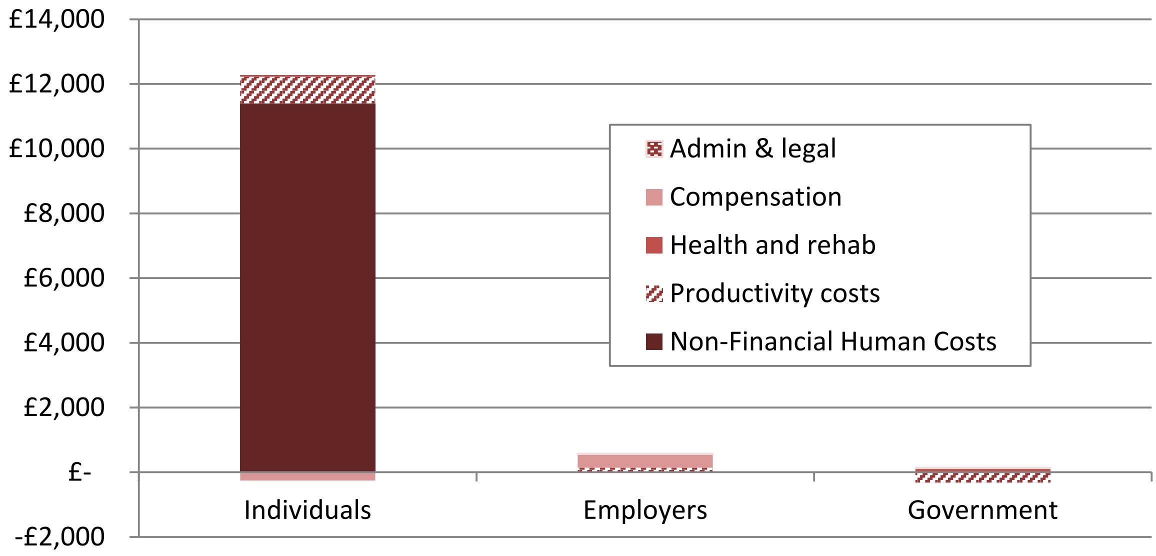
Costs by stakeholder group

Figure E1 shows that individuals bear the vast majority of the costs of work-related cancer: net costs to individuals are around £12 billion, or around 98% of total costs. By comparison, employers bear a much smaller share of the overall costs, at £461 million.

This is primarily due to the latency between exposure to carcinogens and the (possible) development of cancer, which is often decades. By the time most individuals are diagnosed with cancer, they are past state pension age, meaning they are likely to be retired, and many of those who are still working will be with a different employer or even in a different industry. This means that employers do not incur the costs of disruption from sickness absence and paying sick pay.

Government also experiences some net "savings" due to state pensions that are no longer collected by individuals who die as a result of work-related cancer, which outweigh costs to government, such as healthcare (NHS). It is important to emphasise that these are not economic costs, simply transfers from individuals who do not receive state pension payments to Government (and ultimately taxpayers). While there may be some isolated "benefit" for public finances (and this analysis does not claim to be a complete assessment of the public finance impact of work-related cancer), there is a clear and large aggregate loss to society, which is of main concern for Government.

Figure E1: Breakdown of costs by cost component and stakeholder group (£ millions)



Conclusions

- The £12.3 billion estimate of total aggregate costs represents the potential costs to society per year that could have been avoided if exposure to carcinogens was reduced. However, the actual net savings that would be realised would depend on the costs of measures to control risks. The estimate is also subject to considerable uncertainty, so should be considered illustrative of the potential magnitude of costs.

- The estimate of the total costs of work-related cancer can be used by HSE and its stakeholders to illustrate the current overall economic burden of cancers caused by past exposures, and the potential future costs of presently uncontrolled risks.

- Due to the latency of work-related cancers, the costs presented in this report arising from new cases of cancer reflect exposures to carcinogens under ***past working conditions***. Users should take care when comparing HSE's annual 'Costs to Britain' estimate, which reflects, as closely as possible, current working conditions.

- The distributional breakdown is relevant for policy. It suggests that employers do not bear the vast majority of the costs associated with the consequences of exposure to some of the risk factors they control. This limits financial incentives for employers to reduce those exposures based on concern for 'the bottom line' alone. The result provides an economic rationale for HSE to support, incentivise and regulate businesses to address cancer risks.

- The per case or 'appraisal values' can now be used in HSE's economic analyses of policy interventions to estimate the value, in monetary terms, of changes in the number cases of work-related cancer attributable to these interventions. This can be compared with other costs and benefits arising from interventions, in order to inform proportionate regulatory decision-making.

- Unlike the Costs to Britain estimate, the Costs of Work-related Cancer estimate will not be updated annually. It may be updated periodically, depending on the availability of more recent input data, in particular the proportion of cancers attributable to work. It is anticipated that the cost of work-related cancer would be relatively stable in the short term and so the estimates would be relevant for several years.

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1 Background

1.1 Rationale and aims for this study

1. Workplace injuries and ill health involve economic costs – to employers (e.g. disturbance to production), to individuals (e.g. the human costs associated with effects on quality of life, and loss of life in fatal cases) and to the Government (e.g. health care expenditure).

2. Estimating the costs of injuries and ill health related to work is not a new area for HSE: we have published estimates of the costs of workplace injury and work-related ill health periodically over the last two decades. HSE's annual publication *'Costs to Britain of workplace fatalities and self -reported injuries and ill health',* (herein referred to as "Costs to Britain") provides annual estimates of the aggregate costs of injuries and common ill health and unit costs, or 'appraisal values' for use in impact assessments and other economic appraisals.

3. In order to maximise HSE policy relevance, a central aim of the *Costs to Britain* model is to reflect, as closely as possible, the costs of injuries and illnesses arising from workplace health and safety risks posed by contemporary working conditions. Because of this, *Costs to Britain* excludes long-latency illnesses, such as cancer, which are often the product of exposure to workplace hazards decades prior.

4. The latest *Costs to Britain* estimated the total costs associated with workplace injuries and ill health in Great Britain to be some £14.3 billion in 2013/14.[1] This total has fallen since 2006/07, the first year for which they were calculated using the current model, reflecting the downward movement in injury and illness numbers. In 2010, research commissioned by HSE estimated the proportion of general cancer registrations (newly diagnosed cases of cancer) and deaths attributable to occupational risk factors (Rushton *et al. 2010*).[2] The study estimated that in 2005, 5.3% (8,000) of total cancer deaths and 4.0% (13,600) of total cancer registrations were attributable to occupational risk factors; that is, in the absence of these risks, we would expect to see the total number of cancers fall by this number.

5. Given the extent of work-related cancer estimated by Rushton *et al.* (2010), and the fact that many of these cancers are by their nature avoidable, the economic impacts of this burden is a clear gap in HSE's evidence base and one that has been noted by external stakeholders.

6. This study attempts to quantify in monetary terms the total economic burden of work-related cancer in Britain. Cancer sufferers face many physical and psychological losses of wellbeing during the progression and treatment of their disease. Individuals, the Government and employers also incur a range of financial and economic costs.

7. Most existing studies on the economic burden of cancer value parts of what economists term the 'Total Economic Cost' (TEC). Some studies focus on costs to sufferers (or their families) (Macmillan, 2006)[3] or overall costs such as medical costs and lost output (Leigh, 2011),[4]

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[1] HSE (2014), *The Costs to Britain of workplace fatalities and self-reported injuries and ill health, 2013/14.* Available at: http://www.hse.gov.uk/statistics/pdf/cost-to-britain.pdf

[2] Rushton, L., Bagga, S., Bevan, R., Brown., T.P., Cherrie, J.W., Holmes, P., Hutchings, S.J., Fortunato, L., Slack, R., Van Tongeren, M., Young, C. (2012) The burden of occupational cancer in Great Britain. Overview report for the Health and Safety Executive.

[3] Macmillan. 2006. The hidden price of getting treatment.

[4] Leigh, J. Paul (2011), Economic Burden of Occupational Injury and Illness in the United States

and in some cases just medical costs (Lee *et al.* 2012).[5] Some studies such as Orenstein (2010)[6] also seek to value the 'non-market' impact of pain, grief and suffering.

8. Whilst studies such as Featherstone and Whitham (2010)[7] have estimated the costs of general cancers, no attempt has yet been made in Britain to quantify the TEC of cancer related to work. The TEC represents the aggregate economic costs to society of work-related cancer, including the 'intangible' effects on quality and loss of life where possible, net of economic transfers between groups. It is the most complete economic indicator of the overall burden on society, and provides a basis for comparison with other health and safety risks, as well as with the costs of interventions to mitigate cancer risks in economic appraisals. See Section 11 for further discussion of the uses of the costs estimates.

1.2 Structure of this report

9. The basic structure of the report is as follows: Section 2 provides a discussion of the terminology used throughout this report, and defines the scope of the analysis; Section 3 describes the calculation of the attributable registrations – i.e. the methods used to arrive at the number of work-related cancer registrations that form the basis of cost estimates reported in the model.

10. The report is then organised broadly by cost component. Section 4 summarises the approach to valuing the 'human costs', or impact (in terms of effects on quality of life, or loss of life in the case of fatal cancers) on individuals affected by work-related cancer. Section 5 describes the methods used to estimate productivity costs, i.e. all of the costs incurred due to the effects of cancer on an individual's ability to work, such as loss of potential output, costs to firms of responding to a worker absence, etc. Section 6 discusses the various healthcare costs that arise due to work-related cancer. Sections 7 and 8 look at the costs of Employers' Liability insurance and the administrative and legal burden placed on the different stakeholder groups. Within each of the above Sections we first present the economic impacts at the societal level, before discussing how the costs fall to different groups within society.

11. Section 9 provides a summary of the total costs to society of work-related cancers, presenting the costs by cancer type and appraisal values. Section 10 discusses the various sources of uncertainty in the report. Section 11 describes the possible uses of the cost estimates, and finally a brief discussion of areas of further research is offered in Section 11.3.

12. The subject of the report is technical in nature but our aim is to ensure that the report is of interest and accessible to a wider audience. The main body of the report therefore provides a relatively high-level analysis and discussion of each of the various cost estimates; a more detailed and technical discussion can be found in a series of appendices that complement the main report, where appropriate.

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[5] Lee, L. J., Chang, Y., Liou, S. and Wang, J. (2012). Estimation of benefit of prevention of occupational cancer for comparative risk assessment: methods and examples.

[6] Orenstein, M. R., Dall, T., Curley, P., Chen, J., Tamburrini, A. L., & Petersen, J. (2010). The economic burden of occupational cancers in Alberta. Calgary, AB: Alberta Health Services.

[7] Featherstone, H. and Whitham, L. (2010). The cost of cancer. A Policy Exchange research note. This report provides an estimate of the costs of cancer in England (using an incidence-based approach). The results include impacts such as lost output and healthcare costs, however they exclude a monetary valuation of the impact on quality or duration of life, and so are not directly comparable with the results presented herein.

2 Definitions and scope

2.1 Cost structure

13. In attempting to estimate the total economic cost of work-related cancer, we consider a range of different impacts, and how they affect different groups in society. The main impacts of work-related cancer are similar to those estimated in the Costs to Britain report, so we apply the same analytical framework. These fall broadly under five categories:

- **Productivity costs:** These include all of the costs incurred due to the effects of cancer on an individual's ability to work, such as loss of potential output, costs to firms of responding to a worker absence, etc. It also includes a range of benefits payments and other transfers, which compensate individuals for being out of work and for the effects of their illness, See Section 5.

- **Health and Rehabilitation costs:** The costs to Government (i.e. the National Health Service) of medical treatments for cancer sufferers, and any "out of pocket" expenses for individuals. See Section 6.

- **Employers' Liability Insurance costs:** The overhead cost of Employers' Liability Insurance, a compulsory insurance for all employers (except the state). The cost to society represents the overhead cost to insurers of administering the scheme, plus the claim value consumed in legal costs and expenses that is removed from the claims value awarded to individuals. See Section 7.

- **Administration and Legal costs:** The costs of administrative activities to individuals, employers and the Government associated with informing of sickness absence and processing the various money inflows and outflows from sick pay and benefit payments, compensation and insurance claims, etc. The total legal costs and internal labour costs incurred by employers, HSE and Local Authorities are also a net cost to society. See Section 8.

- **'Human' costs:** A monetary estimate of the impact on quality of life experienced by those with work-related cancer, and of the loss of life in the case of fatal cancers, over and above financial impacts, such as loss of income. See Section 4.

14. In some instances, it has not been possible to quantify certain impacts, such as the costs of 'presenteeism', i.e. the extent to which work-related cancers lead to reduced work capacity and hence productivity. Where notable omissions have been made, these are acknowledged in the report and the implications of doing so are discussed.

15. Further, it is important to note that the estimates presented in this report do not account for any non-cancer conditions that might be present prior to the development of cancer from exposure to the same carcinogens, e.g. silicosis prior to the development of lung cancer. In these cases, cancer might represent the 'tail end' of a longer period of ill health and related costs to individuals, businesses and the public purse.

2.2 Impacts on different parties

16. Work-related cancer imposes costs on different groups in society. We distinguish broadly between three groups in our analysis, in addition to society as a whole:

- **Individuals:** we take individuals to mean the workers who are diagnosed with work-related cancer.

- **Employers:** by employers we principally mean current employers of the workers diagnosed with the cancer; however for some impacts, such as the costs of EL insurance, this extends to all existing employers that are required to take out EL insurance.

- **Government:** the costs to Government and the general taxpayer primarily reflect the impact of work-related cancers on public finances.[8]

- **Society:** the total costs of work-related cancer to all members in society. This will be equal to the sum of the costs to individuals, employers and Government, net of transfers.

17. When accounting for distributional impacts, we must account for a number of transfer payments between groups. For example, sick payments received by absent workers represent a financial cost to employers, but these will be an equal and opposite benefit to individuals so are not true economic costs. Impacts that involve equal monetary flows between the different stakeholder groups in society net to zero in the aggregate. Total costs to society therefore represent only economic costs, net of transfers.

18. See Section 9.2 for a breakdown of how the various impacts fall on different stakeholders.

2.3 Estimating costs

19. The majority of the costs in the model are estimated 'bottom-up' – that is, the aggregate cost is obtained by multiplying a unit, or per case cost, by the number of relevant registrations (simply *price* x *quantity*).

20. The availability of data means that some impacts, such as the costs of Employers' Liability Insurance and the costs of investigations and prosecutions, have been estimated using data on total costs (i.e. 'top down'), with an adjustment to derive costs of work-related cancer rather than other work-related injury and illness where necessary.

21. In order to provide appraisal values and costs by cancer types, some assumptions are required when attributing these 'top-down' costs between the 24 cancer types. Where this is the case, these have been noted in the text.

22. All cost estimates presented in this report are in 2013 prices, unless stated otherwise.

23. All financial costs or savings that occur in the future are discounted to the present at a rate of 3.5% to reflect the social rate of time preference applied in UK government analyses. A lower effective rate of 1.5% is applied to human costs, as discussed in Section 4.

2.4 Incidence approach

24. We take an incidence approach in this study; that is, we estimate the number of new cases of work-related cancer ('registrations') diagnosed in a given year (2010), and estimate the future lifetime costs for these cases. The available data was most suited to this approach.

25. An alternative is the prevalence approach, which estimates the total number of new *and* existing cases in a given year, and the costs arising from these cases *in the same year*. Both

[8] To the extent that public expenditure on welfare payments and treatment costs reduces the amount of resources available for public services elsewhere (which are enjoyed by all in society), one could argue that these costs are borne socially through general taxation.

of these approaches are methodologically 'valid', depending on data availability, and both represent annual costs due to work-related cancer. However, no data on the prevalence of work-related cancer is available for Great Britain.

26. Note that under either approach, the resulting estimates of work-related cancers and associated costs would represent the effects of past rather than contemporary working conditions. This is because of latency - i.e. the delay between exposure to carcinogens and the onset of any symptoms. For many of the work-related cancers, latency can be decades. For this reason, the estimates of the cost of occupational cancer are not directly comparable with HSE's publication on the 'Costs to Britain' of injuries and common illnesses, which primarily reflect current working conditions, and cannot be meaningfully added together to obtain a single annual estimate of costs.

3 Calculation of work-related cancer registrations and survival outcomes

27. This Section sets out the approach used in this study to estimate the total number of work-related cancer registrations. It also presents the number of cancers expected to be 'fatal' and the number who 'survive' or are 'non-fatal'. These estimates were derived solely for the purposes of this study and do not replace HSE's official cancer statistics.

28. Sections 3.1 and 3.2 set out the approach to estimating work-related cancer registrations in 2010, and the proportion of fatal / non-fatal cancers. Sections 3.3 and 3.4 present the results and discussion.

3.1 HSE Cancer Burden Study – estimating work-related cancer registrations

29. The HSE Cancer Burden Study (Rushton *et al.*, 2010) produced an estimate of the burden of 24 types of cancer arising from past workplace exposures in Great Britain (GB) up to 2005, using the population attributable fraction (AF) as the primary measure.[9] In the Cancer Burden study, AFs represented the estimated proportion of the cancer cases that would not have occurred in the absence of workplace exposure to carcinogens. Applying these AFs to national cancer incidence statistics, as in the HSE Cancer Burden study, provides an estimate of the number of work-related cancer registrations (AR) in Great Britain in a year. See Box 1 (next page) for further discussion on interpreting AFs.

30. The HSE Cancer Burden study is the most complete and up-to-date estimate available of the burden of work-related cancer in Great Britain. On this basis, we use AF estimates from the study to estimate the number of ARs in our model. We apply the HSE Cancer Burden AFs, which account for historical workplace exposures up to 2005, to the GB cancer statistics in 2010. We do this in order to provide a more 'up-to-date' estimate of ARs for use in the model, on the expectation that AFs are relatively stable in the short term.[10]

31. We use data on 2010 cancer registrations from the Office for National Statistics (ONS), Cancer Statistics, Registrations, Series MB1 for England,[11] the Scottish Cancer Registry[12], and the Welsh Cancer Intelligence and Surveillance Unit.[13]

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[9] Attributable fractions from the Cancer Burden study considered both the known and the probable carcinogens classified by the International Agency for Research on Cancer (IARC).

[10] Researchers from the cancer burden study in Imperial College London were consulted on this and they agreed with our approach. The HSE costs model can be updated with new data on registrations and attributable fractions when they become available in the future.

[11] Available from http://www.ons.gov.uk

[12] http://www.isdscotland.org/Health-Topics/Cancer/Scottish-Cancer-Registry/

[13] http://www.wales.nhs.uk/sites3/home.cfm?OrgID=242

Box 1: Interpreting Attributable Fractions

The Population Attributable Fraction (AF) is a statistical estimate of the proportion of disease that would not have occurred if a particular exposure had not occurred in the population. When AF is multiplied by the total number of disease cases in the population, it will give an estimated number of cases that are potentially preventable due to that exposure - i.e. the number of cases that are "attributable" to that exposure. This does not mean that the exposure was the only cause of these cases - indeed we cannot say which of the actual cases of disease occurring in the population are the "attributable" ones.

The estimate of the burden of work-related cancer does not mean that occupation was the only cause. Many, or most, will have non-occupational causes as well but in theory these non-occupational causes are accounted for in the calculation of AFs.

Lung cancer due to occupational asbestos exposure is a classic example. In fact here, the risk of lung cancer due to asbestos is much higher among smokers than among non-smokers because both exposures interact in creating a higher risk of the disease. Again, many of the lung cancers where asbestos played a role in causing the cancer will be among smokers.

Although there are uncertainties and biases inherent in estimating attributable fractions, it is a useful measure that can translate the available epidemiologic evidence on disease risk and associated exposure into a reasonable estimate of the overall burden of disease, and indicates the potential benefits of preventative measures.

32. In order to derive our cost estimates, we required a breakdown of ARs by gender and age. While the HSE Cancer Burden study provided a breakdown of AFs by gender, it did not do so by age. Therefore, we have applied the same AFs to each age group[14] Doing so introduces some error into the estimates, but it is an unavoidable limitation of the data.[15] See Table 24 in Appendix 4C for detailed registrations by age and cancer type results.

3.2 'Fatal' and 'non-fatal' cancers

33. Distinguishing between cancers that become fatal and cancers that do not is crucial for estimating economic costs in this study, since these will differ vastly in terms of 'human costs' and lost output in particular.

34. In general, following the diagnosis of cancer, the probability of dying from the disease (for those who have survived up to that point) will decrease with time from the diagnosis. A proportion of cancer patients can survive for a long time and may not die from the disease. This group of long-term survivors can be considered, at least in terms of their life expectancy, as cured. In our analysis, we group these into 'non-fatal' cancers.

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[14] For solid tumours, we apply an AF of zero for 15-19 and 20-24 age groups, due to the particularly long latency of these cancers, which according to information provided by Imperial College can be between 10-50 years with peak latency period of 35 years. The latency for haematopoietic neoplasms (blood cancers like leukaemia) is shorter at between 0-20 years, so we apply the AFs for these cancers to all age groups.

[15] We might expect work-related cancers to occur at an older age than non-work-related cancers, on the basis that most people do not start working until at least 18 and often need to be exposed over a sustained period of time for cancer to develop.

35. We estimate the number of fatal and non-fatal cancers from registrations data by applying estimates of the proportion of fatal and non-fatal cases in the cancer registrations for specific cancer types, as shown in Table 1.[16] [17]

Table 1: Attributable fractions, survival probabilities, and attributable registrations used in the model (continued on next page)

	Attributable fraction^ (2005)			Attributable registrations (2010)			
Cancer Site	**Male**	**Female**	**Mean fraction who do not survive^**	**Fatal - Male**	**Fatal - Female**	**Non-Fatal - Male**	**Non-Fatal - Female**
Bladder	0.07	0.02	0.45	231	24	282	30
Bone	0.00^^	0.00^^	0.59	0	0	0	0
Brain	0.01	0.00	0.91	12	2	1	0
Breast	0.00	0.05	0.30	n/a	671	n/a	1,531
Cervix	0.00	0.01	0.40	n/a	7	n/a	11
Kidney	0.00	0.00	0.59	1	1	1	1
Larynx	0.03	0.02	0.41	22	3	32	4
Leukaemia	0.01	0.01	0.59	21	6	15	5
Liver	0.00	0.00	0.98	5	2	0	0
Lung	0.21	0.05	0.94	4,477	914	286	58
Lympho-haematopoietic (LH)	0.00	0.00	0.51	0	0	0	0
Melanoma - eye	0.03	0.00	0.20	1	0	5	1
Mesothelioma	0.97	0.83	1.00	2,011	356	0	0
Multiple Myeloma	0.00	0.00	0.85	9	2	1	0
Nasal / sinonasal	0.46	0.20	0.59	71	22	50	16
Nasopharynx	0.11	0.02	0.85	14	2	2	0
Non-Hodgkin's lymphoma (NHL)	0.02	0.01	0.50	63	24	62	23
Oesophagus	0.03	0.01	0.86	156	26	26	4
Ovary	0.00	0.01	0.68	n/a	24	n/a	11

[16] These were provided by researchers for the HSE Cancer Burden study. who derived the approximate proportion of fatal and non-fatal cases in the cancer registrations for specific cancer types by applying the Weibull relative survival model to the published 1-, 5- and 10-year cancer survival rates for England. An alternative was to use mortality statistics, combined with the occupational attributable fractions to estimate attributable deaths (or fatal cancers), as applied in the HSE Cancer Burden study. Using registrations data simplified the modelling approach. We do not expect a substantial difference between the number of fatal cases estimated from registrations data and annual mortality statistics.

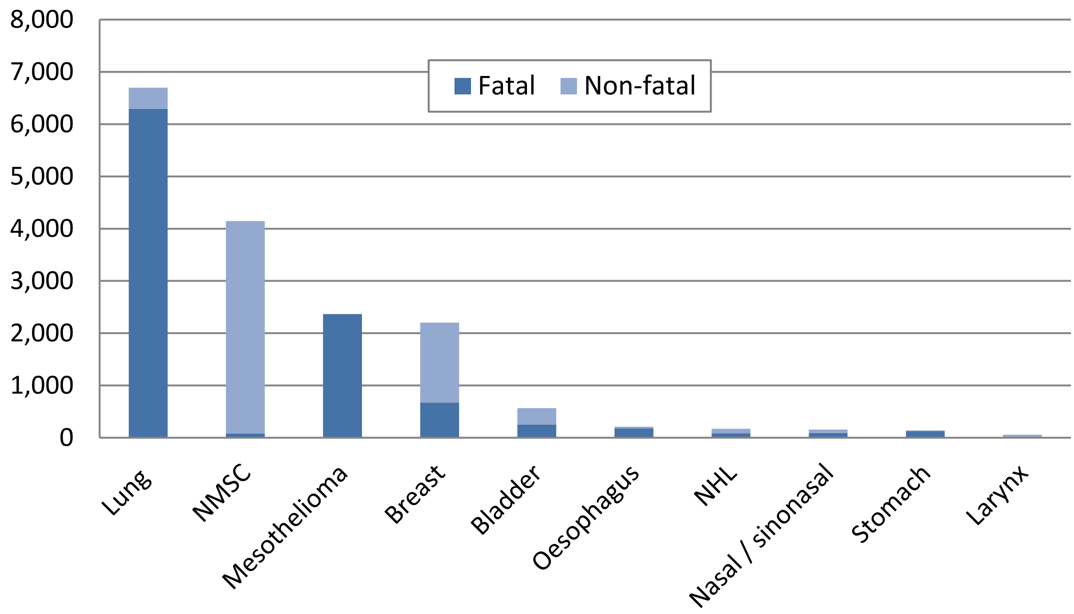
[17] Further information will be provided in a forthcoming supplementary report to the HSE Cancer Burden study. In brief, the statistical analysis was able to estimate the proportion of fatal cases where patients will die from the specific cancer and have an excess of mortality with respect to the general population, and the remaining proportion of non-fatal cancer cases where the patients have the same mortality probability as the general population. Note, therefore, that we assume those who do not die as a result of work-related cancer die of some other cause (i.e. that their work-related cancer does not contribute to their death).

	Attributable fraction^ (2005)			Attributable registrations (2010)			
Cancer Site	**Male**	**Female**	**Mean fraction who do not survive^**	**Fatal - Male**	**Fatal - Female**	**Non-Fatal - Male**	**Non-Fatal - Female**
Pancreas	0.00	0.00	0.97	1	0	0	0
Non-melanoma skin cancer (NMSC)^^^	0.07	0.01	0.02	78	10	3,813	460
Soft Tissue Sarcoma (STS)	0.03	0.01	0.53	15	4	13	3
Stomach	0.03	0.00	0.90	119	7	14	1
Thyroid	0.00	0.00	0.16	0	0	1	0
TOTAL				**7,307**	**2,106**	**4,605**	**2,185**

Note: Totals may not sum due to rounding.
^ Source: HSE Cancer Burden study
^^ For bone cancer, attributable fractions and registrations are rounded to zero.
^^^ NMSC registrations data Registrations data on NMSC is unavailable for Wales. We have approximated the number of NMSC registrations for Wales based on data provided in Table 1 of the HSE Cancer Burden study report on NMSC (http://www.hse.gov.uk/research/rrpdf/rr928.pdf). This shows that for the two years of data available (2000 and 2004), NMSC in Wales accounted for around 5.5% of total GB registrations.

3.3 Work-related cancer registrations in 2010: results

Figure 1: Top ten cancers by number of registrations



36. Table 1 provides detailed results for fatal and non-fatal cancers by gender, based on 2010 registrations data for Great Britain. Figure 1 provides a graphical summary of fatal and non-fatal cancers for the top ten cancers by number of registrations.

37. In total, for the purposes of this study, we estimate around 16,200 work-related cancer registrations in 2010. Note that these differ from HSE's published cancer burden statistics,

because the 2005 attributable fractions have been applied to 2010 cancer registrations data.[18]

38. Male registrations, at 11,900, account for a much greater proportion than female registrations, at 4,300. The relative burden is greater for men due to exposure to airborne carcinogens (e.g. asbestos, silica) in construction and other manual industries, where men account for the majority of employed labour.

39. Exposure to airborne carcinogens is the main factor in the dominance of lung cancer and mesothelioma, which account for a combined 7,800 deaths for men and women, or 82% of total cancer fatalities related to work.

40. Breast cancer is a large contributor of female cancer deaths (671, 32% total female fatal cancers related to work), due to probable effects of shift-working.[19]

41. Non-fatal cancers for men are dominated by non-melanoma skin cancer (NMSC) (3,800 registrations), due to the exposure of outside workers to ultraviolet (UV) light. For women, breast cancers are the largest non-fatal cancer (1,500 registrations).

42. As noted in Section 2.4, these attributable cancer registrations reflect historical rather than current working conditions.

3.4 The age profile of work-related cancers

43. The age profile of work-related cancer registrations in the model mirrors the profile of cancer registrations in the general population.[20] Figure 2 shows the distribution of work-related cancers by age.

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[18] HSE's latest cancer burden statistics can be found at: http://www.hse.gov.uk/statistics/causdis/cancer/index.htm

[19] Attributable fractions from the Cancer Burden study considered both the known and the probable carcinogens classified by the International Agency for Research on Cancer (IARC). The study included shift work, classified by IARC as a probable carcinogen.

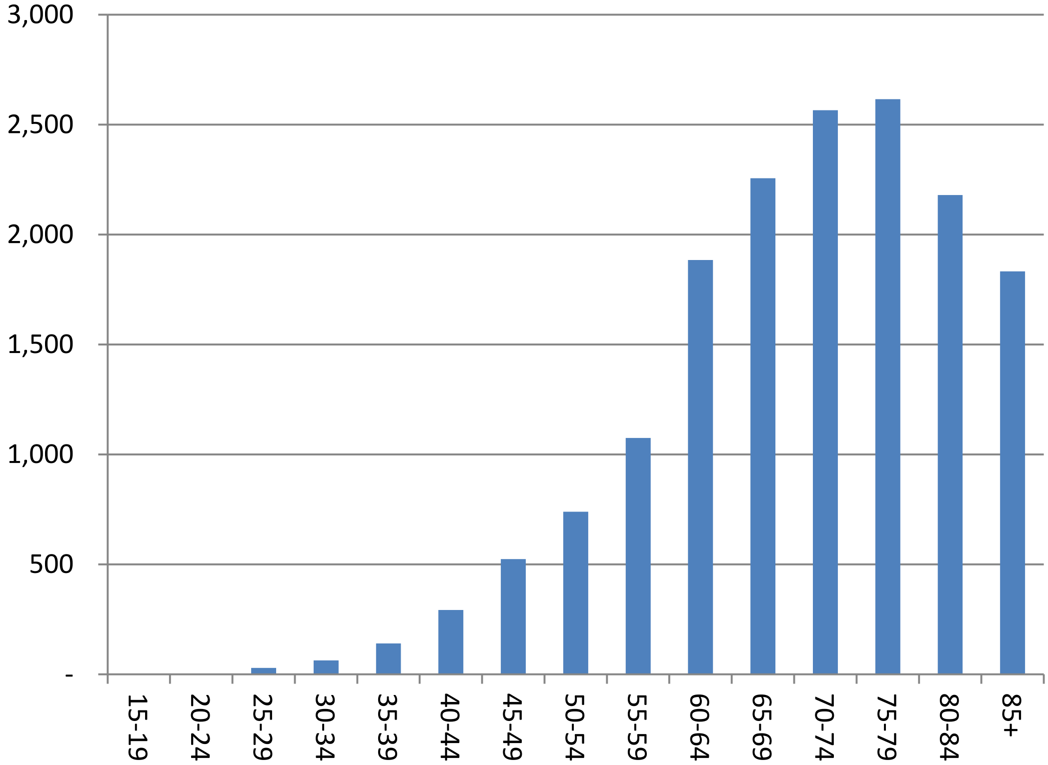
The specific HSE Cancer Burden study for breast cancer can be found at: http://www.hse.gov.uk/research/rrhtm/rr852.htm. See http://www.hse.gov.uk/Statistics/causdis/cancer/cancer.pdf for further information on HSE's latest work-related cancer statistics.

The Costs of Work-related Cancer study assessed the potential costs of all work-related cancers in HSE's official cancer burden estimates, which are based on the HSE Cancer Burden study. However, research on the causal effects of night work on breast cancer is still developing. A recent study conducted by Oxford University (Travis et al. 2016), funded by HSE, has investigated independently the link between night-shift work and breast cancer in a large group of women in the UK and the study did not find evidence of a link.

The new Oxford University breast cancer research was not available at the time that work was undertaken on the Costs of Work-related Cancer study. As is normal when new research becomes available, HSE will consider the implications of the new breast cancer research for its official estimates of work-related cancer burden, and hence of the economic costs of work-related cancer.

[20] This is a direct consequence of the attributable fractions applied, which were not available by age. The age of work-related cancers may differ from cancers in the general population for a given cancer type for a number of reasons, not least because the source and age at exposure is likely to differ. For example, we assume that 15% of cases of lung cancer are attributable to work whether they occur in the 75-79 age group or the 25-29 age group. In reality, while possible, it is unlikely that a worker in
(footnote continued on next page…)

Figure 2: Estimated age distribution of work-related cancers registered in 2010



44. The average age of work-related registrations is around 70, and over 70% of individuals are over 65 at the time of registering. There is usually a long latency between exposure to carcinogens and possible onset of cancer and associated symptoms. Different types of cancers have different average latencies. For example, the latency period for haematopoietic neoplasms (blood cancers like leukaemia) is between 0-20 years and for solid tumours is between 10-50 years, with peak latency period of 35 years. This distribution has direct implications for the cost estimates, in particular estimates of lost output and, depending on the valuation approach taken, human costs for fatal cancers, as summarised below.

45. Economic activity declines rapidly beyond state pension age and, as explained in Section 5 (Productivity Costs), we make the simplifying assumption that individuals retire once they are eligible for state pension. This affects estimates of lost output.

46. There are two possible approaches to calculating human costs for fatal cancers: one that values lives lost due to cancer, and another that values the number of life-years or life expectancy lost. In the latter approach, the age distribution affects human costs for fatal cancers, given that older individuals have fewer expected years of life remaining in the absence of work-related cancer. The valuation of fatal cancers dominates the cost estimates, making them highly sensitive to any changes in assumptions. See Section 4 (and corresponding Appendix) for a full discussion and comparison of the two approaches.

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their twenties has received sufficient occupational exposure to develop work-related cancer. However, as Figure 2 shows, this accounts for a very small proportion of total cases.

4 Human costs

4.1 Background

47. One of the primary impacts of work-related cancer is the effect of ill health on the individual's quality of life: the discomfort and pain associated with treatment, their ability to enjoy life, the consequences for loved ones, and the increased mortality associated with many cancers. We call these 'human costs', representing the effects on quality of life and loss of life, due to work-related cancer.

48. These impacts are real and wholly tangible to those suffering work-related cancer; however, they are challenging to estimate in economic or monetary terms. Like other 'non-market goods and services', such as clean air, national defence, and preservation of wildlife, health and increases in longevity cannot generally be purchased directly. This means that, unlike other impacts of cancer assessed in this report, such as the loss of output or healthcare treatment costs, there is no equivalent payment or transaction for changes in longevity or quality of life that provides a basis to readily estimate the value of losses or gains.

49. We can, however, approximate human costs based on existing evidence of the amount individuals – and society as a whole – are willing to pay to reduce the risk of harm and death.[21]

50. Excluding these costs on the basis that they do not involve a financial transaction would severely underestimate the costs of work-related cancer and diminish its economic importance relative to other, more readily measured impacts, such as the costs to businesses of controlling cancer risks.

51. HSE's Costs to Britain estimates suggest that human costs account for almost 60% of the £14.3 billion total economic costs in 2013/14 (2013 prices) arising from workplace injuries and work-related ill health (excluding cancer and other long-latency illness). Our estimates presented below show that human costs account for an even higher proportion of the costs of work-related cancer – over 90%.

52. The remainder of this section discusses the key methodological issues and approach taken, and presents the results of the assessment of human costs. Many of the methodological issues warrant more detailed discussion, which is provided in the appendixes, as referred to in the text below.

4.2 Valuing cancer risks

53. To estimate the human costs of workplace injuries, including fatal injuries, HSE's *Costs to Britain* applies values derived in the context of road transport injuries.[22] In doing so, we

[21] 'Willingness to pay' (WTP) to reduce risk is strictly a measure of benefit, since it represents the amount that individuals would be willing to pay for some improvement (in this case, a reduction in risk of an adverse outcome). 'Willingness to accept' (WTA) an increase in risk more closely approximates the costs arising from occupational risks, in the sense that they reflect the level of compensation required by individuals who bear the risk. However, for a number of reasons, valuations of costs and benefits in government are typically monetised using WTP valuations. WTP and WTA values can often differ widely, in part because WTA values are not bounded by ability to pay, hence they arguably do not reflect society's budget constraint. We maintain consistency with wider UK government practice in this report, and with HSE's *Costs to Britain* estimates, and use WTP-based values.

make the assumption that workplace injuries are similar to fatal road injuries: like road fatalities, deaths from injuries at work are often near-instantaneous, and the average age of a road fatality is similar to that of a workplace fatality.[23]

54. Cancer differs from injuries and many other work-related conditions in a number of ways. Firstly, there is a typically an extended period of latency – often decades – between the point of exposure to a carcinogen and the (possible) onset of the disease and associated symptoms.[24] This may lead people to place a lower valuation on the avoidance of death from cancer for two reasons: i) there is a large body of evidence that people place a lower weight on costs and benefits occurring in the future (e.g. Frederick *et al* 2002), and ii) the period of latency means that people tend to die of work-related cancer at a much older age than those who die of workplace or transport injuries, meaning fewer years of life are lost.

55. Secondly, death from cancer is commonly preceded by a period of progressive illness and associated pain, anxiety, distress and medical intervention. Thirdly, there are suggestions in some quarters that cancer may evoke dread related to other aspects or preconceptions about cancer. As Sunstein (1997) puts it, *"All deaths are bad. But some deaths seem worse than others".*[25] These two factors, taken in isolation, are likely to lead to a greater valuation of the avoidance of death from cancer. However, considered alongside the possible effects of latency described above, the overall net effect on valuations of cancer relative to fatal workplace and transport injuries is *prima facie* ambiguous.

56. The above discussion suggests that valuing cancer deaths using willingness to pay valuations based on road injuries may not faithfully account for the characteristics of cancer risks. Undertaking new large-scale primary research on valuations regarding cancer risks was outside the scope of this study, Therefore, there are two broad options: either apply a directly-elicited value for public WTP to reduce cancer risks, or make some adjustment to the roads valuation in order to reflect relative public preferences between cancer and road risks, or to otherwise capture the pertinent aspects of cancer summarised above.

57. In the past, HSE has taken a simple approach to valuing deaths from cancer, by applying a factor of 2 to the standard road-based 'value of preventing a fatality' (VPF), as set out in HSE (2001) *Reducing Risks, Protecting People* ('R2P2').[26] The aim of this was to reflect, in a very approximate way, the limited evidence available at the time, which indicated some public 'dread' of cancer (e.g. Jones-Lee *et al* 1985). HSE committed in R2P2 to review evidence for the adjustment in the future.

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[22] *Costs to Britain* also uses values derived from road transport injuries to value non-fatal injuries and short latency work-related illness. The latest report acknowledges that this treatment is less appropriate for work-related illnesses, and HSE analysts are commencing work to assess the feasibility of alternative approaches.

[23] The average age of a road death for all road users was 46 in 2014, based on Department for Transport Statistics: https://www.gov.uk/government/publications/reported-road-casualties-great-britain-annual-report-2014, table RAS30028. By comparison, the average age of death for a workplace injury fatality is approximately 50. See HSE statistics table 'RIDAGEGEN' for the latest fatal injury statistics by age: http://www.hse.gov.uk/statistics/tables/ridagegen.xls

[24] Different types of cancers have different average latencies. For example, based on information provided by Imperial College for the HSE Cancer Burden project, the latency period for haematopoietic neoplasms (blood cancers like leukaemia) is between 0-20 years and for solid tumour is between 10-50 years with peak latency period of 35 years.

[25] Sunstein, C.R. (1997). "Bad deaths", Journal of Risk and Uncertainty 14, 259-282

[26] Available at: http://www.hse.gov.uk/risk/theory/r2p2.pdf

58. In 2010, HSE economists commissioned a short review of the cancer valuation literature in order to assess the available evidence.[27] This concluded that existing evidence did not support the multiplier of 2 used by HSE and further that there were no suitable studies that provided either direct cancer valuations or evidence of a relative "premium" for cancer risks which could be transferred to the GB context. The review therefore advised that a UK-based empirical study to investigate relative public preferences between cancer and road risks should be undertaken.

59. HSE commissioned an empirical study from Newcastle University on the influence of dread and latency on public preferences towards cancer risk in the UK.[28] While the study found evidence of a greater public aversion to death from cancer relative to death from road injury, it also found that this is driven primarily by the morbidity associated with cancer prior to death. In order to take account of this finding, we adopt an approach to value morbidity associated with cancers directly, rather than to value it implicitly within a broad 'cancer premium'. The advantages of this approach are summarised below and discussed further in Appendix 3A:

- It allows us to estimate morbidity values that capture the differences in duration and intensity of illness between cancer types; by contrast, the Newcastle study was designed to elicit relative preferences between dying from a general case of cancer and a road accident, not specifically to elicit values of cancer morbidity. Therefore, using evidence of a cancer premium to infer morbidity costs will arguably capture the effects of cancer morbidity imprecisely, and may to some extent reflect respondents' preconceptions of illness associated with a generic case of cancer, rather than the actual morbidity effects of the types of cancer assessed in this study.

- The approach to valuing mortality in this report, described in Section 4.4, is consistent with the approach to valuing health impacts likely to be advised in a forthcoming update of HM Treasury guidance on economic appraisal in government (the 'Green Book'),[29] and with the way that the costs of illness are valued by a number of other key UK Government departments.

- It also allows the same methodology to be applied to estimate the costs of morbidity for fatal and non-fatal cancers.

60. Hence, we value the costs of mortality (death from cancer) and morbidity (ill health associated with both fatal and non-fatal cancers) separately. Total 'human costs' due to work-related cancer will be the sum of mortality and morbidity costs. Section 4.3 sets out the approach to valuing mortality, while Section 4.4 sets out the approach to valuing morbidity.

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[27] Jones-Lee, M., Loomes, G. (2010) The valuation and costing of work-related cancer. Report to the Health and Safety Executive.

[28] McDonald, R. L., Chilton, S. M., Jones-Lee, M. W., & Metcalf, H. R. T. (2016). Dread and latency impacts on a VSL for cancer risk reductions. Journal of Risk and Uncertainty, 52(2), 137–161. http://doi.org/10.1007/s11166-016-9235-x

[29] The current version of the Green Book can be found at:

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf

4.3 Valuing mortality

4.3.1 Age adjustment

61. The latency of cancers and the effect on the age profile of cancer registrations means that one of the key methodological considerations in valuing cancer mortality concerns 'age-adjustment'. As discussed in Section 3.4, the estimated average age at diagnosis for a cancer that becomes fatal is around 70,,compared with the average age of death for a workplace injury fatality at around 50.[30] Given this, should the analysis make an adjustment for the older age profile of cancer fatalities?

62. This is an empirical question but it also raises important ethical considerations. HSE has conventionally applied an approach that values lives lost, or 'saved', using a constant 'value of preventing a fatality' (VPF),[31] which does not vary with age. This in part embodies a normative judgement based on a principle of equality, that the value society places on a life should not be sensitive to age, or other personal characteristics – for instance, income.[32] It also reflects how HSE makes policy decisions, which do not distinguish between impacts on different age groups.

63. An alternative approach to valuing fatalities is currently being considered by HM Treasury, which may be presented alongside the conventional 'valuing lives' approach in Treasury 'Green Book' guidance. This values 'life years' lost or saved using a constant monetary value of a life year (VOLY) derived from the same studies underlying the Department for Transport's VPF. This results in a direct adjustment for the age of the affected population, as older people on average have fewer years of life remaining. Since the number of life years lost is lower for conditions that emerge later in life, like many work-related cancers, adjusting for age leads to a much lower valuation for work-related cancer.

64. While HSE analysts acknowledge that there are persuasive arguments for some form of age adjustment, there are also persuasive arguments not to do so, including ethical and moral issues. Additionally, the evidence to support a decision on exactly how to adjust is ambiguous.

65. An important function of this work is to provide 'unit costs', or appraisal values, for work-related cancers, which can be applied in appraisals of new policies. Given that the VPF with no age adjustment remains the principal approach to HSE appraisal, it is consistent that the fatal cancer appraisal value reflects this. Therefore, our main approach to estimating human costs presented in the remainder of Section 4 applies a constant value per life lost that does not vary age. Appendix 3 presents results under the alternative 'life years' approach (i.e. with age-adjustment) for illustration.

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[30] See HSE statistics table 'RIDAGEGEN' for the latest fatal injury statistics by age:

http://www.hse.gov.uk/statistics/tables/ridagegen.xls

[31] The VPF represents the value of the willingness to pay to avoid the loss of 'utility' or wellbeing associated with life, based on surveys regarding small changes in risk. It also includes an estimate of medical costs and lost output. HSE bases its VPF, routinely applied in the annual Costs to Britain of workplace fatalities and self-reported work-related injuries and ill health, on the DfT estimate, with some modifications to reflect characteristics of occupational risk. See http://www.hse.gov.uk/statistics/pdf/cost-to-britain.pdf and http://www.hse.gov.uk/research/rrhtm/rr897.htm for further information on HSE's approach.

[32] This is not the only reason why it may be appropriate to apply a universal VPF in government appraisal. If governments implement collective decisions, then it would appear reasonable that they use a single VPF covering the 'collective' they are representing, which reflects the population mean valuation of risk.

4.3.2 Valuing lives lost

66. In simple terms, this study values the 'human costs' from the loss of life due to work-related cancer by multiplying a) the number of fatal cancers, or lives lost by b) the 'human costs' component of the road transport VPF, derived from the Department of Transport's (DfT) published figures. As discussed in Section 4.2, we value the human costs relating to morbidity or illness prior to death from cancer separately. The approach to estimating morbidity costs and the results are discussed in Section 4.4.

67. The 'human costs' component of DfT's VPF represents the willingness to pay to avoid risk of death, *over and above* the (theoretical) loss of the consumption of goods and services that would no longer be enjoyed. [33] Hence we refer to these the 'human costs'.

68. The human costs component of the VPF was £1.2 million in 2013 prices.[34] We apply this directly in our model to estimate the human costs of mortality due to work-related cancer.

69. It is standard practice in government economic analyses to discount impacts that occur in the future, to reflect evidence that people generally place a lower weight future costs and benefits compared with those occurring in the present. Therefore, we perform an additional step of discounting the period between cancer diagnosis (registration) and death, at an effective rate of 1.5% per annum.[35]

Results

70. Table 2 shows aggregate mortality costs across all cancer types, and total costs for each of the 5 cancer types contributing the highest costs. Total estimated mortality costs arising from the estimated 9,400 deaths from cancers registered in 2010 were £10.7 billion.

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[33] As described in Spackman *et al.* (2011), DfT derive 'human costs' by subtracting an estimate of lost consumption from the total value of willingness to pay to reduce risk estimated in the studies on which the VPF is based. This adjustment is important where lost output is estimated separately, such as in the present study and figures estimated by DfT, to avoid double counting.

[34] DfT WebTAG, Table 4.1.1. https://www.gov.uk/government/publications/webtag-tag-data-book-november-2014

[35] See HM Treasury (2011) Green Book, Annex 6. Available at:

https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent.

The HM Treasury Green book advises the use of a 3.5% discount rate, reflecting the social time preference rate (STPR). A rate of 1.5% is conventionally used for health impacts in UK government analyses to reflect the fact that we would expect the value of health to rise at the rate of real incomes, which we assume to be 2% in the long-term (see Appendix 4: Productivity costs).This is discussed further in Glover and Henderson (2010), paragraph 2.15.

Table 2: Total mortality costs for all cancers and top 5 fatal cancers arising from 2010 registrations (2013 prices)

Cancer type	Number of fatal cases	Total Discounted Cost (£ millions)
Lung	5,392	£6,151
Mesothelioma	2,366	£2,708
Breast	671	£722
Bladder	255	£281
Oesophagus	182	£207
Other cancers	*547*	*£613*
All cancers	**9,413**	**£10,684**

Note: Totals may not sum due to rounding.

71. Unsurprisingly, the costs directly mirror the profile of fatal cancer registrations and are dominated by the most common fatal work-related cancers: lung cancer (£6.2 billion) and mesothelioma (£2.7 billion), which account for 83% of human costs for fatal cancers.

72. Breast cancer is the third largest fatal cancer by mortality costs, accounting for around £722 million in total. The remaining 21 cancer types account for only 10% of mortality costs. This roughly reflects the proportion of estimated fatal cancers accounted for by these cancer types in 2010.

4.4 Valuing morbidity

4.4.1 Summary of options and choice of approach

73. The effects of cancer morbidity and treatment on an individual's wellbeing and quality of life can be numerous and severe, though can differ greatly between different types and stages of cancer. During treatment, many patients experience side-effects such as fatigue, psychological distress, pain, and weight loss. This may be a prolonged period of ill health and remission, while those with terminal cancer will typically suffer progressive illness to death.

74. Those who 'survive' cancer may suffer longer-term effects on physical, cognitive or sexual function and wellbeing, even after the disease has gone into remission. This can be accompanied by a long-term fear of recurrence of the disease.

75. HSE analysts considered a number of approaches for valuing morbidity impacts. These fall broadly into two categories: 1) direct valuation of ill health state conditions associated with cancer, or 2) an index-based measure of health-related quality of life, which can be chained to the value of a life year (VOLY) to produce an economic valuation of morbidity effects.

76. As described in paragraph 58, an earlier HSE literature review did not find suitable valuations of cancer that could be transferred to the present study. In the absence of undertaking a primary valuation study, HSE undertook a further review of the literature of index-based approaches to morbidity to inform the chosen method.

77. In brief, there are two common index-based approaches that could feasibly be used to provide a quantitative measure of impact for valuation:

- **Disability Adjusted Life Years (DALYs)**, which are a measure of the total number of healthy years lost and allocate disability weights (DWs) to different health states from 0 to 1 (with 0 representing perfect health and 1 death); or

- **Quality Adjusted Life Years (QALYs)**, which measure quality and quantity of life saved by allocating health-related quality of life (HRQoL) weights to different health outcomes on a scale from 1 to 0 (with 1 representing perfect health and 0 death).

78. In simple terms, these measures are the converse of one another. For example, a condition with a HRQoL weight of 0.4 under a QALY approach could be equally represented by a DW of 0.6. However, there can be important differences in how the weights are typically derived, which are discussed further in Appendix 3A.

79. The primary determinant of the choice of metric for this study was the availability of suitable data transferrable to the GB context (discussed in the next section). On this basis, the DALY index was selected for this analysis. To use a QALY approach would have required primary research to provide data on the disease stages and cancer types included in this model, which was outside the scope of this work.

4.4.2 Application of approach - DALYs

80. Disability adjusted life years can be used to represent the burden of disease in a single index measure. This burden is often measured in terms of Years Lived with Disability (YLD), which measures morbidity, and Years of Life Lost (YLL), which measures mortality. As in Section 4.3, our primary measure of mortality in this study is lives lost, but we present a 'life years' approach in Appendix 3, which estimates YLLs. In the present section we are concerned with morbidity, so we focus on estimating YLDs.

81. A foremost appeal of DALYs for the present study is the availability of data relevant to the types of cancer of interest, and for a range of disease stages. This data was available from work undertaken by Imperial College London for the HSE Cancer Burden study.[36] This allows us to provide an estimate of the disease burden – in quantitative and monetary terms – that is sensitive to differences between the cancer types in intensity and duration of morbidity experienced.

82. We apply the same approach to estimate morbidity for fatal and non-fatal cancers; however, the disease stages necessarily differ. Data on disability weights (DWs) for each of the 24 occupational cancers were provided by Imperial College, according to main disease stages characteristic of fatal and non-fatal cancers.[37]

83. For fatal cancers, the disease stages assessed are:

    - diagnosis and primary therapy;
    - remission (in some cases);
    - disseminated cancer;
    - terminal stage.

84. For non-fatal cancers, the disease stages are:

    - diagnosis and primary therapy;

[36] DALY methodology paper for HSE Cancer Burden Study. Forthcoming as an appendix to the HSE Cancer Burden Study methodology report, available at: http://www.hse.gov.uk/research/rrhtm/rr927.htm.

[37] Where Imperial College did not provide an average time spent in remission, then this was calculated as the difference between survival time and the time spent in the other stages of the disease.

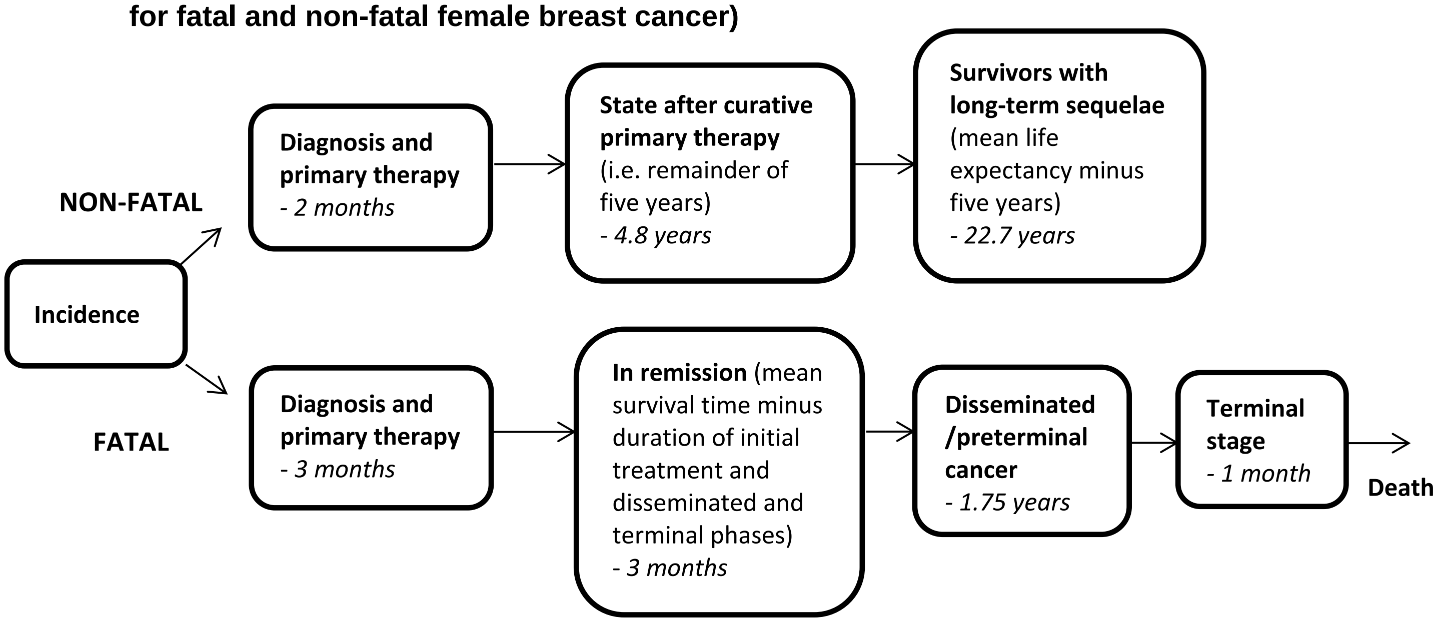
- post curative therapy, up to 5 years from diagnosis;
- long-term effects.

See Figure 3 for an example for female breast cancer.

85. The 'long-term effects' stage accounts for the enduring health effects of cancer and treatment, particularly surgery. These are assumed to last until death but apply to only certain cancers. Note that we assume that surviving individuals have the same life expectancy as those who have not had cancer – i.e. they have no excess mortality relative to the general population. These serve as simplifying assumptions.

86.

Figure 3: General disease stage model for estimating cancer morbidity/YLDs (example for fatal and non-fatal female breast cancer)



87. For each cancer type, data from the HSE Cancer Burden study provided estimates of the average duration of each cancer stage and associated disability weight, which were adapted for Great Britain from the 2003 Australian Burden of Disease (BoD) study.[38] The Australian BoD data on DWs was in turn based on a Dutch Disability Weights project,[39] which had used an expert panel approach to assign DWs to disease stages, based on consideration of a health state description for indicator conditions covering a range of factors.[40] The use of an expert panel means that, while the results may not be fully representative of the general population, they may be better informed about the real effects of cancer than a sample of the general public.

88. Researchers at Imperial College considered that the Dutch DWs would be the most suitable of available data to be used in GB studies, given they were derived in a western European setting and relevant to the cancer types of interest in the present study. Further information on the approach to DALYs for morbidity is provided in Appendix 3A, along with detailed data on the DWs cancer type and disease stage (Table 21 and Table 22).

89. DWs and durations for each disease stage are combined to give total years lived with disability (YLDs) due to cancer for both fatal and non-fatal cases. YLDs are then multiplied by an estimate of the monetary value of a life year to derive the total human costs of cancer, again for both fatal and non-fatal cases.

90. There is considerable variation in the value of a statistical life year that have been applied in economic analyses by UK Government Departments, with values ranging from around £30,000 to £80,000.[41] The value we adopt for this report is the Department of Health's value of a statistical life year of around £60,000 (2012 prices), which we increase by the value of nominal GDP per head to 2013 using the IHXT series,[42] resulting in a value of £61,700.[43] This is the value that is likely to be advised in forthcoming HM Treasury Green Book guidance and is derived from the same studies underlying the DfT VPF, meaning the values are compatible.

91. As with mortality impacts, we discount morbidity impacts at a rate of 1.5% per annum.

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[38] The burden of disease and injury in Australia 2003. Canberra: AIHW Available at: http://www.aihw.gov.au/WorkArea/DownloadAsset.aspx?id=6442459747

[39] Stouthard, M.E.A, 1997. *Disability weights for diseases in the Netherlands*. Rotterdam Department of Public Health Erasmus University. http://dare.uva.nl/document/2/3276

[40] Including ability to walk about, wash and dress, problems with usual activities, pain or discomfort, level of anxiety or depression, and cognitive functioning.

[41] Wolff, J. and Orr, S. (2009) Cross-Sector Weighting and Valuing of QALYs and VTPFs. A Report for the Inter-Departmental Group for the Valuation of Life and Health. Final Report, 8 July 2009. http://www.ucl.ac.uk/cpjh/docs/IGVLH.pdf

[42] Gross domestic product per head at market prices. Seasonally adjusted, £ thousand at current prices. Office for National Statistics, http://www.ons.gov.uk/ons/datasets-and-tables/data-selector.html?cdid=IHXT&dataset=bb&table-id=1.5

[43] For the derivation of this value, see Glover and Henderson (2010), *Quantifying Health Impacts of Government Policies* (2010). Department of Health report. An alternative method has been produced by Franklin (2014) *Monetary Valuation of Statistical Life Years and QALYs.* Paper for the Green Book Refresh on behalf of the Interdepartmental Group on the Valuation of Life and Health, which leads to the same value.

4.4.3 Results – morbidity costs, fatal cancers

Table 3: Estimated morbidity for fatal cancers registered in 2010 (total and top 5)

	Total values			Per case values	
Cancer site	**Total fatal cases**	**Years lived with disability (YLDs)**	**Total morbidity costs (£ million)**	**Average YLDs per case**	**Discounted Morbidity costs per case (£)**
Lung	5,392	3,403	£208	0.63	£38,600
Breast	671	1,555	£92	2.32	£137,500
Mesothelioma	2,366	1,076	£66	0.45	£27,900
Bladder	255	260	£16	1.02	£61,500
NMSC[1]	88	129	£8	1.47	£87,300
Other cancers	*641*	*505*	*£31*	*0.79*	*£48,000*
All cancers	**9,413**	**6,929**	**£421**	**0.74**	**£44,700**

Note: Totals may not sum due to rounding. [1]Non-melanoma skin cancer (NMSC).

92. Table 3 summarises the main results. See Table 21 and Table 22, Appendix 3 for a detailed breakdown of total discounted morbidity costs for fatal cancers by cancer type.

93. Applying this approach, we estimate a total of 6,900 years lived with disability (i.e. health years lost) for fatal work-related cancers, amounting to £421 million in human costs, as shown in Table 3. These costs are dominated by lung cancer (£208 million, 50% total), and to a lesser extent breast cancer (£92 million, 22% total) and mesothelioma (£66 million, 16% total).

94. Table 3 also provides YLDs and morbidity costs per case of cancer. This shows that, on average, those with terminal cancers lost an equivalent of three-quarters of a healthy year of life due to illness prior to death, equating to a discounted value of around £44,700 per case across all cancers types.

95. Breast cancer (£137,500) incurs by far the highest per case morbidity cost, due to a combination of a high DW (effects of treatment and possible surgery) and average length of survival prior to death (almost 5 years). This contrasts with lung cancer (£38,600) and mesothelioma (£27,900), which incur a considerably lower morbidity cost primarily due to the much shorter average survival period (between 6 to 9 months). See Table 21, Appendix 3 for further details.

4.4.4 Results – morbidity costs, non-fatal cancers

Table 4: Estimated morbidity for non-fatal cancers registered in 2010 (2013 prices)

	Total values			Per case values	
Cancer site	**Total non-fatal cases**	**Years lived with disability (YLDs)**	**Total morbidity costs (£ million)**	**Average YLDs per case**	**Discounted Morbidity costs per case (£)**
Breast	1,531	3,589	£195	2.34	£127,100
Lung	344	804	£47	2.34	£137,900
Bladder	311	380	£22	1.22	£69,800
Nasal/sinonasal	66	124	£7	1.90	£112,200
Larynx	36	110	£6	3.10	£172,600
Other cancers	*4,502*	*343*	*£19*	*0.08*	*£4,300*
All cancers	**6,790**	**5,349**	**£297**	**0.79**	**£43,700**

96. Table 4 shows that morbidity associated with non-fatal cancers leads to around 5,300 YLDs, at a total cost of around £300 million. This equates to an average value of about £43,700 of morbidity costs per case of non-fatal work-related cancer. The average value of morbidity per case increases to just under £120,000 when NMSC is excluded, given the very low costs per case discussed below.

97. Breast cancer is by far the largest contributor to non-fatal morbidity costs, accounting for almost two-thirds of costs, while making up under a quarter of non-fatal cases. This is due to the high per case costs for breast cancer (£127,100), arising primarily from the post treatment (after curative) and long-term effects of surgery (mastectomy), which is estimated to occur in just over half of cases (based on Imperial College data). Although the mean disability weight is only 0.09 (see Table 22), lower than other cancers with long-term effects, this is applied over a high number of registrations, leading to high aggregate morbidity costs.

98. Per case morbidity costs are also relatively high for lung and laryngeal cancer, but these make up a smaller share of total costs due to a lower number of non-fatal cases.

99. Non-melanoma skin cancer (NMSC) is notable by its absence from Table 4. Despite making up over 60% of non-fatal registrations, it accounts for only 0.2% of total non-fatal morbidity costs (£552,000). This is because in the vast majority of cases, successful treatment involves only relatively minor surgery to remove the tumour and some surrounding skin, so morbidity costs per case are very low (around £130). Mesothelioma also does not feature, since cases are almost always fatal.

100. We were unable to gather suitable disability weights data for long-term effects on survivors of lung, nasal/sinonasal, stomach, oesophageal, non-melanoma skin cancers and blood cancers, meaning there are no morbidity costs for these cancer types beyond the treatment and after curative phases. This is important, as we might expect that many who are in remission of cancer will suffer ongoing anxiety or fear of recurrence, regardless of the type of cancer, which should be captured by an ongoing disability weight. We were unable to identify a suitable method for capturing this in the literature, though it is likely to represent a significant omitted cost.

4.5 Summary – Human Costs

101. Table 5 shows human costs – the sum of total morbidity and mortality costs – for the 'top ten' cancer types by cost, plus the total for all 24 cancers in the model. It also shows average human costs per case by cancer type.

Table 5: Total human costs by cancer type, £ million

	Total values			Per case values
Cancer type	**Total morbidity costs (£ millions)**	**Total mortality costs (£ million)**	**Total human costs (£, million)**	**Average costs per case (£)**
Lung	£256	£6,151	£6,407	£1,117,000
Mesothelioma	£66	£2,708	£2,774	£1,172,000
Breast	£287	£722	£1,009	£458,200
Bladder	£37	£281	£319	£562,900
Oesophagus	£10	£207	£217	£1,025,000
Stomach	£7	£143	£151	£1,070,000
Nasal / sinonasal	£13	£104	£118	£743,000
NHL[1]	£10	£97	£106	£618,600
NMSC[2]	£8	£96	£104	£23,820
Larynx	£8	£28	£36	£590,700
Other cancers	*£15*	*£145*	*£160*	
All cancers	**£717**	**£10,684**	**£11,401**	**£703,600**

Note: Totals may not sum due to rounding. [1]Non-Hodgkin's Lymphoma (NHL). [2]Non-melanoma skin cancer (NMSC).

102. Total estimated human costs arising from work-related cancers registered in 2010 were £11.4 billion. Mortality costs, representing the monetised value of the estimated 9,400 lives lost, account for over 90% of these costs at £10.7 billion. Morbidity costs, representing a monetised estimate of the total 12,300 years lived with disability (fatal and non-fatal cancers), account for the remainder of costs at £717 million.

103. Unsurprisingly, lung cancer and mesothelioma incur the highest human costs, accounting for a combined £9.2 billion, over 80% of total human costs. This is due to both a high number of total cases (50% total registrations) and a high proportion of fatal cases (around 95% of lung cancers and mesothelioma cases become fatal).

104. Breast cancer has the third largest human costs at around £1.0 billion. Note that morbidity accounts for a much higher proportion of human costs for breast than other cancers, at 28%. This is because a lower proportion of breast cancers become fatal (30%), and per case morbidity costs are relatively high due to long-term effects for survivors and a relatively long average survival period for fatal cancers.

105. Per case human costs by cancer type are driven primarily by the proportion of fatal cases for each type and, to a lesser extent, the average duration and severity (disability weight) of morbidity. Hence, cancers that are typically fatal (lung, mesothelioma, and stomach) have higher per case costs. For the same reason, per case costs for NMSC are the lowest of all cancers at £23,800, because only 2% of NMSC cases are fatal, and per case morbidity costs are low given relatively straightforward treatment and good prognosis.

106. Note that using the alternative life-years approach to mortality would reduce total mortality costs to £5 billion and total human costs to £5.8 billion. Total morbidity costs would be unchanged. The life years approach to mortality is discussed in more detail in Appendix 3.

5 Productivity costs

5.1 Background

107. We define productivity costs as those costs that arise primarily due to the effects of cancer on an individual's ability to work. People having to spend time off work due to work-related cancer involves an opportunity cost to society as well as a cost to employers and individuals – if that worker was not absent, output could be increased.[44] The value that society places on the forgone output is of interest from an economic point of view.

108. Economic costs also arise from the resources that employers expend in reorganising work and recruiting replacement workers in order to mitigate disruption to output following a worker absence – which we term 'Production Disturbance'.

109. Under productivity costs, we also account for the impact of various transfer payments, or money flows from one group in society to another. For instance, a firm will incur additional costs associated with occupational or statutory sick pay arrangements when an employee is absent due to work-related cancer. These payments represent a cost to employers but an equal benefit to individuals. They net to zero in the aggregate, so are not economic costs to society as a whole. However, these transfers are relatively large and it is important to account for them in order to provide a clearer picture of how the costs of work-related cancer are borne by the different stakeholder groups.

110. The remainder of this Section is structured as follows. First, we outline our approach to estimating the main economic costs: lost output and production disturbance. Second, we set out our approach to estimating the range of transfer payments. Third, we provide results and discussion of these costs by stakeholder group.

5.2 Estimating Lost Output

5.2.1 Conceptual basis for using wages as a proxy for lost output

111. There are several possible ways to measure the value of lost output, which are discussed in detail in Appendix 4. In this analysis, we maintain consistency with *Costs to Britain* and several other studies that seek to estimate the costs of workplace injuries and ill health, and use gross earnings as a proxy for the value of output that the worker would have otherwise produced.[45]

112. In the absence of any labour market imperfections, economic theory suggests this is a reasonable approximation: a firm seeking to maximise profit would keep hiring workers until

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[44] 'Opportunity cost' is a key concept in economics, and represents the value of a resource in its most valuable alternative use.

[45] Employing gross earnings as a measure of lost output arising from absenteeism is consistent with the Human Capital approach to valuing productivity costs, a common method used in economic evaluations of the costs of workplace injuries and illness. These include, *inter alia*, J. Paul Leigh's analysis of the costs of occupational injuries and illnesses in the US (Leigh, 2000, *Costs of Occupational Injuries and Illnesses*, University of Michigan Press, 2000), and a research project report estimating the costs of workplace injuries in the Canadian Mining Industry for the Government of Quebec ('Estimating the Costs of Occupational Injuries: A Feasibility Study in the Mining Industry', Institut de Recherche Robert-Sauvé en santé et en sécurité du travail, 2013).

the costs of employing an additional worker were just equal to the value of output that the worker produces. The primary cost faced by the employer is the worker's wage.[46]

5.2.2 Measuring gross lost earnings from employment

113. This Section provides a summary of the method used to estimate gross lost employment income to individuals as a result of work-related cancer, which we use as a proxy measure for lost output. See Appendix 4 for further detail on underlying assumptions and methodology.

114. For those employed, but not able to work during their illness, gross earnings will be forgone. The approach to estimating lost gross earnings to individuals suffering from occupational illness or injury is well established within the *Costs to Britain* framework, and we adapt this method to calculate lost earnings due to work-related cancer.

115. Lost earnings are estimated as the product of average earnings, estimated time unable to work, probability that the individual is working at the point of diagnosis, and the cancer outcome (i.e. whether they survive and, if so, whether they return to work). Average earnings data is available by both age and gender, and where the cancer results in permanent withdrawal from the labour force, lifetime earnings are forecast to account for future earnings growth and are discounted to present values.

116. For those who are expected to be working at the time of diagnosis, the period of lost earnings will vary depending on both the type of cancer and the cancer outcome. The model assumes that people will be unable to work from the point of cancer registration. The period of lost estimated earnings extends until:

- The end of the period of Diagnosis and Primary Therapy for non-fatal cancers in cases where the individual is able to return to work following cancer. This results in an average period of lost earnings for this category of 0.13 years, or around six weeks (calculated as a weighted average length of Diagnosis and Curative Primary Therapy stage across all cancer types).[47] (See Section 4.4 and Appendix 4 for disease stages and durations used in the model);

- Retirement age (65) for non-fatal cases where the individual is unable to return to work ('never returns');

- The individual's demise for fatal cases (or retirement where the individual reaches retirement age before death). The weighted average survival time for fatal cases is 1.04 years. While we model this as one discrete period of time, it may in reality be spread over a longer period of treatment, recovery, remission, further treatment, and so on.

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[46] Gross wages may underestimate the value of lost output to society as a result of work-related cancer, however, insofar as firms face a series of non-wage costs, such as National Insurance and pension contributions, in addition to the wage rate. In this environment, these contributions would represent an additional cost of hiring to be added to the marginal cost of labour and, by extension, the value of any output lost. To maintain consistency with *Costs to Britain*, which estimates lost output using lost gross earnings to individuals, this model does not apply an uprating to wages to reflect non-wage costs when valuing a reduction in potential output as a result of absenteeism. See Appendix 5 for further discussion.

[47] This rises to 0.26 years, or around 12 weeks, if NMSC is excluded. NMSC accounts for over 60% of non-fatal cases and the diagnosis and primary therapy stage is around 2 weeks.

117. In order to identify the number of employed individuals who do not return to work for reasons of (work-related) cancer, we use data provided by Taskila *et al.* (2005) on the relative risk of those with cancer being unemployed compared with those without cancer.

118. Research by Macmillan Cancer Support (2013) indicates that only around a third of cancer patients will stop working temporarily or permanently as a result of their illness,[48] suggesting our approach may overstate lost gross earnings. However, it is unclear whether this finding would be observed for work-related cancers; we might expect that where work has contributed to the development of cancer, individuals would be more likely to leave work temporarily or permanently as a result. Given the small cost of lost gross earnings relative to overall costs, uncertainties around the possible durations of temporary cessations of paid work, and the relatively short average period of absence applied in the model, we consider that it is unlikely that estimates of lost output are significantly overestimated.

5.3 Production Disturbance

119. Firms can respond to a worker absence in two ways: either accept the loss of output, or take action to maintain current levels of output. For consistency with the modelling approach in *Costs to Britain*, which is based on evidence from business case studies (see Appendix 4), we assume the latter. This entails that some effort is undertaken on the part of employers in order to reorganise work and recruit replacements.

120. Any resources used by businesses associated with workplace reorganisation or the recruitment of replacement staff represents a net cost to society. These costs are referred to as 'production disturbance'. We broadly model these costs as follows:

- For shorter-term absences, it is assumed that employers are able to cover the loss of output by reorganising existing efforts and via overtime worked by existing staff, requiring some amount of managerial activity. The amount of time spent by managers on workplace reorganisation is costed using the relevant wage rate from the Annual Survey of Hours and Earnings (ASHE) 2013.[49]

- After a period of six months, employers are no longer liable for paying statutory sick pay. For absences which exceed this time, or in cases where an individual permanently withdraws from the labour force due to cancer, we assume employers act to recruit a replacement for the absent person. In this case, the firm will incur costs associated with the hiring of a new employee, such as advertising the position, and any costs in terms of managerial time and resources required for the induction and training of the new employee.[50] The methodology and assumptions used to estimate the costs of production disturbance are described in more detail in Appendix 4.

[48] Macmillan Cancer Support (2013) Cancer's Hidden Price Tag http://www.macmillan.org.uk/Documents/GetInvolved/Campaigns/Costofcancer/Cancers-Hidden-Price-Tag-report-England.pdf

[49] Mean hourly wage rate of 'Managers, Directors and Senior Officials', ASHE 2013 revised, Table 2.5a: http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-337429

[50] The model assumes that the replacement worker is just as productive (after the initial training period) as the absent individual – this implies some homogeneity on the part of workers. For technical and highly skilled positions, it may be the case that no suitable replacement is available to replace the cancer victim. Under these circumstances, the firm might experience additional net costs in terms of loss of expertise and skills, etc., however this is extremely difficult to quantify and is not currently included in the cost estimates.

5.4 Transfer Payments

121. The net productivity costs to society hide a series of transfer payments, which ensure in effect that individuals do not shoulder all of the costs of their absence from work by shifting the burden of costs and compensating workers for some lost earnings. For instance, those of working age may receive replacement income in the form of statutory or occupational sick pay paid by the employer, in addition to state benefits. In addition, individuals do not pay taxes on forgone earnings (a "saving"), resulting is an equal loss in tax revenue to the Government. Given the equal and opposite flows, these transfers net to zero in the aggregate.

122. Below is a brief summary of the various transfers that are included in the model, which become visible at the distributional breakdown of costs by individual stakeholder.

- Occupational and Statutory Sick Pay (OSP/SSP)
- State benefits, such as Industrial Injuries Disablement Benefit (IIDB), Employment and Support Allowance (ESA), etc.
- Income tax and National Insurance (NI) savings
- State pensions

123. The inclusion of lost state pension income is a departure from the *Costs to Britain* model, which does not account for impacts beyond the age of 65. As the majority of cancer registrations are above state pension age, it was decided that the impact on state pension payments should be taken into account, as this reflects an important element of lost income to a large proportion of individuals with work-related cancer.

124. Only the pension impact on fatal cancers is considered. While it is possible for people who survive cancer but are unable to return to work at a sufficiently young age to suffer reduced pension income because they have not built up thirty years' worth of National Insurance contributions, so few people fall into this category that the cost would be negligible in the aggregate of this model.

125. As above, any losses related to state pension income for the individual are offset by savings to Government and wider society in terms of the pension payments which would otherwise have been paid.

126. Note that we only consider the impact of state pensions; the effect of private pensions is not currently included in the model, as there is no one reliable source of data on private pension arrangements, and accounting for them would add a great deal of complexity to the model.

127. For a fuller discussion of the different transfer payments, see Appendix 4.

5.5 Results and Discussion

5.5.1 Costs to individuals

128. The 'productivity cost' to individuals is the net loss of income as a result of work-related cancer. This will be equal to the loss of gross earnings due to time off work (net of taxes and NI contributions), minus any replacement income that offsets lost pay, such as OSP/SSP, alongside myriad state benefits, such as IIDB and ESA, which seek to compensate workers for being ill and unable to work.

129. We assume that replacement income is received by those eligible for it in the same period as income is lost. While it is not certain that periods off work and periods in receipt of state benefits will coincide exactly, this serves as a simplifying assumption.

130. Total lost gross earnings are estimated to be around £533 million, the majority of which (around 97%) is borne by people with fatal cancers. This is because lost income is forecast into the future up to the age at which we assume individuals would have retired (65), so the period of lost earnings is much longer than in the case of non-fatal cancers, where the period of incapacitation is linked to the period of Primary Diagnosis and Therapy.

131. Those who die as a result of work-related cancer will not draw the state pension income they would otherwise have drawn. Total (gross) lost state pension income to individuals is estimated to be around £615 million. As with lost gross earnings, income tax and National Insurance contributions that are made on this pension income must be deducted to give the net loss of pension income to individuals.

132. Total net lost income to individuals is around £821 million (present value). As shown in Table 6, the vast majority of this is due to fatal cancers.

Table 6: Total productivity costs to individuals

	Estimated costs (£ millions)		
	Fatal cancers	Non-fatal cancers	Total
Loss of gross earnings	£518	£14	£533
Loss of pension income	£615	Nil	£615
OSP/SSP receipts	-£25	-£2	-£27
State benefit receipts	-£90	-£2	-£91
Income tax and NI saving	-£205	-£3	-£208
Total net productivity costs to individuals	**£814**	**£7**	**£821**

Note: Totals may not sum due to rounding. Negative figures show money inflows.

5.5.2 Costs to Employers

133. Net productivity costs to employers comprise the costs of production disturbance, the value of sick payments to absent employees, and any National Insurance paid on sick pay.

134. The total cost of production disturbance to employers is estimated to be around £6 million, comprising both the costs of reorganising existing efforts to cover lost output in the short term, and the recruitment of a replacement worker in the long term.

135. The small costs of production disturbance relative to other cost components reflects the small number of cancer patients that are of working age, which is further reduced by the proportions estimated to be out of work at the time of diagnosis.

136. Employers also incur costs in the form of payments of sick pay to people unable to work. The costs to employers of OSP and SSP will be equal to the amount of sick pay received by individuals, given in Section 5.5.1. This amounts to approximately £27 million.

137. Employers also pay NI on any sick payments they make to workers. This is over and above the actual value of payments the worker receives. NI payments on OSP/SSP are estimated to be around £3 million.

138. Total net productivity costs to employers are estimated to be around £36 million.

Table 7: Productivity costs to employers

	Estimated costs (£ millions)		
	Fatal cancers	Non-fatal cancers	Total
Production Disturbance	£6	£0.4	£6
OSP/SSP Payments net of reimbursements	£25	£2	£27
NI paid on sick pay	£3	£0.3	£3
Total productivity costs to employers	**£33**	**£3**	**£36**

Note: Totals may not sum due to rounding.

5.5.3 Costs to Government

139. Costs to the Government take the form of payments of state benefits and forgone tax revenue. Set against this, savings are made due to the state pension forgone by those who die of work-related cancer.

140. Lost income to the Government is simply the converse of specific inflows or savings to individuals: namely, state benefits and avoided tax. There is also a "saving" to Government that arises because those who die of cancer are unable to claim state pensions, and so these funds can be directed elsewhere. This is corresponding 'cost' to those individuals who die and so do not claim the pension (as discussed in Section 5.5.1).

141. Total 'productivity costs' to the Government are as follows:

Table 8: Productivity costs to Government

	Estimated costs (£ millions)		
	Fatal cancers	Non-fatal cancers	Total
Pension savings	-£615	Nil	-£615
State benefits payments	£90	£2	£91
Net income tax and NI reduction	£202	£3	£205
Total productivity costs to government	**-£324**	**£5**	**-£319**

Note: Totals may not sum due to rounding. Negative values show savings.

142. The Government's net position for fatal cancer results in a negative net cost; that is, Government saves more in terms of reduced pension payments than it loses through benefits and forgone taxation. Although Government does suffer a small net loss from non-fatal cancers, their total net position shows a saving of around £319 million.

143. The impact of premature death due to work-related cancer on state pension liabilities is an unavoidable reality, which will be true for most causes of premature death, not just fatal cancers caused by work. Furthermore, this does not represent a true economic cost. It is a (virtual) transfer from individuals, who would have received pension payments if they had not died prematurely, to taxpayers. [51]

[51] The most well-known example of this observation relates to the costs of smoking. When evaluating the impact of smoking on public finances, studies have typically found that the medical costs of treating smoking-related diseases are outweighed by the savings in terms of reduced expenditure on state pensions and end-of-life healthcare costs which are no longer incurred as a result of premature death (i.e. that smoker's lifetime healthcare costs are, on average, lower than those of non-smokers, *(footnote continued on next page…)*

144. The results are also not indicative of how Government makes decisions more generally. The HM Treasury Green Book advised that UK government appraisals should be conducted from the point of view of society.[52] As discussed in Section 9, work-related cancer imposes vast costs on society, which is the most important result from this research.

5.5.4 Total Costs to Society

Table 9: Total net productivity costs by cost bearer and to society

	Estimated costs (£ millions)		
	Fatal cancers	Non-fatal cancers	Total
Net cost to individuals	£814	£7	£821
Net cost to employers	£33	£3	£36
Net cost to Government	-£324	£5	-£319
Total costs to society	**£524**	**£15**	**£539**

Note: Totals may not sum due to rounding. Negative values show savings.

145. Total net productivity costs at the societal level are the sum of the value of total lost output due to worker absence and production disturbance. Table 9 shows that these costs amount to £539 million per annum. Other elements of loss of earnings (e.g. pension income, sick pay, tax, National Insurance and benefits) are costs transferred between one cost bearing group and another, and so at the societal level all cancel each other out.

146. The net costs by cost bearer reflect the balance of costs and transfers between groups, as discussed in Sections 5.5.1 (individuals), 5.5.2 (employers), and 5.5.3 (government).

Table 10: Total productivity costs and breakdown for top 5 cancer types

Cancer type	Estimated costs (£ millions)
Lung cancer	£279
Breast cancer	£85
Mesothelioma	£74
NHL[1]	£15
Oesophagus	£14
Other cancers	*£70*
Total (all cancers)	**£539**

Note: Totals may not sum due to rounding. [1]Non-Hodgkin's Lymphoma (NHL).

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due to medical costs of treating illnesses that arise with old age). For an illuminating discussion around the ethical and economic implications of analyses that include such impacts, see Viscusi (1999), 'The Governmental Composition of the Insurance Costs of Smoking", *Journal of Law and Economics*, Vol. 42, No. 2, pp. 575-609.

A high-profile example of where an analysis has included the "death benefit" was the report commissioned by Philip Morris, a tobacco retailer, on the 'Public Finance Balance of Smoking in the Czech Republic'. See: http://www.ash.org.uk/files/documents/ASH_719.pdf

[52] See: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf

147. Table 10 presents total productivity costs to society (i.e. costs of lost output and production disturbance) by top five cancer types. Lung cancer results in the largest productivity costs to society, over four times that of the second largest, breast cancer. This is primarily driven by the fact that lung cancer is the leading cause of fatal cases of work-related cancers in the model, responsible for around 5,400 fatal cases (around 57% of total fatal registrations).

148. Breast cancer results in the second largest productivity costs to society. Work-related breast cancer leads to the third highest number of deaths in the model, 671 cases, behind lung cancer and mesothelioma, and results in the second highest number of non-fatal registrations, 1,500. However, breast cancer incurs higher productivity costs than mesothelioma because the majority of those diagnosed with mesothelioma are retired or nearing retirement age (65 in the model). The age distribution of breast cancers, on the other hand, is somewhat younger, meaning that fewer individuals are retired when they are diagnosed and output is lost over a longer period for those who die or are unable to return to work.

5.5.5 Unquantified Costs

149. The model does not currently include the effects on productivity of those that return to work following work-related cancer; that is, the estimates of lost output relate solely to 'absenteeism', and do not include costs associated with 'presenteeism'. It is likely that some individuals diagnosed with cancer may be well enough to be present at work but not be able to operate at the same level of productivity as before their illness, at least for some period of time. In such cases, the employer would incur costs of lower output and profits, The productivity costs associated with reduced work capacity in cancer victims is extremely difficult to quantify, and represents a potential avenue for future research. We expect the costs of presenteeism to be significant.[53]

150. In addition, the contribution of the individual worker to economic and social output should ideally include the value of both paid and unpaid production. The latter is, however, extremely difficult to quantify and measure accurately. Accordingly, the estimates of lost output presented above do not include the impact of any reductions in voluntary or unpaid work (including provision of informal care or childcare to family members) as a result of reduced work ability due to work-related cancer. Nor do they include the costs to society of output lost from individuals who take time off work to care for cancer victims.[54]

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[53] Measurement issues notwithstanding, the costs of absenteeism are well recognised and prevalent throughout most economic evaluations that seek to estimate the costs of workplace injuries and ill health. Less attention is typically paid to presenteeism, given the challenges in quantifying it. In recent years, more studies are attempting to capture this impact, and indeed there is growing evidence to suggest that the costs of presenteeism often outweigh those associated with absenteeism (See Econtech, 'The Cost of Workplace Stress in Australia', Medibank Private Limited, 2008. Available at: http://www.medibank.com.au/Client/Documents/Pdfs/The-Cost-of-Workplace-Stress.pdf). For more on estimating the costs of absenteeism and presenteeism, see a recent literature review by the European Agency for Safety and Health at Work, *'Calculating the cost of work-related stress and psychological risks'* (EU OSHA, 2014). https://osha.europa.eu/en/tools-and-publications/publications/literature_reviews/calculating-the-cost-of-work-related-stress-and-psychosocial-risks

[54] A recent methodology report by the Department of Health presents one approach to estimating the value of unpaid production and other "Wider Societal Benefits" of healthcare treatment. There are a number of challenges in doing this, and it has not been possible to consider this further within the scope of this present study. For further information, see https://www.nice.org.uk/Media/Default/About/what-we-do/NICE-guidance/NICE-technology-appraisals/DH-Documentation-for-Wider-Societal-Benefits.pdf).

151. As described in Section 5.2.2, for those individuals who survive cancer and make a successful return to work, the analysis assumes that income is only lost for the duration of their Diagnosis and Primary Therapy stage. After that, it is assumed that they return to work at the expected average earnings for their age and gender. In reality, this may understate the total loss of income (and hence lost output) insofar as cancer survivors may be unable to return to the same work or resume the same hours as previously. Additionally, they may have missed out on opportunities for development or promotion during their absence. This impact on long-term employment earnings is distinct from the costs of presenteeism discussed above; however we have been unable to account for such effects due to a paucity of data.

152. For the above reasons, it is likely that the estimates of lost output associated with work-related cancer understate the total value of lost output.

6 Health and Rehabilitation costs

6.1 The National Health Service (NHS) costs of diagnosing and treating work-related cancer

6.1.1 Background

153. The costs borne by the NHS in diagnosing and treating work-related cancer include those associated with GP visits and specialist consultations, hospital treatments, out-patient treatments, drugs (including chemotherapy), surgery, administration, etc. These costs are spread over all of the stages of the disease from diagnosis through to rehabilitation and/or terminal care costs.

154. The medical cost of an average case of cancer is best represented by the average whole life treatment cost of each cancer. Ideally, the costs to government of treatment would include:

- Initial consultation
- Diagnosis
- Primary treatment
- Follow up checks and treatment
- Any indirect costs resulting from diagnosing or treating secondary illnesses, e.g. mental health issues, management of temporary or permanent side effects of treatment.

6.1.2 Method and assumptions

155. The relevant cost data for cancers treated by the NHS have not been assembled in a publicly accessible database.[55] Data on the NHS budget for treating cancer is publicly available. However, this relates to the annual cost of treating all new and existing cases of cancer, which is more aligned with a prevalence based approach, meaning it is less well-suited for use with cancer registrations data. It also does not enable us to estimate treatment costs by cancer type, since there is insufficient data to apportion the budget to each type of cancer in the model.

156. We do, however, use this data to triangulate the cost estimates we derive based upon a literature review, and this is discussed in Appendix 5B.

157. Research by the Department of Health was available on the lifetime cost of a small number of cancer types[56] including lung and breast cancer which forms the unit cost we apply with respect to those cancers.

158. .HSE also undertook a literature search[57] using ISI Web of Knowledge to look more widely for studies in the UK (and internationally) which have considered lifetime treatment costs.

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[55] HSE analysts contacted NHS England, the Health and Social Care Information Centre, and Public Health England, but no data on typical lifetime cancer treatment costs were readily available.

[56] UK Department of Health. 2011. The Likely Impact of Earlier Diagnosis of Cancer on Costs and Benefits to the NHS. UK Department of Health. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/213788/dh_123576.pdf

[57] Baulcomb, C. (2013a) Unpublished internal Advice Note for UK Health and Safety Executive: costs to the National Health Services of cancer treatment.

The literature review established good coverage of different cancers by a wide range of studies. Studies varied in their coverage of costs but were all assessed for quality (see Appendix 5A for details of the criteria). Some studies provided whole life costs of cancers categorised by the stage of cancer at which diagnosis was first made. Where this is the case, a probability weighted average cost is used to define a weighted average total cost.

159. Table 29 in Appendix 5A (page 105) presents a comparison of the coverage of the cost components along the treatment pathway in the underlying studies used for this analysis. Given that around 90% of registrations are represented by only four work-related cancers with the remaining 10% spread over 20 cancers, it is proportionate that particular attention is paid to these. They are lung, NMSC, mesothelioma and breast cancer.

160. For these cancers, Table 29 shows a generally good coverage of treatment and outpatient costs, which we would expect to account for the majority of total NHS costs. There is less complete coverage for palliative care (not included for lung and NMSC) and aftercare / home care (not included for lung and mesothelioma), which could represent significant costs, and GP costs (not included for lung and mesothelioma), which will incur relatively smaller costs.

6.1.3 Results

Table 11: Lifetime treatment costs for the top 90% of occupational cancer registrations (2013 prices)

	Total values		Per case values
Occupational cancer treatment costs	**Total NHS cost (£ millions)**	**Percentage of total NHS cost**	**Average NHS cost per case (£)**
Lung	£42	32%	£7,400
Mesothelioma	£29	22%	£12,100
Breast	£25	19%	£11,500
NMSC	£8	6%	£1,700
Other cancers	*£29*	*22%*	-
All cancers	**£132**	**100%**	**£8,200**

[1]**Non-melanoma skin cancer (NMSC).**

161. Based on the best available costs, we estimate that the total costs to the NHS of work-related cancer registrations amount to £132 million per year. This includes fatal and non-fatal cancers. The result initially appears somewhat low and implies an average treatment cost of a work-related cancer registration of around £8,000. However, it is important to bear in mind that this represents the average treatment cost for each cancer type, across cases where treatment was relatively low cost (e.g. where diagnosis was made early) and cases were treatment was more costly.

162. Although, as explained in paragraphs 159 and 160, some studies used for the per cancer type treatment costs do not cover the full treatment pathway, particularly community / hospice care, the analysis presented in Appendix 5B shows that we derive a similar estimate of total costs using NHS programme budgeting data (between £126 million and £139 million). This provides some external validity and reassurance that the estimate is commensurate with the NHS budget.

163. The model assumes that all of the medical costs for both fatal and non-fatal work-related cancers are funded by the National Health Service (NHS). We do not account for private health insurance costs, on the basis that we expect only a very small fraction of health insurance premiums relate to work-related cancer.

6.2 Out of pocket expenses – costs to individuals

6.2.1 Background

164. While the majority of the costs related to healthcare are borne by the Government via the National Health Service (NHS), some out-of-pocket costs will fall upon individuals. Some costs may also be paid by the individual related to their treatment, or to make arrangements for the end of their life.

6.2.2 Method and Assumptions

165. Costs borne by the individual include:

- Funeral costs for fatal cancers
- In/outpatient travel and parking costs
- Healthcare costs, such as prescriptions, private healthcare and dietary supplements
- Clothing, equipment and home modifications
- Increases in the day-to-day cost of living, such as household fuel bills, food and home help

166. The cost of funerals is discounted in the model to account for the fact that it is a 'brought forward' cost. People would inevitably need to pay for a funeral at some point; fatality due to work-related cancer has brought this event forward. The typical period of 'bring forward' of funeral costs in the model is around 16 years.

167. With the exception of funeral costs, out-of-pocket healthcare costs have been sourced from a Macmillan survey of 1,600 cancer patients looking at their actual monthly spending related to cancer. Where possible, Macmillan's average costs have been weighted to reflect the cancer profile of our model.[58]

168. In addition, the 2013/14 *Costs to Britain* update estimated that around £21 million (2013 prices) in private medical insurance premiums paid by individuals were related to occupational injury and illness. As this was originally estimated by BUPA in the aggregate, some proportion will relate to work-related cancer. However, no satisfactory method has been found to identify the proportion due work-related cancer, so this has not been included in the Costs of Work-related Cancer estimate.

6.2.3 Results and Discussion

169. Total health-related costs to the individual are summarised in Table 12.

Table 12: Health and rehabilitation costs to Individuals

	Estimated costs (£ millions)		
	Fatal cancer	Non-fatal cancer	Total
Funeral costs	£13	Nil	£13
Out-of-pocket costs	£26	£2	£28
Total health and rehabilitation	**£39**	**£2**	**£42**

Note: Totals may not sum due to rounding.

[58] The inclusion of prescription costs may be counterintuitive given that cancer patients are entitled to free prescriptions. Macmillan conclude that this is due to a lack of awareness among patients and medical staff.

170. Health costs related to fatal cancers are far greater than those due to non-fatal cancers. This is due to the cost of funerals, which is exclusive to fatal cancers, and the greater duration over which fatal cancers are expected to accrue out-of-pocket costs.

6.3 Health and rehabilitation

171. The total cost to society of health and rehabilitation consists of:

- NHS expenditure on medical treatment of cancer registrations of £132 million, and;
- Out of pocket costs to individuals of £42 million.

172. This results in total health and rehabilitation costs of £174 million.

7 Employers' Liability Insurance

7.1 Background

173. All employers (except public organisations) are required by law to have Employers' Liability Insurance cover.[59] This is the principal form of compensation for individuals who suffer an injury or illness caused by work.

174. The Employers' Liability (Compulsory Insurance) Act 1969 (ELCI) ensures that all employers have a minimum level of cover against claims made by employees associated with a workplace injury or illness, and enables employers to meet the cost of claims by spreading the risk across all employers. Any premiums paid represent a cost to employers, and any claims paid by insurance companies represent an inflow to individuals.

175. The net cost to society is the overhead cost of ELCI, which represents the overheads for the insurance companies, and the claim value to individuals consumed in legal costs and expenses. This will be equal to the difference between the total premiums paid by employers and the net receipts to individuals.

176. There might also be an additional cost to society associated with higher ELCI premiums. If an employer's premium increases as a result of a workplace accident or illness, then that increase is part of the employer's cost of the accident. If this leads to an increase in premiums elsewhere in the economy then this is a cost that is borne socially. Any increased premiums that employers face as a result of work-related cancers is not currently considered in the model directly.

7.2 Method and assumptions

177. Data on aggregate ELCI claims and premiums was available from the Association of British Insurers (ABI). Only a proportion of the aggregate payments will relate to work-related cancer, so we make an adjustment to account for this.

178. Data from DWP's Compensation Recovery Unit (CRU) showed that, using a 5-year average across 2007/08 to 2011/12, total recovered benefits relating to mesothelioma and other work-related cancers are approximately 26% of total benefits recovered. This is used as a proxy for the proportion of ELCI claims that relate to cancer.

179. There is also a cost to individuals associated with claiming EL insurance for a work-related injury/illness. The assumption in *Costs to Britain* and in the present study is that only 60% of the claims value would be received by the victims, with the rest going on legal fees and expenses, which represents a net cost to society. Discussions with an ABI representative suggest that this assumption is reasonable.

180. Previous *Costs to Britain* reports used data on EL premiums and claims as an average of three years to estimate the overhead cost to society of administering the insurance scheme.

[59] Most public organisations, including Government Departments and agencies, Local Authorities, police authorities, health service bodies, etc. are exempt from the Employers' Liability (Compulsory Insurance) Act 1969. Family businesses (except those listed as limited companies) and companies employing only their owner (where that employee also owns 50% or more of the issued share capital in the company) are also exempt.
http://www.hse.gov.uk/pubns/hse40.pdf

In line with the latest *Cost to Britain* report, this model uses an average of ELCI premiums and claims over fifteen years (1999-2013). This is more reflective of premiums and claims over the longer-term, and less sensitive to in-year underwriting results.

181. Measuring the cost of Employers' Liability Insurance in this way is also complicated by the fact that the premiums employers face now reflects the current state of knowledge about existing working conditions. However, due to the latency of some work-related cancers, the claims that individuals receive relate to historical working conditions. The difference between premiums and payouts or claims may therefore not be representative of the overhead costs of ELCI for that particular year. By looking at an average over a longer time period, i.e. 15 years, we observe that EL premiums and claims have remained relatively stable, and hence the issue of latency is assuaged somewhat. Further, using a longer time period is more reflective of insurance schemes in the long term, over which we would expect premiums and claims to converge in a competitive market.

182. When presenting the costs by cancer type, it was necessary to find a method of apportioning the costs of ELCI among the various different cancers. However, no information was available on the proportion of EL claims that related to the different cancer types directly.

183. Data from the CRU suggested that the majority of benefits relating to cancer caused by work related to mesothelioma, for which it is much easier to make the robust link between exposure at work and diagnosis.

184. Accordingly, we attribute all of the costs of EL insurance to mesothelioma when estimating the costs by cancer type as a simplifying assumption. While it is possible that some proportion of EL claims will relate to other work-related cancers, this is expected to be relatively small.

7.3 Results and discussion

Table 13: Costs to society of Employers' Liability Compensation Insurance

	Costs (£ millions)
Individuals	-£254
Employers	£422
Government	Nil
Net costs to society	**£168**

Note: Totals may not sum due to rounding. Negative costs represent money inflows.

185. Total ELCI premiums paid by employers are estimated to be around £1.6 billion.[60] Of this, 26% are estimated to be associated with work-related cancer, based on DWP CRU data. Therefore, total EL premiums associated with work-related cancer are estimated to be around £422 million.

As noted in Section 7.2, we assume that 40% of the claim value is consumed in legal fees and expenses, and must be subtracted from any compensation receipts. Therefore, the total claims value received by individuals associated with work-related cancer, net of legal fees, is estimated to be £254 million. The net cost to society of EL insurance (taking the difference between total employers' premiums and individuals' net claims) is therefore estimated to be £168 million.

[60] Data from ABI 'Income & Outgo' Spreadsheet (2014), 15-year average Gross Written Premiums for period 1999-2013, inflated to 2013 prices.

8 Administration and Legal

8.1 Background

186. As discussed in Section 5.4 (Productivity Costs), the myriad state benefits and occupational and statutory sick payments give a useful indication of the existing welfare system and workplace schemes in place to compensate individuals for being unable to work. However, these costs represent a transfer between different groups in society, and so are not economic costs and net to zero at the societal level.

187. However, there is an economic or opportunity cost to society associated with the various transfer payments, in terms of the resources spent by individuals, employers and Government departments in claiming for and processing the different payments.

188. There are also costs to employers and Government associated with any prosecutions and fines that are charged for breaches relating to work-related cancer.

8.2 Method and Assumptions

8.2.1 Claims

189. Time spent by individuals, employers or the Government on administrative activities represents an economic cost. Some effort is required by individuals and their families to notify and claim for the various sources of replacement income available to compensate them for an absence due to cancer, and that this places an administrative burden on their employers and Government departments, such as HMRC and DWP, associated with processing these claims.

190. The approach to valuing the costs of administrative activities in the model is based on a 'three administrative points' (TAP) approach, i.e. assuming that administrative activity occurs at the beginning, the middle and the end of a claim, and that the amount of effort (time) required will vary depending on the nature of the absence (i.e. a short or long-term absence).[61]

191. The amount of time spent for each administrative activity is then valued using the opportunity cost of time for individuals, employers and Government. For individuals, the Department for Transport publishes a value for non-working time in its web-based Transport Appraisal Guidance. The appropriate value for 2013 is £6.48 per hour.[62]

192. For employers and Government (employees of HMRC/DWP), the opportunity cost of time is assumed to be equal to the marginal cost of labour, given by the wage rate of the affected worker, plus any non-wage costs that the employer pays on its labour.[63] The average wage cost for clerical staff in 2013 was £11.44 per hour.[64]

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[61] For a fuller discussion of TAP approach, please see Section 5 of the Risk Solutions (2011) paper on the administration costs for employers. http://www.hse.gov.uk/research/rrpdf/rr897.pdf

[62] DfT Transport Appraisal Guidance, value for non-working time (Updated in November 2014). Table A 1.3.1: Values of Working (Employers' Business) Time by Mode (£ per hour, 2013 prices, 2013 values). https://www.gov.uk/government/publications/webtag-tag-data-book-november-2014

[63] The HM Treasury Green Book gives no specific guidance on the rate to use for non-wage costs, Eurostat publishes data on unit labour costs per hour from Eurostat (data for the UK is supplied by ONS). The latest figures suggests that non-wage labour costs in the UK are typically around 16.5% of total labour costs, or 20% of wage and salary costs. See:
(footnote continued on next page…)

8.2.2 Prosecutions and legal costs

193. Enforcement activity by HSE or Local Authorities (LAs) can result in firms being investigated and, if found guilty of a material breach, prosecuted. This entails costs to HSE and LAs in terms of resources spent investigating incidents of work-related cancer, and costs to employers in terms of responding to the investigation, and any legal costs and fines that arise from proceedings.

194. Prosecutions and fines had been estimated in the *Costs to Britain* in the aggregate; i.e. those related to work-related cancer had already been accounted for. In order to identify which were related to cancer, prosecutions brought against asbestos legislation have been used as a proxy.[65]

8.2.3 Insurance overheads

195. Also included under administration and legal costs to individuals is the overhead cost of life insurance, relating to the value of premiums consumed by insurance companies in profit and administration costs. The overhead cost of life insurance is estimated using the differential between premiums and claims in much the same manner as Employers' Liability insurance (see Section 7). No data on premiums paid is available, however, and so gross claims are uprated by 15% to reflect the likely insurance company profit and administration costs, for consistency with *Costs to Britain*.

8.3 Results and Discussion

8.3.1 Total Costs to Society

Table 14: Total administration and legal costs to society

	Estimated costs (£ millions)		
	Fatal cancer	Non-fatal cancer	Total
Administering claims	£5	£1	£5
Insurance overheads	£10	£0	£10
Prosecutions and legal costs	£3	Nil	£3
Total admin and legal	**£18**	**£1**	**£18**

Note: Totals may not sum due to rounding.

196. The administrative overhead associated with informing people about sickness absence and processing the various money inflows and outflows from sick pay, insurance claims and state benefit payments is a net cost to society.

197. The large component of insurance overheads relates mainly to the costs associated with the administration of life insurance schemes.

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http://ec.europa.eu/eurostat/documents/2995521/6761066/3-30032015-AP-EN.pdf/7462a05e-7118-480e-a3f5-34e690c11545

[64] ASHE (2013) revised Table 2.5a, SOC Code 4: Administrative and secretarial occupations - http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-337429

[65] In reality, prosecutions related to work-related cancers are unlikely to take place in the same year as the cancers diagnosis, and will span a number of years. It is not possible to trace prosecutions to the cancers estimated in the model, and so the average of prosecutions brought against asbestos breaches from 2009/10 -2011/12 is used as a proxy.

198. Fines paid by employers following successful prosecutions represent a transfer cost and so are not included in the total cost to society. The legal costs and administrative burden incurred by employers, HSE and LAs are a resource cost, however, and therefore represent a net cost to society.

199. The total administration and legal costs to society associated with work-related cancer are estimated to be around £18 million.

8.3.2 Costs to Individuals

Table 15: Total administration and legal costs to individuals

	Estimated costs (£ millions)		
	Fatal cancer	Non-fatal cancer	Total
Administering claims	£2	£0.3	£2
Insurance overheads	£10	Nil	£10
Total admin and legal	**£12**	**£0.3**	**£11**

Note: Totals may not sum due to rounding.

200. The main administrative cost to the individual or their friends and family is the time spent initiating and managing claims for sick pay and state benefits, and compensation and insurance payouts. The cost model assumes that this takes between half a day and a day per claim for absences up to six months, rising to up to three days per claim for long term absences. This is costed using the value for non-working time published by DfT and multiplied by the number of claims to give an aggregate cost to individuals.

201. The costs of administering claims amount to just under £2 million. The large component of insurance overheads due to fatal cancers relates to life insurance.

202. Note that for simplicity we attribute all of the costs of life insurance to fatal cases of cancer. In reality individuals who do not suffer a fatal case of work-related cancer also take out life insurance policies, and thus shoulder some of the costs associated with higher premiums. Attributing all costs to fatal cancers reflects that these are the main driver of life insurance costs.

8.3.3 Costs to Employers

Table 16: Total administration and legal costs to employers

	Estimated costs (£ millions)		
	Fatal cancer	Non-fatal cancer	Total
Administering claims	£0.5	£0.3	£0.8
Prosecutions and legal costs	£2	Nil	£2
Total admin and legal	**£2**	**£0.3**	**£3**

Note: Totals may not sum due to rounding.

203. Employers incur a cost associated with the administrative activities necessary to deal with sickness absence, for example processing sick pay claims and dealing with insurers over health insurance and compensation claims. This is over and above the costs of production disturbance.

204. Gordon and Risley (1999) assumed conservatively that these administrative activities would take half an hour per day for the duration of the absence.[66] Pathak (2008) preferred the Three Administrative Points (TAP) approach.[67] The cost model makes a similar assumption, allowing 2.5 to 3.5 hours per case for routine activities such as OSP/SSP claims, rising to 2.5 days per case for complex compensation claims arising from never returns. This is costed using the average wage rate for clerical staff (uprated to account for non-wage costs).

205. In addition, employers incur costs through legal proceedings brought against them for breaches related to work-related cancer and any resulting fines.

206. The administrative and legal costs to employers are as summarised in Table 16.

207. Nearly all of the costs are borne by fatal cancers. No current method is in place to estimate the split of prosecutions and legal costs between fatal and non-fatal cancer. As such, they are arbitrarily presented as all being due to fatal cancer.

8.3.4 Costs to Government

Table 17: Total administration and legal costs to Government

	Estimated costs (£ millions)		
	Fatal cancer	Non-fatal cancer	Total
Administering claims	£3	£0.2	£3
Prosecutions and legal costs	£1	Nil	£1
Total admin and legal	**£4**	**£0.2**	**£4**

Note: Totals may not sum due to rounding.

208. Government incurs an administrative and legal cost related to the processing of SSP and benefit claims and prosecutions. The clerical overhead associated with administering state benefits and statutory sick pay is a cost to the government. The cost model again uses the Three Administrative Points (TAP) approach, allowing 2.5 hours per case for SSP claims and 6 hours per case for short term benefits claims, rising to 2.5 days per case for long term benefits claims. This is multiplied by the average wage cost for clerical staff, plus non-wage costs, as above.

209. Government also incurs a cost associated with prosecutions and legal proceedings brought against firms.

210. Total administration and legal costs to Government are summarised in Table 17.

211. Nearly all of the costs are borne by fatal cancers. No current method is in place to estimate the split of prosecutions and legal costs between fatal and non-fatal cancer. As such, they are arbitrarily presented as all being due to fatal cancer. Given the small overall costs, we do not consider it proportionate to assess this further.

[66] Gordon, F, Risley, D, and EAU economists, 1999. The costs to Britain of workplace accidents and work related ill health in 1995/96. Second Edition. HSE Books ISBN 0 7176 1709 2

[67] Pathak, M., September 2008. The costs to employers in Britain of workplace injuries and work related ill health in 2005/06, HSE Analytical Services Division.

9 Summary of total annual costs to society (Great Britain)

9.1 Total annual costs to society

212. The total annual costs to society of work-related cancer include those borne by individuals, employers, and the Government (or general taxpayer). Deriving the net costs at the societal involves accounting for a number of money transfers between these groups, which cancel each other out. In line with Costs to Britain, we present results by the separate cost bearers alongside the total costs to society, as it is important in understanding how the costs of work-related cancer fall on different groups in society.

213. Table 18 summarises the total costs to society. The total annual economic costs to society of work-related cancer are estimated to be £12.3 billion in 2010. This is clearly a vast economic cost; to put it into context, it is of a similar magnitude to the latest *Costs to Britain* estimate (for 2013/14) of £14.2 billion for all workplace injuries and common ill health complaints, while the Department for Transport (DfT) estimate of the cost of reported road casualties (which uses a similar costing methodology) is £10.3 billion in 2013. [68]

214. We should reiterate, however, that the costs of work-related cancer presented in this report arise from new cases of cancer caused by *past* working conditions, while the *Costs to Britain* estimates reflect current working conditions. They are therefore not directly comparable.

Table 18: Total annual costs to society in 2010

	Estimated costs (£ millions)		
	Fatal cancer	Non-fatal cancer	Total
Human costs	£11,104	£297	£11,401
Productivity Costs	£524	£15	£539
Health and Rehabilitation costs	£133	£41	£174
Employers' Liability Insurance	£168	£0	£168
Admin and Legal costs	£11	£8	£18
Total costs	**£11,939**	**£360**	**£12,300**

Note: Totals may not sum due to rounding.

215. It is clear that human costs (a monetary valuation of the effects of cancer on quality of life, and loss of life in the case of fatal cancers) overwhelmingly dominate the total cost estimates, accounting for around £11.4 billion per year, or just over 93% of total costs. Fatal cancers account for over 97% of human costs, due to the value placed on the loss of life. The magnitude of human costs demonstrates the importance of estimating these in monetary terms; however, readers should note the challenges in doing so and the considerable degree of uncertainty around this estimate, which is discussed further in Section 10.

216. Productivity costs (i.e. the value of lost potential output as a result of worker absence and production disturbance) are largest of the 'financial' costs, around £640 million, and the second largest overall. However, this is not the case for non-fatal cancer, for which the costs

[68] http://www.gov.uk/government/statistical-data-sets/ras60-average-value-of-preventing-road-accidents. (Table RAS60003) Including the costs of 'damage only' accidents (which is not included in the HSE estimate) the cost of reported road accidents in 2013 was £14.7 billion.

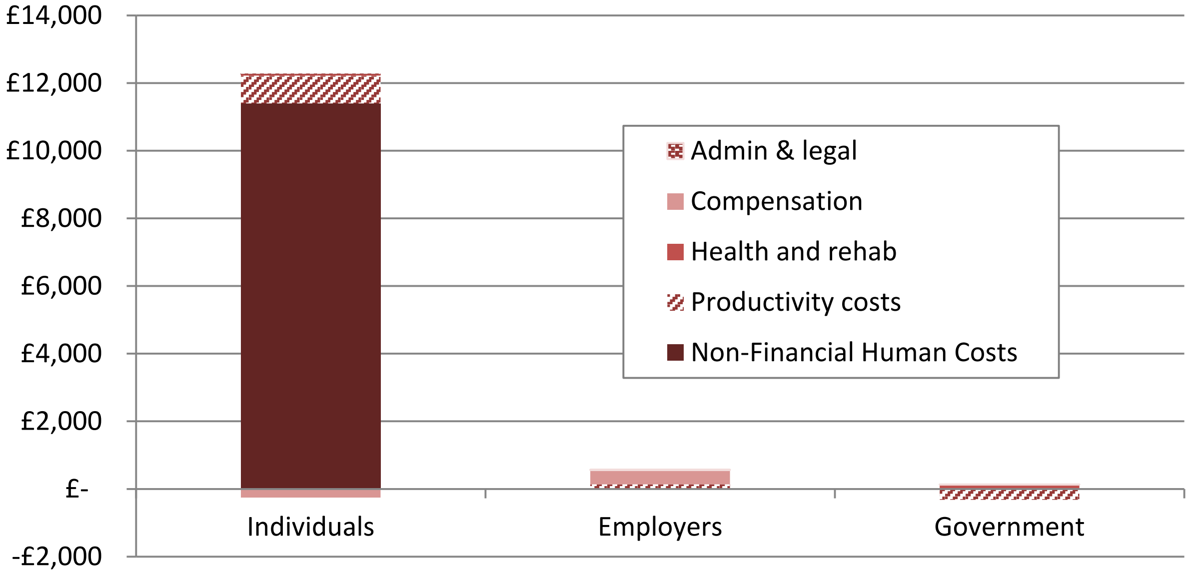
of health and rehabilitation are more than double productivity costs. Fatal cancers account for the vast majority of lost output, given that in these cases the output they would otherwise have produced over their remaining working lives is lost.

217. Productivity costs account for a much smaller proportion of overall costs here than in the *Costs to Britain* model (4% versus 32%).[69] This is primarily due to the age profile of work-related cancers, with about 70% of cancer registrations in the model estimated to be 65 or over, which we assume to be retired and hence not producing output, as opposed to the *Costs to Britain* model, in which all individuals are likely to be at work for the period of illness (given that the input data represents injuries and illnesses arising from work in the past 12 months).

9.2 Costs by stakeholder

218. Figure 4 presents the total costs to society broken down by stakeholder group. Individuals bear the overwhelming majority of the costs of work-related cancer: net costs to individuals are around £12.0 billion, or around 98% of total, the biggest contributor being the human costs, i.e. the monetary valuation of the impact on quality of life and loss of life.

Figure 4: Total costs by stakeholder (£ millions)



219. Employers incur costs of around £461 million per year, which, although large in absolute terms, is a a very small proportion of the overall costs, at around 3% of total costs to society. Costs to employers include the costs of production disturbance and sickness payments incurred due to worker absence, but the largest costs arise from the Employers' Liability premiums that they are required to pay.

220. The small proportion of costs falling to employers is driven by the latency between exposure to risk factors and the (possible) development of cancer, which is often decades. By the time most individuals are diagnosed with cancer, they are beyond retirement age, and many of those who are still working will be with a different employer or even in a different industry. This does not generate large financial costs, because individuals do not lose income from employment and the employers do not incur the costs of disruption from sickness absence and paying sick pay.

[69] See the Costs to Britain report: http://www.hse.gov.uk/statistics/pdf/cost-to-britain.pdf

221. As a result, employers do not bear the vast majority of the costs associated with the consequences of exposure to some of the risk factors (i.e. carcinogens) they control. This limits the financial incentives for employers to reduce those exposures based on concern for 'the bottom line' alone, but provides an economic rationale for HSE to support, incentivise and regulate businesses to address cancer risks.[70] It should be noted, however, that these estimates do not include any costs incurred by employers, as well as individuals or the Government, associated with conditions which precede the onset of cancer, for example in cases where silicosis occurs prior to lung cancer due to exposure to respirable crystalline silica.

222. It is also important to note some omissions from overall costs to employers in this instance. As described in Section 1, the net costs to employers do not currently include some of the impacts associated with 'presenteeism' (the reduction in productivity observed from those that return to work following successful cancer treatment), or the costs in terms of loss of reputation and expertise from workers who are forced the withdraw from the labour market due to work-related cancer. It is expected that the costs of these impacts may be significant, and hence the costs to employers are likely to understate the true cost to employers of work-related cancers, though they will still be limited by the fact that most individuals diagnosed with work-related cancer are likely to be retired.

223. Government also experiences some "savings" in terms of forgone state pensions that are no longer collected by individuals who die as a result of work-related cancer. Section 5.5.3 discusses this outcome further, which arises from the inclusion of state pensions in the model. It is important to emphasise that these are not economic costs, simply transfers from individuals who do not receive state pension payments to Government (and ultimately taxpayers). While there may be some isolated "benefit" for public finances (and this analysis does not claim to be a complete assessment of the public finance impact of work-related cancer), there is a clear and large aggregate loss to society due to work-related cancer, which is of main concern for Government.

9.3 Appraisal values

Table 19: Appraisal values (costs per case)

	Human Costs (£, rounded)	'Financial Costs' (£, rounded)	Total Costs (£, rounded)
Average case of cancer	£703,600	£55,500	£759,100
Average case (excluding NMSC)	*£956,000*	*£74,300*	*£1,030,000*
Fatal cancers	£1,180,000	£88,300	£1,268,000
Non-fatal cancers	£43,700	£9,400	£53,100
Non-fatal cancers (excluding NMSC)	*£118,900*	*£18,800*	*£137,700*

70 This analysis does not include risk premiums paid to workers via higher wages for the risks they face at work. The existence of such premiums will provide employers an additional incentive to address risks. Premiums will be more reflective of risks where there is good information on risks (they are known and easy to detect). This is not always the case for many carcinogens – for example, while risks from asbestos are well known, the fibres themselves are difficult to discern without testing. Employer market power can also limit the effectiveness of wage bargaining to secure wages that compensate adequately for risk.

224. The cost model also provides a series of ‘appraisal values’, costs per case of cancer that can be applied in policy appraisal. These represent net costs to society per case, or net economic costs. The table above presents values for ‘average’ cases of cancer, as well as for fatal and non-fatal cancers.

225. The average cost per case of a work-related cancer in the model is just under £800,000 (accounting for both fatal and non-fatal cancers), the vast majority of which is accounted for by human costs, or impact on quality and loss of life.

226. The average cost of a fatal workplace cancer is estimated to be around £1.3 million, compared with £53,100 for a non-fatal case. The disparity between the two is largely due to the valuation placed on the loss of life associated with fatal cancers.

227. The cost per fatal cancer estimate is lower than the cost per injury fatality estimated in our 2013/14 Costs to Britain report (£1.6 million, including financial costs). This may be contrary to some expectations about cancer being generally more ‘costly’ and imposing greater human costs.

228. The greater fatal injury costs relative to fatal cancer are driven by higher ‘financial’ costs; workers who lose their life due to a fatal injury are typically younger (average age around 50) than those who die of work-related cancer (average age 70), so the loss of output from work is greater for a typical fatal injury case. In contrast, our estimate of human costs is slightly higher for cancer than for fatal injuries, reflecting morbidity associated with cancer.

229. Note that these values would typically be discounted at a rate of 1.5% in UK government appraisals of policies designed to mitigate cancer risks and reduce the probability of cancers developing in the future. This would have the effect of substantially diminishing the values, given the typically long latency between exposure to carcinogens and effects of cancer. A latency of 5 years would reduce values by around 7%, giving a cost per fatal cancer of around £1.2 million, while a latency of 20 years would reduce values by 26%, resulting in a cost per fatal cancer of £970,000.It is also interesting to look at the appraisal values without NMSC. As can be seen in Table 19, NMSC has the effect of reducing the average costs per case considerably. Excluding NMSC, the average cost per case of cancer (including fatal and non-fatal cases) increases to just over £1 million. This is driven by the fact that NMSC is rarely fatal. The costs per non-fatal case also increase substantially to £137,700, arising largely due to much lower morbidity costs. The costs per fatal cancer are almost unchanged (so not included above), given that the mortality costs are unchanged (due largely to the fact that each fatal case represents a death, and a ‘life is a life’ approach to valuing fatal cancers is adopted).

9.4 Costs by cancer type

230. The cost model also generates a series of total and unit costs for each of the different cancer types included in the model. These are presented in Table 20 below, which gives the total costs to society by cancer type, alongside unit costs for each of the top ten cancer types.

231. The largest overall costs to society arise from lung cancer (£6.8 billion), mesothelioma (£3.1 billion), and breast cancer (£1.1 billion). The total costs are driven largely by the total number of cancer registrations attributable to work: the study estimates around 5,700 work-related lung cancers, 2,400 cases of mesothelioma, and 1,600 work-related breast cancer cases.

232. A notable exception is NMSC, of which there are an estimated 4,400 work-related cases but relatively low costs at £118 million. Very few NMSC cases lead to premature death, however (there are only an estimated 83 cases of fatal NMSC in the costs model). This means that

the monetary value attached to the impact on quality of life is much lower than the cancer types, such as mesothelioma and lung cancer, which have high mortality rates.

Table 20: Total costs to society per cancer type, ten most costly cancers[71]

	Total costs by cancer type (£ millions)	Average cost per case of cancer (£)
Lung	£6,753	£1,177,000
Mesothelioma	£3,059	£1,293,000
Breast	£1,132	£514,000
Bladder	£338	£597,000
Oesophagus	£235	£1,111,000
Stomach	£161	£1,146,000
Nasal / sinonasal	£136	£861,000
NHL^	£123	£713,000
NMSC^^	£118	£28,300
Leukaemia	£46	£978,000

[1]Non-Hodgkin's Lymphoma (NHL). [2]Non-melanoma skin cancer (NMSC).

233. It is also useful to look at the appraisal values per case of cancer. The cancers that result in the greatest overall costs to society do not necessarily have the highest average cost per case. As mentioned earlier, this is driven largely by the proportion of cancers in that category that become fatal, and consequently have much higher human costs and productivity costs.

234. The cancers that lead to the highest appraisal vales (or average costs per case) are mesothelioma, brain and nasopharynx. Almost all cases of these cancers lead to premature death, and hence human costs are much greater.

[71] Attributable fractions from the Cancer Burden study considered both the known and the probable carcinogens classified by the International Agency for Research on Cancer (IARC). The study included shift work, classified by IARC as a probable carcinogen.

The specific HSE Cancer Burden study for breast cancer can be found at: http://www.hse.gov.uk/research/rrhtm/rr852.htm. See http://www.hse.gov.uk/Statistics/causdis/cancer/cancer.pdf for further information on HSE's latest work-related cancer statistics.

The Costs of Work-related Cancer study assessed the potential costs of all work-related cancers in HSE's official cancer burden estimates, which are based on the HSE Cancer Burden study. However, research on the causal effects of night work on breast cancer is still developing. A recent study conducted by Oxford University (Travis et al. 2016), funded by HSE, has investigated independently the link between night-shift work and breast cancer in a large group of women in the UK and the study did not find evidence of a link.

The new Oxford University breast cancer research was not available at the time that work was undertaken on the Costs of Work-related Cancer study. As is normal when new research becomes available, HSE will consider the implications of the new breast cancer research for its official estimates of work-related cancer burden, and hence of the economic costs of work-related cancer.

[71] This is a direct consequence of the attributable fractions applied, which were not available by age. The age of work-related cancers may differ from cancers in the general population for a given cancer type for a number of reasons, not least because the source and age at exposure is likely to differ. For example, we assume that 15% of cases of lung cancer are attributable to work whether they occur in the 75-79 age group or the 25-29 age group. In reality, while possible, it is unlikely that a worker in their twenties has received sufficient occupational exposure to develop work-related cancer. However, as Figure 2 shows, this accounts for a very small proportion of total cases.

235. The lowest average cost per case of cancer relates to NMSC. This is primarily because most cases tend to be non-fatal in nature, and typical treatment costs and period of absence from work are much lower than for other cancer types.

10 Accounting for uncertainty

236. There are two primary sources of uncertainty in our model: in the incidence data and in the 'price' data. We should highlight that these [sources of uncertainty] are considerable, as with any study of this nature, meaning that the results can only be indicative of the scale of true welfare costs, rather than precise estimates. Values from the study should be used with the necessary caution and analysts should undertake sensitivity analysis where possible to test the robustness of appraisal outcomes to changes in the valuation placed on cases of cancer.

Bias and uncertainty in incidence data

237. The critical parameters in our estimates of the number of new cases of work-related cancer in 2010 are the attributable fractions taken from the HSE Cancer Burden study. There are many sources of uncertainty and bias in the AF estimates, including incomplete evidence on occupational carcinogenic hazards, inaccurate or approximate data (e.g. information on historical workplace exposure in GB) and other potential methodological issues.[72] The main authors of the study at Imperial College provided HSE with confidence intervals for the AFs; however, these only account for statistical uncertainty relating to random errors in the underlying relative risk estimates. They do not account for the potential sources of bias described above.

238. Estimating 'credibility intervals' by accounting for bias and uncertainty is inherently very challenging. However, researchers from the Imperial College London have assessed and compared the confidence interval and credibility interval using occupational exposure to respirable crystalline silica (RCS) and lung cancer in men, for example. The estimated occupational AF was 3.9% in the cancer burden study, which could be translated into about 700 lung cancer deaths per year in GB due to RCS exposure. The corresponding confidence interval that accounts for random errors only was 2.9%-4.9%, which could be equal to about 600-900 lung cancer deaths per year. In comparison, the credibility interval that has accounted for known bias and uncertainty was 2.0%-16.2%, which could give a wide range of estimates of 400 to 3,000 lung cancer deaths per year.

Bias and uncertainty in price data

239. We have necessarily made a number of assumptions and judgements regarding key parameters and data sources in assembling the cost model. The costing framework for the main impacts is based upon HSE's established *Costs to Britain* model.[73] An earlier version of this report describing the methodological approach to estimating the key cost components has been subject to external peer review, while the many issues arising in the model have been consulted on with experts within and outside HSE. However, there is inevitably a substantial degree of uncertainty in the chosen parameters and the resulting estimates.

240. This is particularly true for human costs, which are by their nature extremely challenging to value. While estimates for other cost components are largely based on – or can be corroborated by – available market data, human costs are by their nature 'non-market' and

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[72] See Section 4.0 of the HSE Cancer Burden study for further discussion (RR931 - The burden of occupational cancer in Great Britain: Overview report)

[73] A recent review by EU-OSHA of published studies worldwide on the costs of accidents and ill-health at work, aimed at informing the development of a framework for estimating costs at the EU-level, recommended HSE's *Costs to Britain* model as a good-practice example. See https://osha.europa.eu/en/publications/reports/estimating-the-costs-of-accidents-and-ill-health-at-work/view.

must therefore be elicited from surveys or inferred from existing market data on the purchase of other goods and services.

241. Our estimates of human costs use the Value of Preventing a Fatality (VPF), a well-established value used by the Department for Transport. It is, however, based on an increasingly dated 1999 study.[74] A 2011 review of the VPF did not recommend that a new study should be undertaken to update the value before further methodological issues are addressed, but it did emphasise that government analyses should make clear the uncertainties surrounding the estimate.

242. Considering these uncertainties, the 'human costs' valuations we derive based on the VPF are indicative of potential costs. Although these estimates reflect what we consider to be current best evidence based on current guidance, we will seek to update our methodology in the future to reflect new studies, developments in valuation methodologies, and any changes in government-wide appraisal guidance

Approach to uncertainty in this study

243. Considering the many sources of uncertainty present in this study (and in all similar studies), much of which are extremely difficult – if not impossible – to quantify, we consider that presenting confidence intervals for the cost estimates based on random error in the AFs alone would provide a spurious picture. Furthermore, unlike our *Costs to Britain* estimates, we do not plan to update the cost estimates annually, or make comparisons between years, meaning there is less of a need to quantify uncertainty.[75] We therefore do not attempt to present confidence or credibility intervals around estimates. However, we emphasise that readers and users of the estimates should be mindful of the considerable sources of uncertainty discussed above.

[74] Carthy, T., Chilton, S., Covey, J., Hopkins, L., Jones-Lee, M, Loomes, G., Pidgeon, N., and Spencer, A. (1999), On the Contingent Valuation of Safety and the Safety of Contingent Valuation: Part 2 – The CV/SG 'Chained' Approach, Journal of Risk and Uncertainty, 17, 187-213

[75] Costs to Britain presents 95% confidence intervals based on sampling uncertainty. The same degree of bias uncertainty is not present in the Costs to Britain estimates, since the incidence data is taken from a statistical survey (Labour Force Survey). While the similar potential for uncertainty is present in the price data, this is arguably not important for comparisons between years (which is the main purpose of estimating confidence intervals in the Costs to Britain study), since we would expect the uncertainty to be relatively constant between years.

11 Uses of the economic cost estimates

244. The development of the model enables HSE to produce estimates of both aggregate and unit costs. This section describes the uses to which each of these sets of figures can be put, and explains how the new estimates are designed to meet these needs more fully than has been possible in the past.

11.1 Uses of the aggregate costs

245. The aggregate costs of work-related cancer can be used by HSE and other stakeholders to indicate the current overall economic burden of cancers caused by previous exposures. It is anticipated that the costs of work-related cancer would be fairly stable in the short term.

246. The cost estimates provide a means of adding together very different cost components from both fatal and non-fatal cancers so that they can be presented in a single summary measure. There is interest in such a measure from a wide range of stakeholders: Government departments; the media; private sector organisations; employer organisations; trade unions; academics and the public. HSE believes that this overall measure needs to be robust, transparent and based on sound evidence: the methodology has involved extensive internal peer review with HSE analysts and scientists, as well as external expert peer review.

247. It is important to note that the *aggregate* costs figure cannot be used to infer the benefit, or avoided costs, of more stringent control of exposure to carcinogens (which could be compared with the regulatory and control costs). However, the *unit* costs can be used in this way for particular interventions, as described in Section 11.2 below, and can be employed to illustrate the 'cost savings' from improvements achieved in health and safety outcomes.

248. The distribution of the costs is also of interest. Most obviously, they indicate the relative burden of costs between stakeholders. The share between employers and individuals – where individuals bear the vast majority of costs – also provides some insight into incentives with respect to taking risk control measures, as discussed in Section 9.2. This distribution is starkly different to that of HSE's Costs to Britain estimate (only injuries and short-latency illnesses), where employers and Government account for a much greater share of costs (roughly a fifth each).

11.2 Uses of the 'appraisal values'

249. Appraisal values, or average costs per case, can be in HSE's appraisal of proposed interventions (e.g. regulatory impact assessments) and evaluations.[76] These represent the avoided costs, or benefits, of policies and measures designed to reduce cases of work-related cancer, which can be compared with any costs to employers and/or Government arising from the policy being assessed..

250. Whilst the appraisal values reflect the same range of cost categories as the total costs to society, for simplicity of presentation the appraisal values can be divided into two main component costs: 'human costs' (a monetary valuation of the loss of quality of life and loss of life due to cancer) and 'financial costs' (comprising productivity costs, healthcare costs, employers liability insurance costs, and administration and legal costs).

[76] More information on impact assessments is available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/211981/bis-13-1038-better-regulation-framework-manual-guidance-for-officials.pdf

251. The choice of which appraisal value(s) to apply will depend on the policy intervention in question. Where the intervention targets carcinogens that cause specific types of cancer, the relevant cancer-type appraisal values provided in Section 9.4 should be used. For more general interventions, or where a high-level analysis is being conducted and the specific type(s) of affected cancers are unknown, the appraisal values for all cancers (or all cancers excluding NMSC) provided in Section 9.3 may be more appropriate.

11.3 Priorities for further research

252. To our knowledge, this study is the most comprehensive estimate of the economic costs of work-related cancer so far conducted in Europe and possibly worldwide. Nevertheless, as with HSE's *Costs to Britain* estimates, there is always scope to improve the cost estimates by increasing the scope of impacts accounted for. Moreover, there are a number of areas where further research and methodological developments could refine the existing estimates of impacts, particularly given the limitations and assumptions highlighted throughout the report, and summarised in Section 10.

253. The following areas are considered potential candidates for further research and development of the estimates, depending on the availability of suitable data:

- Breakdown of economic costs by industry sector and/ or causative agent;
- Accounting for unquantified productivity costs discussed in Section 5.5.5, such as presenteeism and the loss of informal care (e.g. grandparents unable to provide childcare due to cancer)
- Reflect further developments in valuation methodology, particularly relating to human costs, and potential changes in government appraisal guidance
- Estimate of the economic costs of future cancers arising from current working conditions
- Application of the costs model to other long latency illnesses, such as chronic obstructive pulmonary disease;

254. Given the likely stability of estimates of work-related cancer, and the level of resources involved in producing this report, we do not plan to update these estimates annually. This would not produce meaningful results without updated attributable fractions estimates. The stability in registrations and deaths in the short term means that a single year's costs should give a broad indication of the level of costs for the next few years.

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Appendix 1: Costing framework

Note: Cost components in red and denoted by (-) show money outflows; cost components in black and denoted by (+) show money inflows

<table>
<tr><th>Cost component</th><th colspan="3">Description</th></tr>
<tr><td rowspan="6">Productivity costs</td><td colspan="3">At the societal (total) level</td></tr>
<tr><td colspan="3">Captures costs associated with productivity:
• Loss of output (gross loss of earnings) – the cost model assumes full employment in the economy, therefore at the macro level the effect is one less productive worker;
• Production disturbance (reorganisation and recruitment)
(At the societal level, transfer payments (e.g. sick pay, benefits, tax, National Insurance) cancel out.</td></tr>
<tr><td colspan="3">How the productivity costs fall to the different cost bearers</td></tr>
<tr><td>Individual</td><td>Employer</td><td>Government</td></tr>
<tr><td>(-) Loss of gross earnings
Loss of gross earnings due to absence from work (both short-term absences in the current year and absences in future years for those whose cancer leads to their permanent withdrawal from the workforce).</td><td></td><td></td></tr>
<tr><td>(-) Loss of state pension income
Loss of state pension income for individuals who die as a result of work-related cancer.</td><td></td><td>(+) Savings in state pensions not paid
State pension income that is no longer paid to individuals represents a saving to the public purse.</td></tr>
</table>

	(+) OSP/SSP receipts Many employers offer an occupational sick pay scheme (OSP), but others offer only statutory sick pay (SSP) and the self-employed will receive nothing at all from their employer. OSP and SSP provide the individual with income to offset their lost earnings. (The OSP/SSP receipts to the individual are exactly equal and opposite to that paid out by employers and government).	(-) OSP/SSP payments net of reimbursements It is assumed that the employer maintains production at the same marginal cost prior to the individuals' absence by either rearranging work or hiring a replacement. Therefore, the employers' OSP/SSP payments represent an additional cost to the employer.	(-) SSP reimbursements Up until March 2014, the Government provided employers some reimbursement of their SSP payments under certain conditions (known as the percentage threshold scheme).
	(+) State benefit receipts There are a range of state benefits available to people who are not able to work because of work-related cancer, including jobseekers allowance, industrial injuries disablement benefit, disability living allowance, housing benefit and council tax benefit. Like OSP/SSP receipts, these offset individuals' lost earnings		(-) State benefit payments The State benefits paid by the Department of Work and Pensions are exactly equal and opposite to the state benefits received by individuals not able to work.
	(+) Income tax and NI savings The loss of gross income results in the individual 'saving' on their income tax and National Insurance contributions to Government.	(-) NI paid on OSP/SSP Payments to absent employees continue to attract employers' class 1 National Insurance contributions.	(-) Net income tax and NI reduction The loss of income tax and NI paid by the individual to the Government is partly offset by the employer NI received on OSP/SSP payments

		(-) Work reorganisation For the first 6 months of any absence the model assumes that the employer will reorganise work to cover the absent employees' duties: this reorganisation incurs managerial/supervisory time.	
		(-) Recruitment and induction costs The model assumes that for absences of 6 months or more, the employer will recruit temporary or permanent replacement staff and provide them with suitable induction support.	
Employers' Liability Insurance	**At the societal (total) level**		
	Captures the overhead cost of Employers' Liability insurance, a compulsory insurance for all employers, other than the state. The cost to society represents the overhead cost to insurers of administering the scheme, plus the claim value consumed in legal costs and expenses that is removed from the claims value awarded to individuals.		
	How the compensation costs fall to the different cost bearers		
	Individual	***Employer***	***Government***
	(+) Lump sum payments to individuals made from claims against Employers' Liability insurance cover (associated with work-related cancer), net of legal costs	(-) Total cost of Employers' Liability insurance premiums made by employers (associated with work-related cancer)	
Human costs	**At the societal (total) level**		
	A monetary value of the impact on quality of life of affected workers: often the greatest impact of work-related cancer is on quality of life, including lost life. It is standard practice in the economics of public policy to place a monetary value on non-financial costs where possible.		
	How the human costs fall to the different cost bearers		
	Individual	***Employer***	***Government***
	(-) A monetary value of the impact on quality of life of affected workers, and loss of life in the case of fatal cancers.		

<table>
<tr><td rowspan="5">Health and rehabilitation</td><td colspan="3">At the societal (total) level</td></tr>
<tr><td colspan="3">Total cost of health and rehabilitation associated with work-related cancer (whilst the majority of costs are borne by the Government through NHS funding, there are some additional costs borne by individuals (e.g. “out of pocket” expenses). Added to this are the profit margins and overheads for insurance companies providing private health insurance.</td></tr>
<tr><td colspan="3">How the health and rehabilitation costs fall to the different cost bearers</td></tr>
<tr><td>Individual</td><td>Employer</td><td>Government</td></tr>
<tr><td><u>(-) Out of pocket expenses…</u>
… including funeral expenses (for fatal injuries), prescription charges, additional travel and living costs, home modifications.</td><td></td><td><u>(-) NHS treatment and rehabilitation costs…</u>
... including ambulance costs, hospital and clinic costs, GP costs, NHS prescription costs.</td></tr>
<tr><td rowspan="6">Administration and legal</td><td colspan="3">At the societal (total) level</td></tr>
<tr><td colspan="3">The costs of administrative activities to individuals, employers and Government associated with informing of sickness absence and processing the various money inflows and outflows from sick pay and benefit payments, compensation and insurance claims etc. The total legal costs and internal labour costs incurred by employers, HSE and Local Authorities are also a net cost to society.</td></tr>
<tr><td colspan="3">How the health and rehabilitation costs fall to the different cost bearers</td></tr>
<tr><td>Individual</td><td>Employer</td><td>Government</td></tr>
<tr><td><u>(-) Administration of insurance, compensation and benefit claims</u>
Individuals incur costs from the administrative activities associated with initiating and managing claims for sick pay and state benefits and compensation and insurance payouts.</td><td><u>(-) Administration of SSP/OSP, insurance and compensation claims</u>
Employers incur costs from the administrative activities necessary to deal with the above payments and claims.</td><td><u>(-) Administration of SSP and benefits claims</u>
The clerical overhead associated with administering state benefits and statutory sick pay is a cost to the government.</td></tr>
<tr><td><u>(-) Insurance company profit margin</u>
Individuals can have various insurance products to protect their income, including life insurance. The cost of insurance to the individual is the net difference between premiums paid and payments received which represent the insurance companies’ profit margin and overheads.</td><td></td><td></td></tr>
</table>

		(-) HSE or LA investigation/prosecution – internal costs + legal costs Cost to employers of management time for dealing with HSE or Local Authorities investigations/ prosecutions and the arising legal costs.	(-) HSE or LA investigation/prosecution – internal costs The internal costs borne by HSE and Local Authorities for investigating work related incidents.
		(-) Fines paid The cost of any fines paid by employers due to breach of health and safety regulations.	(+) Fines received The cost of any fines received by government due to breach of health and safety regulations (equal and opposite to that paid by employers).

Appendix 2: Detailed breakdown of costs by cost bearer (2013 prices)

	A. Individuals and their families	£ m	B. Employers	£ m	C. Government and general taxpayer	£ m	D. Total cost to society = A + B + C £m
Productivity costs							-533
(Due to lost income/output)	Loss of gross earnings: (i) temporary losses prior to return to work, (ii) permanent losses due to withdrawal from workforce or death	-533					
	Loss of state pension income	-615			Savings in state pensions payments	615	0
	OSP/SSP receipts	27	OSP/SSP payments net of reimbursements	-27	SSP reimbursements	0	0
	State benefit receipts	91			State benefit payments	-91	0
	Income tax and NI saving due to difference between pre and post illness income, assuming all compensation payments are tax free	208	National Insurance paid on OSP/SSP	-3	Net income tax and NI reduction	-205	0
(Due to production disturbance)			Work reorganisation	-0			-0
			Recruitment and induction costs for temporary/permanent replacement staff	-6			-6

					Loss of profit on economic output not produced by individual absent from workforce	0	0
Employers' Liability Insurance	EL insurance receipts, net of legal costs	254	EL insurance premiums	-422			-168
Human Costs	Monetised value of human costs	-11,401					-11,401
Health and Rehabilitation	Out of pocket funeral expenses, travel expenses, prescription charges, home expenses	-42			NHS treatment and rehabilitation costs (short and long term)	-132	-174
Administration and Legal	Administration of insurance, compensation and benefit claims	-2	Administration of SSP/OSP, insurance and compensation claims	-1	Administration of SSP and benefits claims	-3	-5
	Insurance company profit margin and administration costs on other insurance products	-10					-10
			HSE or LA investigation / prosecution - internal costs + legal costs	-2	HSE or LA investigation / prosecution - internal costs	-2	-3
			Fines paid	-0	Fines received	0	0
Total Costs		-12,021		-461		183	-12,300

Source: HSE Cost model

Appendix 3: Human costs

A. Further information on the approach to valuing morbidity in this study

A1. As discussed in Section 4.2, there may be important differences between deaths from cancer and deaths from fatal injuries in the workplace, which could influence people's aversion to cancer risks and which we should consider when estimating costs. A literature review for HSE identified a number of potentially pertinent factors: latency (the time lag between exposure to carcinogen and possible death from cancer); illness or morbidity prior to death; and possibly a psychological "dread" of the morbidity or relating to other qualitative factors, such as fear of recurrence, (in)voluntariness and (lack of) control, or a fear of cancer itself unrelated to its clinical and qualitative effects.

A2. One approach discussed in the literature to capture these effects is to apply a generalised adjustment to estimates of non-cancer values (e.g. the DfT Value of a Prevented Fatality). An example of such a generalised adjustment is HSE's previous "cancer premium" recommendation of doubling the standard roads-based VPF as set out in HSE (2001) *Reducing Risks, Protecting People* ('R2P2').[77] This approach loosely reflected the very limited available evidence on preferences regarding cancers risks at the time (e.g. Jones-Lee *et al.* 1985) and HSE committed in R2P2 to review evidence for the adjustment in the future.

A3. This appendix summarises the research HSE has undertaken since and the reasons for the approach adopted in the main report.

The Newcastle University literature review and pilot study

A4. In 2010, HSE (which, at the time, included the Office for Nuclear Regulation, now a non-departmental public body) funded a small literature review to examine whether there was consensus on the combined effect of dread and latency on people's willingness to pay to avoid cancer relative to road risk. The review concluded that, while the evidence on a cancer premium was mixed and inconclusive, there was no evidence to support HSE's approach of applying a "x2 multiplier" to the roads VPF. [78]

A5. It suggested, based on consideration of the available literature at the time and theoretical argument, that the effects of latency and dread (of morbidity or other factors) may offset each other, such that there is effectively no premium for cancer, but that an empirical study would need to be undertaken in the UK context to investigate further.

A6. Based on these findings, in 2012 HSE (still then including ONR) funded a small study to test the combined effects of dread, latency and illness on risk preferences.[79] The study took a sample of around 150 people through an extensive exercise to examine how they trade-off risks of fatality due to cancer against risks of fatality due to road accident. This provides an

[77] Available at: http://www.hse.gov.uk/risk/theory/r2p2.pdf

[78] Jones-Lee, M., Loomes, G. (2010) The valuation and costing of work-related cancer. Report to the Health and Safety Executive.

[79] McDonald, R. L., Chilton, S. M., Jones-Lee, M. W., & Metcalf, H. R. T. (2016). Dread and latency impacts on a VSL for cancer risk reductions. *Journal of Risk and Uncertainty*, *52*(2), 137–161. http://doi.org/10.1007/s11166-016-9235-x

indication of the strength of preference for avoiding these risks, i.e. how much worse the respondent thinks cancer is than road risk (or vice versa).

A7. The empirical study was a pilot in nature. It had a small sample size and was not a full nationally representative survey. In anticipation of lack of resources for a full survey, the research took measures to ensure the survey produced high quality outputs, including face to face surveys, pre survey 'training' on understanding risk and qualitative follow up interviews.

A8. The main findings of the study were as follows:

- There is no empirical support for HSE's current approach of doubling the value of a prevented fatality for cancer;
- In the same time period, there was evidence of a cancer 'premium', relative to road, of 40%, which respondents discounted at an observed private rate of time preference of around 7.5% annually;
- There was evidence that the greater aversion to cancer is associated with illness or morbidity prior to death that is associated with cancer, rather than dread of the cancer label per se, or related to other qualitative factors. The main basis for this conclusion was that when the morbidity period of road and cancer deaths was equalised at 12 months, the results did not show any statistically significant premium for cancer.

A9. If morbidity is the driver of the greater aversion to cancer risks, this suggests that we should consider valuing the effects of morbidity directly, rather than measuring implicitly via a generalised adjustment such as the cancer premium.[80] While the Newcastle University study employed a very high quality, carefully trialled and conducted survey, the aim of the research was not to elicit specific valuations of cancer morbidity, so it was not designed as such. In particular, the survey approach did not include a detailed description of the quality of life effects or health states arising from cancer morbidity, or explore the differences between specific types of cancer, in terms of the illness and treatment experienced. This means that morbidity costs inferred from the results may to some extent reflect individuals' preconceptions of the ill health effects of a generic case of cancer, rather than the actual effects of the types of cancer assessed in this research.

A10. Therefore, while the Newcastle study provides evidence that individuals in the UK are willing to pay a greater amount to reduce cancer risks relative to road risks (i.e. that the 'human costs' are higher) because of the morbidity associated with cancer, it (and other similar studies in the literature) arguably does not provide a suitable measure of the magnitude of morbidity costs to apply in the present study.

A11. We therefore sought an approach to value morbidity directly, using a methodology that satisfied the requirements below:

a. **A consistent approach to valuing morbidity associated with both fatal and non-fatal cancers.** While there are often important differences in the psychological and physical effects of morbidity associated with fatal versus non-fatal cancers, we needed a consistent framework within which to value these effects. Many cancer valuation studies in the literature, including the Newcastle University study

[80] This indeed was a recommendation of a report produced for HSE in 2007 by leading economists on the valuation of life and health. See Jones-Lee, M., Loomes, G. and Spackman, M. (2007). *Human Costs of a Nuclear Accident: Final Report.* Available at: http://www.hse.gov.uk/economics/research/humancost.pdf

commissioned by HSE, were aimed at fatal cancers and do not provide a clear means of valuing non-fatal cancers.

b. **Capture the differences in duration and severity of morbidity between cancer types.** Some cancer types typically involve prolonged periods of treatment and suffering, with enduring effects on health in cases that are not fatal, while other cancers are often easily treated with no adverse long-term implications. Non-melanoma skin cancer (NMSC) is a clear example of the latter – often treatable with relatively minor surgery – which contrasts with breast cancer, which may require lengthy treatment and surgery with effects that endure for many years. Given that NMSC accounts for over 60% of non-fatal cancers estimated in this study, it was imperative that the adopted methodology was sensitive to these differences. A generic valuation of cancer morbidity would considerably overweight the costs of NMSC relative to other cancers.

c. **An approach that can in principle be applied in the future to value the morbidity of other work-related illnesses on a consistent basis**, such as for chronic obstructive pulmonary disease (COPD) and other respiratory disease.

d. **A methodology that is broadly consistent with forthcoming HM Treasury guidance for economic appraisal in government.** An imminent update of the HM Treasury 'Green Book' will include revised guidance on the valuation of life and health impacts.[81] Ensuring that our analysis is consistent with this guidance will mean that the appraisal values we derive – and the economic analyses we apply them in – will be comparable with those used elsewhere in government, and continue to stand up to scrutiny of the Regulatory Policy Committee.[82]

A12. It was beyond the scope of this study to undertake a primary valuation study of cancer morbidity. Very few studies in the literature have attempted to derive values for cancer morbidity specifically.[83] An alternative is to apply an index-based approach chained to either the value of a prevented fatality or the value of a life year (VOLY). HSE takes the former approach in the *Costs to Britain* study for workplace injuries and ill-health, which uses estimates of the severity of non-fatal injuries relative to death (from the road transport context) on a scale of 0 to 1, multiplied by the VPF to derive values for non-fatal cases.[84] This approach gives a human cost per average case of ill health of £9,900 in 2013 prices.[85]

A13. UK government appraisals increasingly use an index-based measure of healthy years gained or lost to quantify the health impacts, such as quality adjusted life years (QALYs) or disability adjusted life years (DALYs), which are then valued using an estimate of the

[81] Available at: https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

[82] The Regulatory Policy Committee provides the UK government with external, independent scrutiny of new regulatory and deregulatory proposals.

[83] Magat, Viscusi and Huber (1996) looked at the value of avoiding the morbidity associated with non-fatal lymphoma. They found that when survey respondents were presented with a risk-risk trade-off between non-fatal lymphoma and an equivalent increase in the risk of an immediate fatal car accident, the magnitude of the morbidity value was 58% of the value of the fatal accident. This suggests that the value of morbidity could be large; however, it is not directly transferable to the UK context and does not provide values for other cancers.

[84] This approach is described in further detail in Appendix 3 of the detailed *Costs to Britain* methodology report available at: http://www.hse.gov.uk/research/rrpdf/rr897.pdf

[85] See http://www.hse.gov.uk/economics/eauappraisal.htm

monetary value of a ‘full health’ year. The most well-known use of QALYs in UK public appraisal is by NICE, which applies the metric to assess the cost-effectiveness of medical treatments in health technology appraisals. Recently published guidance by the Department for Environment, Food and Rural Affairs (DEFRA) advises the use of DALYs in the valuation of impacts of environmental noise impacts on health[86], while an index-based approach is also likely to be advised in a forthcoming update of HM Treasury Green Book guidance.

A14. There are a number of important differences between the two metrics, for example in how the quality of life weights are determined. Health-related quality of life (HRQoL) weights used in QALYs are typically derived based on surveys of the patients or the general population, while disability weights used to derive DALYs, on the other hand, are typically based on clinical expertise.[87] Utility-theoretic approaches, where respondents are required to trade risks, are more compatible with economic valuation.

A15. A further difference is that QALYs tend to be estimated for treatments – they reflect the improvement in quality of life which is expected if a given treatment is administered to an individual in a given health state. Thus, the QALY estimates tend to capture the difference between the ‘untreated health state’ and the ‘treated health state’, which may differ from the actual loss of quality of life which accrues from the health state itself (for instance, since treatments are rarely 100% successful). DALYs, on the other hand, estimate the loss in quality of life from being in the health state compared with full health, so are more readily applicable to policies designed to prevent, rather than treat, disease.

A16. As described in the main body (Section 4.4.2), based on a further literature review, we adopted the DALY as a measure of morbidity, due primarily to the availability of suitable data transferrable to the GB context. The remainder of this appendix provides further detail on the sources of data for the DALY estimates and the values used in this study, which were provided by Imperial College London as part of the HSE Cancer Burden study. The text below is based on an appendix to the HSE Cancer Burden study produced for HSE by Imperial College.

Further information on approach to estimating DALYs for morbidity in this study

A17. The data provided by Imperial College drew on existing disease burden data. The primary source was the most recent estimate of burden of disease in Australia[88], which draws on Dutch weights developed for burden of disease estimation[89] and medical knowledge of disease effects and their durations for each cancer.

[86] Defra (2014). Environmental Noise: Valuing impacts on: sleep disturbance, annoyance, hypertension, productivity and quiet. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/380852/environmental-noise-valuing-imapcts-PB14227.pdf

[87] The latest World Health Organisation Global Burden of Disease study derived disability weights based on household and web surveys in a number of countries. However, the study provides only generic values for cancer, rather than values specific to the cancer types in this study.

[88] Begg S, Vos T, Barker B, Stevenson C, Stanley L, Lopez AD, 2007. The burden of disease and injury in Australia 2003. PHE 82. Canberra: AIHW. At the time of writing, the Australian Institute for Health and Welfare is in the process of updating its burden of disease estimates for 2011, with an expected release in the first half of 2016. http://www.aihw.gov.au/burden-of-disease/

[89] Stouthard M , Essink-Bot M, Bonsel G, Barendregt J, Kramers P. 1997. *Disability weights for diseases in the Netherlands*. Rotterdam, Department of Public Health, Erasmus University.

Disability weights

A18. The Dutch study provided disability weights specific to a Western European (Dutch) context, following an adapted form of the expert panel-based approach of the World Health Organisation's *Global Burden of Disease Burden* protocol. In brief, groups of experts considered a set of 16 indicator conditions defined to encompass a range of disability severities and different health states. Individuals in the group made their own assessment, and were then asked to reach a consensus on the weights to be applied. A person-trade-off (PTO) method was used as the primary measure to elicit health-state preferences to estimate disability weights.[90]

A19. Health state descriptions for indicator conditions were based on the EQ5D+ protocol, covering problems such as walking, washing and dressing, performing daily activities, pain/discomfort, anxiety or depression, and cognitive functioning. Two cancer-related indicator conditions were used: breast cancer (clinically disease free after 1 year) and colorectal cancer (irradically removed or disseminated). Participants then took part in an 'interpolation' exercise, to place additional diseases and disease stages on the disability weight scale relative to the indicator conditions.

A20. The use of an expert panel approach means that the disability weights (and by extension the monetary values based on these in this study) reflect medical expert assessments of the disutility from cancer morbidity rather than subjective assessments of general population. This has the benefit that the respondents are highly knowledgeable about the effects of the diseases and so able to make well-informed judgements, which can often be challenging for lay participants in valuation studies, and means the results are less like to reflect people's preconceptions about the effects of cancer. However, it also means that the results do not necessarily represent the preferences of the broader population. While the latter point is a limitation for application in economic valuation, we consider that on balance these weights provide reasonable results suitable for application in the current study.

Disease stages and durations

A21. The Dutch disability weights apply to successive disease stages. This means that country-specific knowledge is required on lengths of time spent in each disease stage, and on the proportion 'cured' and therefore not entering the terminal stages of disease, so that the incident cases can be apportioned between the disease stages.

A22. The stages used in this study were 'diagnosis and primary therapy' (for fatal and non-fatal cancers), 'state after intentionally curative primary therapy' (for the non-fatal cases, lasting the remainder of the first five years from diagnosis) and 'survivors with long-term sequelae' (lasting to normal life expectancy); and 'in remission', 'disseminated/ preterminal' and 'terminal' stages for fatal cancers. See Figure 3 on page 33 of the main body of the report for a diagrammatic example for female breast cancer.

A23. For cancers missing from the Dutch study, Imperial College researchers applied values from the Global Burden of Disease. Where no values were available from either source, the weight for a cancer of similar prognosis is used (e.g. mouth and oropharynx for sinonasal cancer, non-operable lung cancer for mesothelioma).

A24. As no information is available at present on average duration in each disease stage in the UK, the durations used for the Australian BoD update are used for all stages except 'survivors with long-term sequelae' (for non-fatal cancers) and 'remission' (for fatal cancers).

[90] The person trade-off method requires the expert panel members to trade off person years lived in full health against those lived with some defined disability, with the judgments made for a population (e.g. of 1,000 individuals gaining one full health-year) rather than for individuals.

For ‘survivors with long term sequelae’, the duration is taken as normal life expectancy less the durations of the first two stages. For ‘remission’, the duration is taken as the average survival time for the uncured disease less the lengths of all other relevant stages.

A25. To estimate the proportion cured and the average survival time for the uncured, a Weibull distribution of survival times is assumed.[91] The method used to estimate proportion cured and average survival time is described in more detail in a forthcoming appendix to the HSE Cancer Burden study.

A26. Table 21 and Table 22 on the following pages summarise the survival times, disease stages and durations, disability weights, and resulting DALY and morbidity values used in this study.

[91] Verdecchia A, De Angelis R, Capocaccia R, Sant M, Micheli A, Gatta G and Berrino F, 1998. The cure for colon cancer: results from the Eurocare study. *Int. J Cancer*, 77, 322-329

Table 21: Disability weights (DW), durations, DALYs, disease stages and total morbidity costs for fatal cancers

Fatal cases	Average years survival – reg. to death	Diagnosis and primary therapy		Remission		Disseminated / preterminal		Terminal		DALY per case over period to death	Discounted costs per case	Total costs – morbidity (fatal cancers)
		DW	Average duration (years)	DW	Average duration (years)	Disability weight	Average duration (years)	Disability weight	Average duration (years)			
Bladder	2.92	0.27	0.12	1.81	0.18	0.64	0.92	0.93	0.08	1.02	£61,459	£15,668,557
Bone	1.56	0.60	1.00	-	0.30	0.75	0.67	0.93	0.08	1.17	£71,052	£4,493
Brain	1.04	0.68	0.25	-	-	0.75	0.71	0.93	0.08	0.77	£47,161	£637,255
Breast	4.67	0.81	0.22	2.62	0.26	0.79	1.75	0.93	0.08	2.32	£137,487	£92,316,866
Cervix	2.09	0.43	0.25	1.34	0.20	0.75	0.42	0.93	0.08	0.76	£46,320	£339,727
Kidney	1.57	0.27	0.17	0.41	0.18	0.64	0.92	0.93	0.08	0.78	£47,331	£106,991
Larynx	2.22	0.56	0.25	1.23	0.37	0.90	0.67	0.93	0.08	1.27	£76,744	£1,894,425
Leukaemia	1.49	0.55	0.33	0.83	0.19	0.75	0.25	0.93	0.08	0.60	£36,641	£1,017,110
Liver	0.43	0.43	0.17	0.10	0.20	0.83	0.08	0.93	0.08	0.23	£14,420	£106,671
Lung	0.72	0.76	0.17	-	0.54	0.91	0.47	0.93	0.08	0.63	£38,631	£208,291,733
LH	2.22	0.75	0.33	1.39	0.19	0.75	0.42	0.93	0.08	0.90	£54,749	£1,583
Melanoma eye	3.09	0.35	0.25	2.01	0.43	0.83	0.75	0.93	0.08	1.65	£98,633	£145,343
Mesothelioma	0.50	0.76	-	-	-	0.91	0.42	0.93	0.08	0.45	£27,887	£65,990,522
Multiple Myeloma	2.49	0.19	0.75	1.24	0.19	0.75	0.42	0.93	0.08	0.77	£46,188	£472,903
Nasal/sinonasal	1.57	0.56	0.25	0.57	0.37	0.90	0.67	0.93	0.08	1.03	£62,386	£5,787,098
Nasopharynx	2.43	0.56	0.25	1.44	0.37	0.90	0.67	0.93	0.08	1.35	£81,264	£1,252,577
NHL	2.22	0.75	0.33	1.39	0.19	0.75	0.42	0.93	0.08	0.90	£54,749	£4,754,906
Oesophagus	0.71	0.56	0.17	0.38	0.90	0.93	0.08	0.93	0.08	0.59	£35,873	£6,517,817
Ovary	2.11	0.43	0.25	1.36	0.20	0.75	0.42	0.93	0.08	0.77	£46,546	£1,099,173
Pancreas	0.42	0.43	0.08	-	-	0.83	0.26	0.93	0.08	0.33	£20,003	£21,045
NMSC	3.33	0.07	0.04	0.80	-	0.58	2.42	0.93	0.08	1.47	£87,262	£7,656,818
STS	1.51	0.35	0.33	0.43	0.30	0.75	0.67	0.93	0.08	0.82	£49,882	£917,223
Stomach	1.08	0.53	0.50	0.33	0.73	0.93	0.17	0.93	0.08	0.74	£45,054	£5,690,550
Thyroid	3.21	0.27	0.17	2.22	0.18	0.64	0.75	0.93	0.08	1.00	£59,990	£10,763

[1]Lympho- haematopoietic (LH). [2]Non-Hodgkin's lymphoma (NHL). [3]Non-melanoma skin cancer (NMSC). [4]Soft Tissue Sarcoma (STS).

Table 22: Disability weights (DW), durations, DALYs and total morbidity costs for non-fatal cancers

		Diagnosis & primary therapy		After curative <5 years		Long-term effects						
Cancer type	Non-fatal cases	Disability Weight (DW)	Average years	DW	Average years	Proportion who suffer long-term sequelae	Number who suffer	DW	Average years	DALY per case	Discounted costs per case	Total costs – morbidity (non-fatal cancers)
Bladder	311	0.27	0.1	0.18	4.9	12%	38	0.20	13.0	1.22	£69,754	£21,723,797
Bone	0	0.6	1.0	0.3	4.0	8%	0	0.30	23.3	2.33	£132,090	£5,909
Brain	1	0.68	0.3	0.18	4.8	5%	0	0.35	21.4	1.39	£78,676	£108,589
Breast	1,531	0.26	0.2	0.26	4.8	51%	782	0.09	22.7	2.34	£127,120	£194,629,848
Cervix	11	0.43	0.3	0.20	4.8	46%	5	0.18	32.6	3.76	£184,495	£2,029,738
Kidney	2	0.27	0.2	0.18	4.8	-	0	0.00	0.0	0.92	£54,060	£86,248
Larynx	36	0.56	0.3	0.37	4.8	35%	12	0.20	17.6	3.10	£172,612	£6,131,551
Leukaemia	20	0.55	0.3	0.19	4.8	-	0	0.00	0.0	1.04	£61,627	£1,205,874
Liver	0	0.43	0.2	0.2	4.8	-	0	0.00	0.0	1.04	£61,401	£11,014
Lung	402	0.44	0.5	0.47	4.5	-	0	0.00	0.0	2.34	£137,851	£47,443,036
LH	0	0.19	0.3	0.19	4.7	-	0	0.00	0.0	0.95	£56,096	£1,581
Melanoma eye	6	0.35	0.3	0.2	4.8	45%	3	0.30	20.6	3.89	£200,551	£1,217,120
Mesothelioma	0	0.76	0.5	0	4.5	-	0	0.00	0.0	0.38	£23,276	£55
Multiple Myeloma	2	0.19	0.8	0.19	4.3	-	0	0.00	0.0	0.95	£56,093	£98,517
Nasal	66	0.56	0.3	0.37	4.8	-	0	0.00	0.0	1.90	£112,155	£7,353,158
Nasopharynx	3	0.56	0.3	0.37	4.8	-	0	0.00	0.0	1.90	£112,155	£310,857
NHL	85	0.19	0.3	0.19	4.7	-	0	0.00	0.0	0.95	£56,096	£4,778,840
Oesophagus	30	0.56	0.2	0.37	4.8	-	0	0.00	0.0	1.88	£111,175	£3,346,138
Ovary	11	0.43	0.3	0.20	4.8	64%	7	0.18	20.8	3.46	£179,915	£1,999,353
Pancreas	0	0.43	0.1	0.2	4.9	-	0	0.00	0.0	1.02	£60,217	£1,634
NMSC	4,063	0.05	0.0	0	5.0	-	0	0.00	0.0	0.00	£128	£552,423
STS	16	0.35	0.3	0.3	4.7	8%	1	0.30	22.1	2.00	£113,178	£1,831,594
Stomach	15	0.53	0.5	0.38	4.5	-	0	0.00	0.0	1.98	£116,791	£1,703,576
Thyroid	1	0.27	0.2	0.18	4.8	-	0	0.00	0.0	0.92	£54,060	£50,222

[1]Lympho- haematopoietic (LH). [2]Non-Hodgkin's lymphoma (NHL). [3]Non-melanoma skin cancer (NMSC). [4]Soft Tissue Sarcoma (STS).

B. Life years approach to mortality

A27. UK Government policy appraisal typically employs one of two approaches for valuing deaths: account for either the number of lives lost or saved, or the number of life-years lost or saved.

A28. The ‘lives saved’ approach has been the conventional method for evaluating changes in mortality risk due to transportation, health and safety, various public health and environmental policies. It is normally applied in appraisal as a constant value across different groups and populations, regardless of the age of the affected population. While this means that each loss of each life is valued equally, it also means that the value of each remaining life year is implicitly allowed to vary across individuals, according to their remaining life expectancy (with older people having an increasingly higher implied value per year).

A29. The ‘life years’ approach, on the other hand, is typically applied using a constant value of a life year (VOLY), regardless of age and remaining life expectancy. The result is that the implied value for each life lost (or VPF) is allowed to vary across individuals, with a progressively lower VPF for older people. This approach has been applied by the Department of Health in health appraisal and by the Department for Environment, Food and Rural Affairs for the appraisal of air quality policies.

Issues regarding ‘age-adjustment’

A30. Applying a constant VOLY to remaining years of life expectancy introduces a form of age-adjustment to economic appraisals – deaths at older ages are valued at a lower rate than deaths at younger ages. Given that the average age of work-related cancer registration in the HSE costs of work-related cancer model is around 70, the issue of age adjustment is particularly salient (see Section 3.4 on the age profile of cancers in the current model).

A31. Age adjustment is the subject of on-going ethical and methodological debate. Using a universal VPF is a normative judgement reflecting a principle of equality, i.e. that the value society places on a statistical life should not be sensitive to age, or other personal characteristics, such as wealth or health. In other words, a ‘life is a life’ regardless of age. The value applied reflects the population mean valuation of risk, which is not differentiated between groups.

A32. Many commentators, including the American legal and economics scholar Cass Sunstein, make an opposite argument that life years achieves better equality by not discriminating against young people who have not yet had the opportunity to enjoy the additional years that older members of society have already had:

> *“A program that saves young people produces more welfare than one that saves old people. Nor does a focus on life-years run afoul of ethical limits on cost-benefit analysis. It is relevant in this connection that every old person was once young, and that if all goes well, young people will eventually be old. In fact, a focus on statistical lives is more plausibly a form of illicit discrimination than a focus on life-years, because the idea of statistical lives treats the years of older people as worth far more than the years of younger people.”* [92]

[92] Sunstein, C. (2003). Lives, Life-Years, and Willingness to Pay. The Law School, University Of Chicago.

A33. Empirically, there is a rather unclear picture of how willingness to pay for reduced mortality risk varies with baseline risks, age, and health status. A major factor in aversion to the risk of death may be the perception of how much grief and hardship their death would bring on others. "This might be expected to follow, over a lifetime, not a near-linear decline but an inverted U, as people acquire more dependants and in due course become themselves dependent" (Spackman, 2009).[93] There may also be a constant "love of life element" that is invariant to age.[94] A 'scarcity' effect might further imply that WTP for each additional unit of life expectancy increases with age, as remaining years of life diminish, and the opportunity costs of spending money falls.[95] While theoretical and empirical studies have advanced our knowledge and provided insights, they have been unable to consider all key aspects of the issue simultaneously, and it is therefore difficult to draw broad, clear conclusions (Dockins *et al.*, 2006).[96]

Illustration of the effect of a constant VOLY on estimated mortality costs

A34. One proposal being considered by HM Treasury is to apply a constant value to each year of life lost, regardless of age – effectively assuming a linear relationship between the VPF and the VOLY. This reflects an alternative ethical basis for 'equity valuation': that each year of life has the same intrinsic value regardless of personal characteristics. In this approach, theoretical or empirical evidence on variations in the VOLY with personal characteristics is overridden by the normative judgement that all life years have equal intrinsic value.[97] This contrasts with the value judgement made under the 'life is a life' approach, that all lives at a given point in time have equal intrinsic value, regardless of remaining life expectancy.

A35. The result of the constant VOLY is a simple form of age adjustment, with total willingness to pay implied by the discounted sum of VOLYs falling rapidly with age. This is demonstrated by Figure 5, which applies a constant 'human cost' VOLY of £43,000.[98] The effect is somewhat tempered by the use of ONS period expectation of life tables, which mean that every age group has some remaining life expectancy, even those who are well above average life expectancy, e.g. the 85+ group.[99]

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[93] Spackman (2009). Review of the J-value literature – Final Report for the HSE/ONR. http://www.onr.org.uk/j-value.pdf. Further discussion is provided in Jones-Lee (1989), *The Economics of Safety and Physical Risk.*

[94] Loomes, G. (2002) Valuing life-years and QALYs: 'transferability' and 'convertibility' of values across the UK public sector. Chapter 5 in Towse, A., C Pritchard, and N Devlin (eds) Cost-Effectiveness Thresholds: Economic and Ethical Issues, King's Fund

[95] Dolan, P., Metcalfe, R., Munro, V., & Christensen, M. C. (2008). Valuing lives and life years: anomalies, implications, and an alternative. Health Economics, Policy, and Law, 3(Pt 3), 277–300.

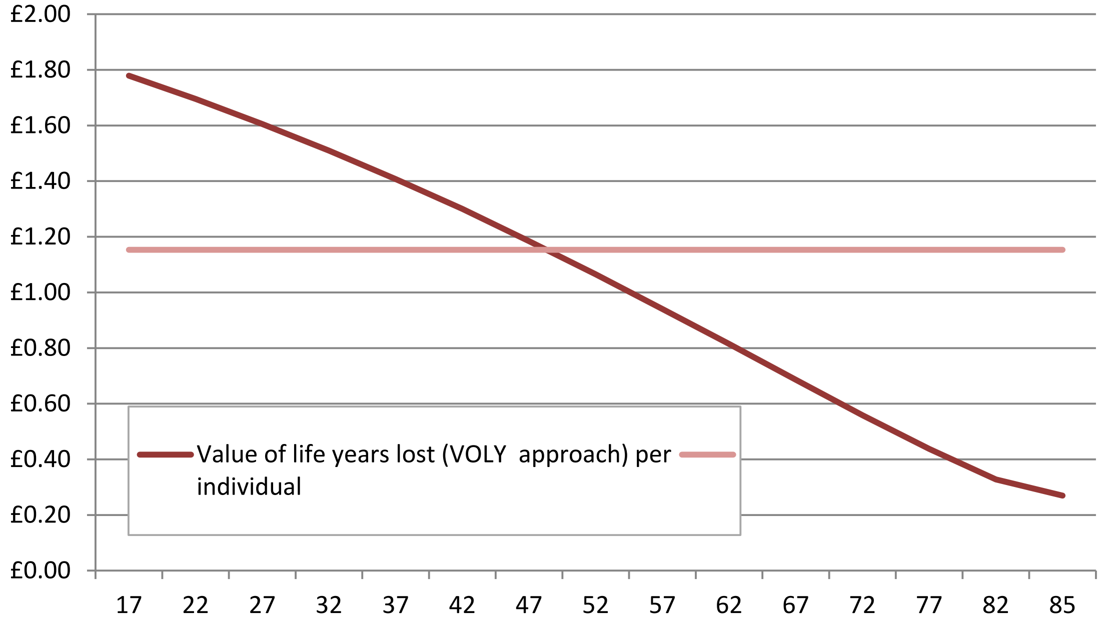
[96] Dockins, D., Maguire, K. and Simon, N. (2006). Willingness to Pay for Environmental Health Risk Reductions when there are Varying Degrees of Life Expectancy: A White Paper.

[97] As with a constant VPF, a constant VOLY could also be interpreted as reflecting an equivalent population mean valuation of risk.

[98] This figure is derived from the Department of Health's estimate of £60,000 for the monetary value of a life year. We have adjusted this to provide a figure comparable with the 'human costs' component of the VPF, which we apply in the present assessment. See paragraphs A39 and A40 for further details on this.

[99] ONS period expectation of life tables 2008 – 2010. http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-223324

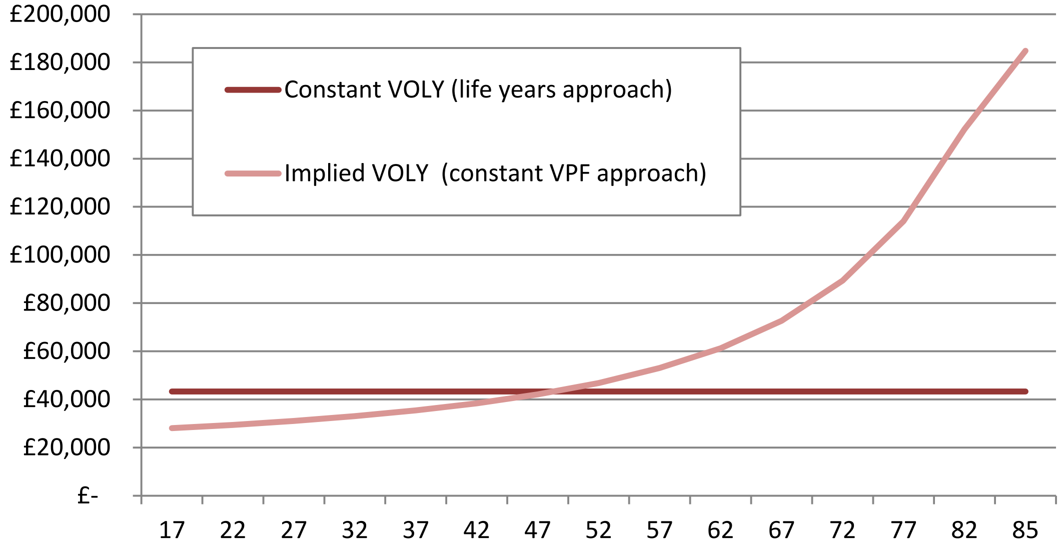
Figure 5: Total 'human costs' applying human costs components of VPF (£1.2 million) and VOLY (£43,000) by age of death (£ million)



^ Using average of male and female life expectancy, from ONS expectation of life tables
^^ Discounted at 1.5% per annum

A36. Proponents of the VOLY approach illustrated above point out that a constant VPF, unadjusted for age, implies a VOLY that approaches infinity as life expectancy moves to zero (see Figure 6). This is also clearly problematic, particularly for policies that affect the very old or very young.

Figure 6: Value of a life year: comparison using constant VOLY with value implied by constant VPF approach



A37. HSE is actively engaged in the ongoing debate on the valuation of lives/life years amongst academics and other government departments. It is not within the remit of this study to resolve these debates. Given ambiguity and lack of consensus on the appropriate method to monetise life years, the VPF remains HSE's preferred approach to valuing mortality impacts in the context of health and safety risks. Nevertheless, in recognition of arguments in favour of using the life years approach and to reflect possible developments in HM Treasury *Green Book* guidance, we apply the VOLY approach for comparison and present the results below.

Value of life years lost

A38. Years of life lost (YLLs) are calculated in the model using the life expectancy for each age group at the point of registration. The midpoint of the age range for each group is taken, except the 85+ group, for which we assume 85 is the average age due to lack of data. Remaining life expectancy is sourced from ONS life tables so that every age group has some remaining life expectancy, even those who are well above average life expectancy, e.g. the 85+ group.[100]

A39. To derive YLLs, we take remaining life expectancy at age of registration and subtract average duration between registration and death, leaving the years of life lost due to cancer. Doing so results in an estimated total of 137,000 years of life lost due to work-related cancer.

A40. As discussed in Section 4.4.2, we adopt the Department of Health's value of a statistical life year of around £60,000 (2012 prices), which we inflate to 2013 prices using the IHXT index.

A41. We adjust this value to make it compatible with the 'human costs' component of the VPF applied in the 'valuing lives' approach (see Section 4.3), which represents the additional value of life lost, over and above the (theoretical) loss of goods and services that can no longer be consumed.[101] To do this, we apply the ratio of 'human costs' to the full willingness to pay value to avoid risk of death derived from the studies underlying the VPF. 'Human costs' account for around 71% of total WTP; applying this to the £62,000 VOLY in 2013 prices gives a 'human costs' component of the VOLY of £43,300.[102] We discount this at 1.5% per annum.

A42. Table 23 shows the total discounted value of YLLs per fatal registration for each cancer type and aggregate costs. Total estimated mortality costs are £5.0 billion, which is dominated by

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[100] ONS period expectation of life tables 2008 – 2010. http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-223324

[101] This is a rather arbitrary construct, and is difficult to define, but can be broadly interpreted as the value of all the other things that make life worth living, over and above the value of consuming market goods and services (which is captured under 'lost income').

[102] It will be clear that we have applied a different VOLY for morbidity impacts (years lives) compared with mortality impacts (years lost). This is done to maintain consistency with the treatment of the VPF, which shares a common base with the VOLY. In *Costs to Britain,* the estimate of willingness to pay (WTP) to avoid fatality risks is adjusted to remove lost consumption, in order to avoid double counting lost output (income), which is estimated separately. For non-fatal cases, by contrast, the full WTP value is used.

The difference between these approaches arises because in the case of a fatal cancer, an individual will no longer consume resources, so the direct cost to society will be the individual's future net production ,i.e. what the individual would produce over and above what they would consume in the future. Therefore, we must subtract this lost consumption from our estimates when valuing years of life lost (as we do in the 'human costs' value applied to lives lost).

By contrast, during years lived with cancer morbidity (in either fatal or non-fatal cases), the individual will continue to consume, meaning that the rest of society must bear the costs of his or her consumption. Therefore, the full VOLY *including* consumption should be applied to YLDs.

Note that this is also consistent with how the Department for Transport estimates costs of fatal and non-fatal road traffic accidents. See the detailed *Costs to Britain* methodology report for more information: http://www.hse.gov.uk/research/rrhtm/rr897.htm.

lung cancer (£2.7 billion) and mesothelioma (£1.2 billion), together accounting for over 80% total mortality costs. Note that these costs do not account for morbidity prior to death, which is estimated in Section 4.4 of the main body.

A43. The effect of age adjustment is apparent between cancer types: cancers with a lower age of registration, where more life years are lost, are valued higher (e.g. cervical: average age at registration 49, £1.1 million per case), while cancers that occur in older workers are valued lower (e.g. bladder: average age 73, £0.39 million per case). The weighted average age of registration for fatal cancers is 71, with an average of 15 life years lost represented a discounted cost of £0.54 million per case.[103]

A44. Mortality costs using the life years approach are almost half of those estimated using the VPF approach (£5.0 billion versus £10.7 billion).

A45. Adding the costs of morbidity for fatal and non-fatal cancers estimated at £717 million in Section 4.4, total human costs (morbidity + mortality) using the life years approach are £5.8 billion.

A46. Total costs of work-related cancer under the life years approach, are £6.7 billion, including £899 million total 'financial' costs summarised in Section 9. It is clear that regardless of the approach adopted valuing mortality impacts, human costs are still very large and account for the vast proportion of total costs – around 90%.

[103] Note that, as discussed in Section 3.1, because attributable fractions for work-related cancers were not available by age, the age profile by cancer type in the model reflects the profile of these cancer types in the general population and is not specific to work-related cancers.

Table 23: Human costs from mortality, using value of life years lost per cancer type, VOLY = £43,000

	Total registrations Cases	Total Discounted Cost (£ millions)	Average age at registration Years	YLLs per case Years	Present Value of YLLs per fatal case (£)
Bladder	255	£100	73	11	£392,000
Bone	0	£0	56	26	£856,400
Brain	14	£10	62	21	£733,900
Breast	671	£430	63	19	£640,300
Cervix	7	£8	49	34	£1,076,000
Kidney	2	£1	68	17	£595,000
Larynx	25	£14	66	16	£586,100
Leukaemia	28	£19	64	19	£673,900
Liver	7	£4	70	16	£583,100
Lung	5,392	£2,869	71	14	£532,000
LH	0	£0	47	34	£1,045,000
Melanoma eye	1	£1	62	19	£658,800
Mesothelioma	2,366	£1,215	72	14	£513,600
Multiple Myeloma	10	£6	68	15	£541,300
Nasal	93	£59	66	18	£638,800
Nasopharynx	15	£11	60	22	£739,700
NHL	87	£58	63	19	£666,600
Oesophagus	182	£103	70	15	£568,800
Ovary	24	£16	65	20	£691,100
Pancreas	1	£1	71	15	£555,500
NMSC	88	£39	71	12	£439,300
STS	18	£13	63	20	£701,500
Stomach	126	£64	72	14	£504,300
Thyroid	0	£0	55	25	£816,100
All cancers	**9,413**	**£5,041**	**71**	**15**	**£535,500**

[1]Lympho- haematopoietic (LH). [2]Non-Hodgkin's lymphoma (NHL). [3]Non-melanoma skin cancer (NMSC). [4]Soft Tissue Sarcoma (STS).

C. Detailed tables for human costs

Table 24: Cancer registrations by cancer type and age

Site	ICD10	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+	Total
Bladder	C67	-	-	0	1	2	3	7	14	26	50	74	96	105	97	91	566
Bone	C40-C41	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brain	C70-C72	-	-	0	0	0	1	1	1	1	2	2	2	2	1	1	15
Breast	C50	-	-	7	25	60	133	220	249	216	303	270	186	187	162	185	2,203
Cervix	C53	-	-	2	2	2	2	2	1	1	1	1	1	1	1	1	18
Kidney	C64-C66,C68	-	-	0	0	0	0	0	0	0	1	0	1	1	0	0	4
Larynx	C32	-	-	0	0	0	1	2	5	7	10	10	9	7	4	3	60
Leukaemia	C91-C95	1	1	1	1	1	1	2	3	4	6	6	8	8	5	-	47
Liver	C22	-	-	0	0	0	0	0	0	1	1	1	1	1	1	1	8
Lung	C33-C34	-	-	2	5	17	37	96	193	382	667	865	1,017	992	821	642	5,736
LH	C81-C96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0
Melanoma eye	C69	-	-	0	0	0	0	1	1	1	1	1	1	1	0	0	8
Mesothelioma	C45	-	-	-	-	2	8	22	45	107	279	375	450	472	367	239	2,366
Multiple Myeloma	C90	-	-	0	0	0	0	0	1	1	2	2	2	2	1	-	12
Nasal / sinonasal	C30-C31	-	-	1	1	3	6	10	9	17	26	17	20	15	18	14	158
Nasopharynx	C11	-	-	0	1	0	1	2	2	2	2	1	2	2	1	1	18
NHL	C82-C85	1	1	2	3	5	7	9	12	17	25	25	28	26	14	-	172
Oesophagus	C15	-	-	0	0	1	3	6	11	18	28	31	33	29	28	24	212
Ovary	C56	-	-	0	1	1	2	2	3	3	5	4	4	4	3	3	35
Pancreas	C25	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	1
NMSC	C44	-	-	10	21	44	83	135	182	260	459	549	677	732	630	604	4,367
STS	C49	-	-	1	1	1	2	2	3	2	4	4	3	4	3	3	35
Stomach	C16	-	-	0	0	1	2	4	5	8	12	17	25	26	22	19	141
Thyroid	C73	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL		2	2	30	64	141	293	524	739	1,075	1,884	2,256	2,566	2,616	2,180	1,833	16,203

[1]Lympho- haematopoietic (LH). [2]Non-Hodgkin's lymphoma (NHL). [3]Non-melanoma skin cancer (NMSC). [4]Soft Tissue Sarcoma (STS).

Table 25: Total mortality costs to individuals of fatal cancers by cancer type - VPF (cancer) approach

Cancer type	Number of fatal cases	Estimated years until death	Total Discounted Cost (£ million)	Discounted VPF per case (£)
Bladder	255	2.9	£281	£1,104,000
Bone	0	1.6	£0	£1,127,000
Brain	14	1.0	£15	£1,135,000
Breast	671	4.7	£722	£1,076,000
Cervix	7	2.1	£8	£1,118,000
Kidney	2	1.6	£3	£1,126,000
Larynx	25	2.2	£28	£1,116,000
Leukaemia	28	1.5	£31	£1,128,000
Liver	7	0.4	£8	£1,146,000
Lung	5,392	0.7	£6,151	£1,141,000
Lympho-haematopoietic (LH)	0	2.2	£0	£1,116,000
Melanoma - eye	1	3.1	£2	£1,101,000
Mesothelioma	2,366	0.5	£2,708	£1,145,000
Multiple Myeloma	10	2.5	£11	£1,111,000
Nasal / sinonasal	93	1.6	£104	£1,126,000
Nasopharynx	15	2.4	£17	£1,112,000
Non-Hodgkin's lymphoma (NHL)	87	2.2	£97	£1,116,000
Oesophagus	182	0.7	£207	£1,141,000
Ovary	24	2.1	£26	£1,117,000
Pancreas	1	0.4	£1	£1,146,000
Non-Melanoma skin cancer (NMSC)	88	3.3	£96	£1,097,000
Soft Tissue Sarcoma (STS)	18	1.5	£21	£1,127,000
Stomach	126	1.1	£143	£1,135,000
Thyroid	0	3.2	£0	£1,099,000
Total	**9,413**		**£10,684**	

Table 26: Total human costs by cancer type, morbidity and mortality, VPF approach

Cancer type	Total morbidity costs (£ million)	Total mortality costs (£ million)	Total human costs (£ million)	Average costs per case (£)
Lung	£256	£6,151	£6,407	£1,117,000
Mesothelioma	£66	£2,708	£2,774	£1,172,000
Breast	£287	£722	£1,009	£458,200
Bladder	£37	£281	£319	£562,900
Oesophagus	£10	£207	£217	£1,025,000
Stomach	£7	£143	£151	£1,070,000
Nasal / sinonasal	£13	£104	£118	£743,000
NHL	£10	£97	£106	£618,600
NMSC	£8	£96	£104	£23,820
Larynx	£8	£28	£36	£590,700
Leukaemia	£2	£31	£34	£708,500
Ovary	£3	£26	£29	£849,100
STS	£3	£21	£23	£679,200
Nasopharynx	£2	£17	£19	£1,029,000
Brain	£1	£15	£16	£1,080,000
Multiple Myeloma	£1	£11	£12	£996,100
Cervix	£2	£8	£11	£576,300
Liver	£0.1	£8	£9	£1,134,000
Melanoma eye	£1	£2	£3	£395,800
Kidney	£0.2	£3	£3	£710,500
Pancreas	£0.02	£1	£1	£1,138,000
Thyroid	£0.1	£0.2	£0.3	£232,900
Bone	£0.01	£0.1	£0.1	£756,100
LH	£0.003	£0.03	£0.04	£620,200
All cancers	**£717**	**£10,684**	**£11,401**	**£703,600**

Note: Totals may not sum due to rounding. [1]Lympho- haematopoietic (LH). [2]Non-Hodgkin's lymphoma (NHL). [3]Non-melanoma skin cancer (NMSC). [4]Soft Tissue Sarcoma (STS).

Appendix 4: Productivity costs

A47. The following technical appendix is intended to complement Section 5 of the report. It provides further detail on the approach taken to estimate the various impacts included under 'productivity costs'.

Estimating lost output

A48. People having to spend time off work due to work-related cancer involves an opportunity cost to society as well as a cost to employers and individuals – if that worker was not absent, output could be increased. There is a cost to society in terms of a reduction in overall social welfare from the lost potential output that is no longer produced and thus available for further production and/or consumption.

A49. The macro assumption underlying the model is that the economy is operating at full employment – that is, the output lost from an absent worker cannot be replaced at low opportunity cost from a pool of unemployed workers.[104] The macroeconomic effect is therefore the full loss of the worker's output for the period of absence.[105] This assumption is maintained from *Costs to Britain*.

Gross Wages

A50. There are a number of different approaches to valuing any output lost as a result of worker absence. The two most common approaches are the 'Human Capital' and 'Friction Cost' approach. In brief, the human capital approach is based on the hypothesis that a worker's wage is equal to the value of their marginal product (that is, the additional productivity that

[104] The concept of full employment, or a 'natural rate' of unemployment, does not preclude the existence of frictional unemployment of a temporary nature. There must be temporary unemployment of some workers due to imperfect information about job market opportunities, machinery breakdown, etc. Similarly, there may be those not willing to work despite the prevailing market wage – that is, there is some level of voluntary unemployment consistent with the natural rate of unemployment.

[105] The lost potential output resulting from an absence due to work-related cancer can be thought of in much the same way as a reduction in the productive potential of the economy (be it temporary or permanent). Under full employment, a workplace absence leads to a reduction in the available supply of labour, seen graphically as an inward shift of the production possibility frontier (PPF) for a simple, two-good economy, as in the figure below.

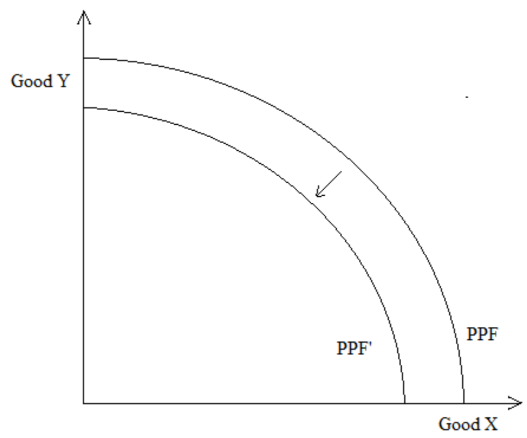

Figure 1: Production Possibility Frontier

can be attributed to their employment).[106] The rationale being that a firm will only take on additional workers if the value they receive for the additional output associated with the employment of an extra worker is at least equal to the cost of hiring that worker.[107]

A51. Under these conditions, in an environment of 'full' employment, the opportunity cost to society from a worker absence as a result of work-related cancer can be estimated by equating the value of marginal product (i.e. the potential output lost due to worker absence) with the firm's marginal cost of hiring that worker, assuming there is no compensating gain in welfare to individuals from not working.

A52. Despite its prevalence in economic evaluation, there remains a paucity of empirical studies that seek to validate whether or not wages are an accurate measure of the marginal product of labour, and hence the output that is lost following a worker absence. One such study, however, was conducted by Zhang *et al.* (2013), who attempted to test the hypothesis that the wage rate is equivalent to the marginal product of labour using linked employer-employee data from Canada. Their results suggest that wages were broadly appropriate in measuring absenteeism effects, except when the absent individuals worked as part of a team, when the resulting productivity losses exceeded the wage rate.[108] Empirical evidence from Biewen and Weiser (2011) also suggests that labour receives, on average, the value of its marginal product.[109]

A53. In a competitive labour market, the marginal cost of labour will be equal to the wage rate that the employer faces. Thus, the gross earnings lost by individuals can be used as a proxy for the cost to society in terms of any lost output forgone.

A54. The alternative approach, the frictional cost approach, rejects any simple relationship between absenteeism and reduced productivity. This method suggests that it is wrong to assume that firms will necessarily lose all of the output associated with a marginal worker's absence, insofar as they have a number of means available to cover this lost output. Accordingly, any lost production is purely transitory, and the only true net costs will be associated with resources required to maintain output levels. For a fuller discussion on the different approaches to valuing productivity costs, see Sculpher (2001).[110]

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[106] This relationship between wage and marginal product is known in neoclassical economics as the marginal productivity theory. Marginal productivity theory posits a rational, profit-maximising firm that employs labour up until the point at which the cost of hiring an additional worker (i.e. marginal cost) is equal to the value of the additional output that is associated with the extra worker (i.e. marginal revenue).

[107] The profit-maximizing condition of equating marginal cost with marginal revenue suggests that the cost of hiring the last worker will be equal to the additional revenue raised from their contribution to output. However, within the firm's total costs (from which marginal cost is calculated) is some element of normal profit, defined as the minimum amount of return required to keep the entrepreneur engaged in this activity. Thus, for the last unit of labour, the marginal cost includes some 'profit'.

[108] See http://www.chesg.ca/images/30000102/ConferencePapers/2013/Zhang.pdf.

The extent to which wages underestimate the value of lost output in team environments was also examined first theoretically by Pauly *et al.* (2002), and then empirically by Nicholson *et al.* (2006), who found evidence of the existence of an 'absenteeism cost multiplier' when injured or ill workers formed part of a team.

[109] See http://ftp.iza.org/dp6113.pdf

[110] Sculpher M. The role and estimation of productivity costs in economic evaluation; in: Drummond MF, McGuire A (eds): Economic evaluation in health care: merging theory with practice. Oxford: Oxford University Press pp 94-112; 2001.

A55. We use a combination of the two approaches within our model when estimating productivity costs associated with work-related cancers: that is, we assume that the firm directly affected by the absent worker is able to maintain output at the same marginal labour cost (but incurs the various additional costs of production disturbance in doing so), but due to the macroeconomic assumption of full employment that underpins the model, we assume that at the societal level, the total value of the output from the absent worker is lost. It may be the case that this leads to an overestimate of the real-world costs to some extent; however these estimates can be seen to represent the *potential* loss of productive capacity to the economy.

Non-wage Costs

A56. Standard practice in the economics of policy appraisal is to equate the opportunity cost of a worker absence (i.e. the value of any output lost) with the cost to the firm of employing that worker. This will be equal at the margin to the wage rate that the firm pays the worker, plus any additional non-wage labour costs associated with the employment of an additional worker. There is little consensus and guidance as to what should be included as part of these non-wage costs, however.

A57. HM Treasury's *Green Book* offers the following (p. 59):

> "The value of employees' time-savings (working) is the opportunity cost of the time to the employer. This will be equal at the margin to the cost of labour to the employer: the gross wage rate plus non-wage labour costs such as National Insurance, pensions and other costs that vary with hours worked." [111]

A58. Eurostat currently provide data on labour costs that uses data from the Labour Costs Survey (produced every four years – most recent 2012). Estimates for years after 2012 are obtained by extrapolating 2012 hourly labour costs data using the Labour Costs Index. The most recent data (March 2015) suggests that non-wage labour costs in the UK are approximately 20% of total wage costs.[112] This figure includes wage and salary costs (i.e. direct remuneration, bonuses, payments to employee saving schemes, etc.) and non-wage costs such as employers' social contributions (i.e. sick pay) plus employment taxes (NI). The estimate does not include vocational training costs or other expenditures such as recruitment costs and spending on working clothes, etc.

A59. However, there are a number of methodological issues with uprating gross wages when valuing lost output: for instance regarding what costs should and should not be included in any "non-wage costs", and thus part of the marginal cost of labour, and where then to attribute this additional element of lost output.

A60. To maintain consistency with the current *Costs to Britain* framework, and in anticipation of a review of the approach to updating HSE's annual cost estimates for workplace injuries and ill health, the primary estimates of lost output do not contain any non-wage costs. Uprating gross wages in the model by around 20% to account for non-wage costs paid by employers would add a further £105 million to the estimate of lost output.

[111] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf

[112] Eurostat data suggests that non-wage costs are typically 16.5% of total unit labour costs. These are then divided by the proportion of total labour costs made up of wages to estimate non-wage costs as a proportion of gross wages, equivalent to 19.8% (16.5*(100/ (100-16.5))).

http://ec.europa.eu/eurostat/documents/2995521/6761066/3-30032015-AP-EN.pdf/7462a05e-7118-480e-a3f5-34e690c11545

Gross Value Added (GVA)

A61. An alternative to using gross wages to estimate the costs of absenteeism would be to use GVA. At the micro-level, GVA measures the contribution of each individual producer, industry or sector to the economy. The value added by the firm is defined as the value of its output minus the value of the intermediate goods (such as raw materials, energy and services) used in production.

A62. Out of GVA, the firm pays wages, salaries, National Insurance contributions, and other costs associated with employment (collectively termed Compensation of Employment, (CoE)), and also taxes on production. Subtracting intermediate consumption, taxes (less subsidies) and labour costs (CoE) from output leaves a residual that can be broadly described as profit/loss (or Gross Operating Surplus (GOS)).[113]

A63. The Office for National Statistics suggests that CoE and GOS more accurately measure the returns to employed labour and capital respectively.[114] Simply dividing GVA by the number of employed workers would therefore overstate the contribution of labour to the firm's profits, insofar as GOS is attributed to labour, and thus no returns to other factors of production, such as capital, are accounted for.

A64. An alternative would be to use data on the CoE to value explicitly the lost output resulting from the absent worker. The main obstacle to using CoE as a measure of output, however, is that the data is currently unavailable in the format required for the cost models; i.e. by age, gender and industry.

Profit

A65. The additional costs to employers 'directly affected' by the workplace cancers in this model, such as production disturbance, sickness payments, and administrative and legal costs, will erode profit margins and reduce firms' profits (to the extent that these increased costs cannot be passed on to consumers in the form of higher prices).

A66. There is also an argument for saying that employers would suffer a loss of profit associated with the removal of one member of the workforce due to work-related cancer, insofar as firms are able to extract some profits on the value added produced by the labour they employ; however this is difficult to quantify (we have explored the possibility of using GVA data, as above) and has not been estimated. Risk Solutions (2011), the authors of the main *Costs to Britain* methodology report, recognised this; however they suggested that this will likely be small at the margin and the aggregate effect likewise.[115] Given the challenges in estimating employers' lost profit on output, and the likely small effect at the margin we do not attempt to estimate this further.

Lost Gross Earnings

A67. The following section sets out in more detail the approach to valuing total earnings (gross) lost by individuals in the model.

[113] http://www.ons.gov.uk/ons/rel/regional-analysis/measuring-the-economic-impact-of-an-intervention-or-investment/measuring-the-economic-impact-of-an-intervention-or-investment/economic-impact--paper-one.pdf

[114] http://www.ons.gov.uk/ons/rel/icp/productivity-measures/revised-methodology-for-unit-wage-costs-and-unit-labour-costs--explanation-and-impact/explanation-and-impact.html

[115] The Risk Solutions (2011) methodology report is available on the HSE website: http://www.hse.gov.uk/research/rrpdf/rr897.pdf.

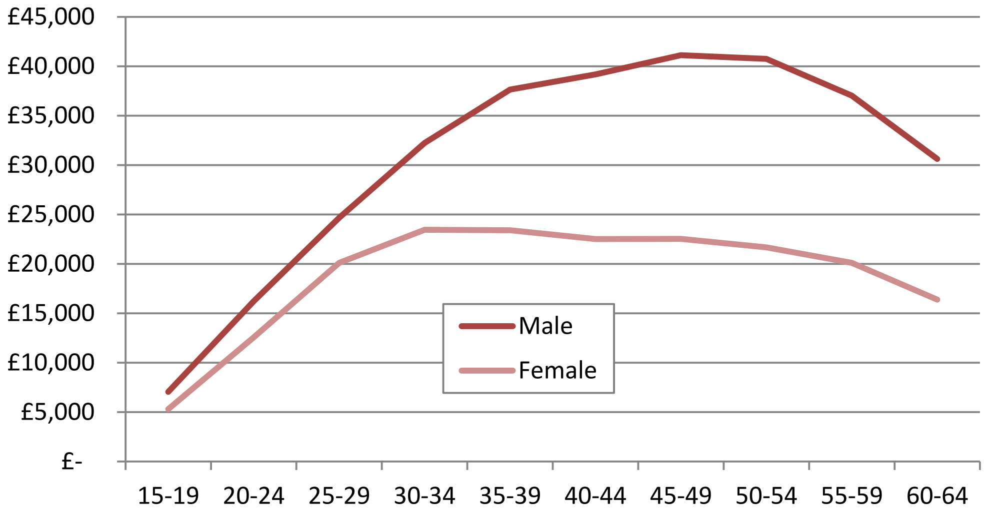
A68. Lost earnings will be the product of average earnings, estimated time unable to work, probability that the individual is working and the cancer outcome (i.e. whether they survive and, if so, whether they return to work).

Average Earnings

A69. The average wage for each age group is used and the changes in average earnings over lifetime is modelled[116], adjusted for inflation[117] and baseline life expectancy[118], and discounted using the social time preference rate. In addition, income is assumed to be lost up until the age of 65 when people are expected to retire, in line with *Costs to Britain*.

A70. We apply the same method to lost income due to cancer. In addition, the cancer estimate is able to distinguish between differing average earnings for men and women as the registrations data allows a distinction to be made between them, which was not possible in *Costs to Britain*.[119] While it was not possible to do this in *Costs to Britain*, that estimate did assume that all fatalities were male in order to account for income differentials, which are shown in Figure 7.

Figure 7: Average Earnings by Age and Gender (£/annum)



[116] Average earnings are sourced from the Annual Survey of Hours and Earnings (ASHE) 2012, and inflated to 2013 prices using the KAC3 index of average earnings growth. http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-280149. Although ASHE does produce estimates for annual gross pay by age (in ASHE Table 6.7a), we found that their age groupings were incompatible with those given by our cancer registration data. The earnings data that appears in the model is specific to our age groups and was kindly produced for us by the Office for National Statistics (ONS). The same data source (although with different age groupings) is used for *Costs to Britain*.

[117] Real earnings are expected to grow at a level of 2% per annum, in line with the long term growth rate of per capita income used in HM Treasury's Social Discount Rate. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf

[118] The model employs period interim life expectancy tables produced by ONS based on Great Britain data from 2008 to 2010: http://www.ons.gov.uk/ons/rel/lifetables/interim-life-tables/2008-2010/rft-ilt-gb-2008-10.xls. This source is an update of the figures used in Costs to Britain, which are based on 1987 to 1989 data.

[119] Using average earnings by gender in this way, however, may underestimate lost income to females if there is future convergence in male-female earnings.

A71. For example, average annual earnings for the 20-24 age group in 2013 were £16,200 for males and £12,600 for females. This rises for the 45-49 age group to £41,100 for males and £22,500 for females. A long term growth rate of real earnings of 2%, as prescribed by HM Treasury's *Green Book*, is then used to calculate annual earnings growth over and above inflation. This is then added to the expected changes in future earnings over the course of one's career forgone at the point of withdrawal, based on:

- the average salary for the age band in which withdrawal occurs;
- the change in salary that would have occurred as the individual advanced through the age bands;
- and the probability that the individual might die in each age band for reasons other than work-related cancer.

A72. Costs are then discounted to the present using the *Green Book* discount rate of 3.5% per annum.[120]

A73. We use average earnings across all occupations and industries rather than industry-specific earnings when calculating lost income/output primarily due to the latency of cancer. HSE publishes data on the number of the estimated number of cancer registrations/deaths that could be attributed to the ten leading occupational carcinogens by industry; however this reflects the industry in which the individual was working when they were initially exposed to the carcinogen.[121] In any case, HSE analysts looked at the effect on lost income of using average earnings by main industries related to exposure (manufacturing, construction, agriculture and services), and found little difference in earnings between the two. Weighted-average (of attributable registrations) Full Day Equivalent (FDE) earnings across these industries in 2013 was estimated at £123, whereas average FDE earnings across all industries for 2013 was £121. Therefore, using an all-industry average wage does not introduce undue error to the estimates.

Estimated Time Unable to Work

A74. It is assumed in the model that people will be unable to work for at least the duration of their Diagnosis and Primary Therapy stage (see Table 21 and Table 22 for details of disease stages for fatal and non-fatal cancers). In the case of fatal cancers, income is lost from this point until age 65, when individuals become eligible for state pension and we assume they would otherwise have retired. For non-fatal cases unable to return to work due to cancer, employment income is also lost from diagnosis to retirement. In this way, the period during which fatal cancer and never-returns forgo income from employment (and during which output is lost) is similar.

A75. For those who survive cancer, but do return to work, income is only forgone for the duration of their Diagnosis and Primary Therapy, as used in the human costs of non-fatal cancers calculations (see Section 4.4). After that, it is assumed that they return to work at the expected average earnings for their age and gender. In reality, this might be an underestimate of the loss of income as cancer survivors may be unable to return to the same

[120] This rate is sourced from HM Treasury's *Green Book*, and is based on the principle that, in general, individuals prefer to receive goods and services now rather than later. The same data source is used in Costs to Britain. Currently set at 3.5% per annum for all costs and benefits accruing over a 30 year period (longer term discount rates are advised for impacts beyond this timescale).

[121] See tables CAN04 and CAN05 for data on work-related cancer registrations and deaths by industry: http://www.hse.gov.uk/Statistics/tables/index.htm#cancer

work or resume the same hours as previously. Additionally, they may have missed out on opportunities for development or promotion during their absence.

A76. The assumption that all individuals in the model will cease work entirely for the duration of their illness is a simplifying one. It is possible that this approach may lead to an over-estimation of lost gross earnings as there is some evidence that not all people in employment cease working when diagnosed with cancer. However, this does not have a large impact on costs in the model, so we maintain it as a simplifying assumption.

Probability in Employment at Time of Registration

A77. Unlike the Costs to Britain model, where data comes from people who have been working in the last twelve months, we cannot assume that all people are currently in employment in the Costs of Work-related Cancer model. Due to the latency of cancer, people may have moved out of employment or out of the labour market altogether since their period of occupational exposure. Indeed, given the age profile in the model, many may have retired.

A78. The cancer estimate is therefore adjusted to account for the fact that some percentage of the cohort of working age will be out of work when they enter the model. This is accounted for by using rates of unemployment and economic inactivity by age.[122]

A79. The general population rates of unemployment and inactivity are probably overestimates of the rates in the Costs of Work-Related Cancer model. This is because the people in the cancer cost model have already been in employment for a sufficiently long period to develop work-related cancer and as such are more likely to be in employment upon being diagnosed. However, no satisfactory method could be found to control for this in the model and, given that less than one third of total registrations are of working age, it was considered proportionate to use the general population figure.

Individuals who do not return to work

A80. For non-cancer occupational injuries and illness, the proportion of individuals of working age that do not return to work is a very important driver of lost income, contributing in 2013/14 to just over 60% of lost earnings.[123]

A81. For work-related cancer, around 70% of new registrations are estimated to be over 65. Further, the relatively high proportion of registrations that become fatal, compared with other illnesses and injuries, considerably reduces the pool of workers who survive but may be unable to return to work. Therefore, 'never returns' account for a much smaller proportion of overall costs in this study than in the Costs to Britain estimates.

A82. Taskila *et al.* (2013) notes that "Studies have indicated that only about 64 per cent of those who were employed at the time of diagnosis achieved a successful and sustained return to work 2-3 years after diagnosis, compared to a control group in which 76 per cent were employed."

A83. This study and its source did not provide a breakdown of cancer return rates for all cancer types, but Taskila (2005) provides estimates of relative risk of (un)employment between cancer patients (by cancer type) versus a reference group.

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[122] Unemployment is defined by ONS as those out of work, but actively looking for employment. Economic inactivity covers those who are not seeking work, such as students or retirees. Rates used are averages of 2008 to 2012 data sourced from ONS: Table A05 http://www.ons.gov.uk/ons/rel/lms/labour-market-statistics/may-2013/index-of-data-tables.html#tab-Summary-tables

[123] See the Costs to Britain report: http://www.hse.gov.uk/statistics/pdf/cost-to-britain.pdf

A84. We apply the relative risk estimates to Labour Force Survey employment rates and then calculate economic inactivity levels. We then apply this to non-fatal registrations data to estimate the proportion of economic inactivity that is related to having had cancer. This is used as a proxy for the number of employed workers who do not return to work after developing a cancer caused by work.

A85. Based on this approach, we derive an estimate of 44 of 'never returns', resulting in total net lost lifetime income of around £6 million.[124] This is made up of a loss of gross employment income of around £8 million, offset against 'inflows' due to cancer of sick pay (£97,200), benefits (£56,500) and the tax and National Insurance that would not be paid (£2 million).

Production Disturbance

A86. In economic theory, the traditional model of the firm is one with diminishing returns and rising marginal cost, so the firm adds more variable factors (e.g. labour) to fixed factors (usually capital) until marginal cost equals the price, and the last unit of input makes no contribution to profit.[125] If a person is absent, the output that they would have otherwise produced for the firm is lost. Loss of output means the employer loses revenue but does not have to spend on materials or wages (except for sick pay). For the marginal output, revenue equals wages plus other variable costs (i.e. NI and pension contributions) so the net cost to employers is the amount paid in sick pay, and any loss of profit that the firm would normally be making on the labour it employs (Davies and Teasdale, 1994, p. 33).[126]

A87. Firms are likely to respond in two ways to a worker absence due to illness (cancer): accept the loss of output associated with the worker being off sick (as in the example above); or take action to maintain current levels of output. We make the assumption that affected firms seek to maintain current levels of output/production. This is based on evidence from case study research investigating the response of five organisations to a worker absence carried out by HSE's Accident Prevention Advisory Unit (APAU) in 1993, the results of which suggested that, in general, the impact of worker absence on production would be minimal. For further discussion, see Davies and Teasdale (1994).

A88. Firms have a range of means available to cover the output of the absent worker, including reorganising existing efforts so that less essential (and less profit-making) tasks are temporarily postponed, generating extra effort by colleagues, overtime (possibly at higher

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[124] Given the total number of cancer registrations in the model, the number of 'never returns' appears relatively small. However, this reflects the fact that the majority of cancer cases are above working age, a large proportion prove fatal, and, of the overall number, there are those that are unemployed for reasons other than cancer. After applying ONS general population rates of unemployment to the number of non-fatal registrations, 1,545 cancer registrations are (potentially) able to return to work. Of these, 44 are estimated to withdraw from the labour market due to work-related cancer.

[125] In a perfectly competitive labour market, the profit-maximizing level of employment for the individual firm is given by the point at which the marginal cost of hiring an additional worker (wage) is equal to the value of the marginal product of labour (i.e. the price at which the firm is able to sell the extra output that is produced from adding the last worker). At this point, marginal costs equal marginal revenue, and no profit is earned (except for normal profit).

[126] Davies, N.V. & Teasdale, P., (1994). *The Costs to the British Economy of Work Accidents and Work-Related Ill Health*, HSE books

wage rates), temporary reduction in any emergency stocks, etc. The choice will depend upon the circumstances of each of the firms affected, and the costs of each will vary.[127]

A89. Following our assumption about the response of firms to a worker absence is the assumption that firms are able to maintain output at the same marginal cost as before – that is, the cost of maintaining current levels of output is equal to the marginal cost of employing the absent worker (i.e. the wage rate). Consequently, the overall costs of production are unchanged. This assumption is reasonable, in that if it costs employers more than this to maintain current output levels then they would rationally choose to forgo the output.

A90. In its efforts to maintain output, the firm will inevitably incur a certain amount of disturbance to normal production that represents an additional cost to employers. For injuries or illnesses which result in short periods of absence, there is likely to be some overhead costs associated with work reorganisation to cover the absent employee's duties. For longer term absences, or following an employee's permanent withdrawal from the workforce, however, the firm will recruit temporary or permanent replacement staff and provide them with suitable orientation and induction support.

A91. The approach to estimating costs of production disturbance is well established in Costs to Britain, and this model takes a near identical approach to valuing production disturbance. We assume that most employers will postpone recruitment of a replacement for the absent worker for six months, as SSP is payable for the first six months (28 weeks) of absence. For absences of less than six months therefore, it is estimated that an average of only half a day of managerial / supervisory time is spent per case on work reorganisation. The average salary of a manager for 2013 was £24.48 per hour, and typical non-wage costs add 20% to this total.[128]

A92. Employers are assumed to incur the cost of recruiting temporary or permanent replacement staff and providing them with suitable orientation and induction support for all absences of greater than six months and for cancer fatalities. The CIPD estimates that the typical external cost for recruiting clerical grade staff in 2011/12 was £2,659 (advertising and agency costs).[129] The employee induction process and any losses of productivity whilst the new employee 'learns the ropes' are assumed to add another £589 to the unit cost, making a total of £3,248 per case.[130]

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[127] Where output is made up through extra effort, the cost is borne by the rest of the workforce, and this is not necessarily an indicator of slack or disguised unemployment in the organisation as extra effort may only be practical for a short time in special circumstances.

Most organisations do, however, operate with a degree of flexibility to allow cover for people being away (i.e. annual leave, training, sickness absence, unforeseen events, etc.) and other uncertainties. Hence, it may be reasonable to assume that a temporary loss of output associated with a worker absence is able to be covered by existing resources at no extra cost (at least in the short term), although there remains an opportunity cost in the sense that managerial effort may be required to co-ordinate current efforts, and resource flexibility to cover other potential demands is reduced.

[128] Source: Table 2.5a, Hourly Gross Pay by Occupation, Annual Survey of Hours and Earnings 2013, Office for National Statistics, Code 1: Managers, directors and senior officials http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-337429

[129] CIPD (2011) http://www.cipd.co.uk/binaries/resourcing-and-talent-planning_2011.pdf. This has been inflated to 2013 prices using RPI.

[130] Four days multiplied by the average daily wage of all employees of £123 (ASHE, 2013), plus 20% for non-wage costs.

A93. Table 27 shows the total production disturbance to employers. The vast proportion of costs relate to the recruitment and induction of a replacement worker following a fatal cancer.

Table 27: Costs of production disturbance to employers

	Estimated costs (£ millions)		
	Fatal cancer	Non-fatal cancer	Total
Work reorganisation	£0.2	£0.2	£0.4
Recruitment	£5	£0.2	£6
Total production disturbance	**£6**	**£0.4**	**£6**

Note: Totals may not sum due to rounding.

Accounting for transfers

Structure of Relevant Benefits

A94. Included within 'productivity costs' are a variety of state benefit schemes such as IIDB and ESA that offset lost earnings. Although not visible in the overall costs to society estimates, the inclusion of state benefits provides a useful indication of the existing welfare system that is in place to compensate workers for being unable to work due to work-related cancer.

A95. The benefits that will feature in Costs of Work-related Cancer are similar to those found in Costs to Britain. One exception to this relates to benefits that extend beyond the age of 65, which were not included in Costs to Britain.

A96. It is assumed that people with cancer who are eligible for the various benefits will receive them for the duration of their absence from work. The benefits, headline rates and key assumptions are outlined below.

Employment Support Allowance (ESA)

A97. This benefit initially puts claimants under the age of 65 into weekly rates based on age for the first thirteen weeks of support. This is the Assessment Phase when the appropriate degree of support and ability to work is evaluated.

A98. From the fourteenth week, claimants who pass means testing will move into one of two groups: the Support Group (SG), for those unable to look for work, and the Work-Related Activity Group (WRAG), for those able to do some light work who are expected to look for employment while on ESA.

A99. The average rate at which SG was paid out in 2013/14 was £129pw and for WRAG is £102pw. These rates are taken forward into the model.[131]

A100. According to DWP, the proportions of cancer patients successfully entering the two groups are as follows.[132]

[131] This is based on estimates from DWP: http://83.244.183.180/100pc/esa/ccdate/esa_phase/a_cawklyamt_r_ccdate_c_esa_phase.html

[132] ibid

Table 28: Proportions of cancer patients progressing to grouped stages of ESA

ESA Group	Individuals with primary cancer diagnosis (%)
Support Group	66
Work-Related Activity Group	18
Fit for Work	16

A101. The cost model assumes that 83% of people are eligible for ESA in general (as sourced from DWP).[133] The data in Table 28 indicates that of these, only 84% will successfully transfer to the Grouped Stage. Multiplying 83% and 84% together results in an assumed 70% of all cancer patients below the age of 65 receiving ESA in the model.

A102. The actual rate received in the model depends on the cancer outcome. For the majority of non-fatal cancers, a weighted average of the SG and WRAG rates is received based on the proportions in Table 28. For fatal cancers and never-returns, however, the assumed severity of their condition means they receive only the SG rate.

A103. For the purposes of the Costs of Work-related Cancer model, the initial Assessment Phase spent at the lower rate is not accounted for and it is assumed that cancer patients enter ESA at the Group stage. This is a simplifying assumption. Although this may lead to an overestimate of ESA receipts, there is a converse effect in that the model currently omits cancer patients who receive the Assessment Phase rate in the first thirteen weeks, but are then declared Fit for Work at the Grouped Stage. These two effects may go some way to cancel each other out.

Housing Benefit (HB) and Council Tax Benefit (CTB)

A104. As with Costs to Britain, it is assumed that the more severe cases will warrant additional state support in the form of HB and CTB. This is assumed to be received by those on the higher ESA rate (that is, fatal cancers and never-returns) at the average rate in 2013/14 of £90pw for HB and £16pw for CTB.[134]

Disability Living Allowance (DLA)

A105. DLA is available only to those below the age of 65 and is based on the amount of care and assistance an individual may need. Claimants must have needed the assistance for three months before they are eligible and must expect to need it for a further six months. This benefit would only then apply to people incapacitated for at least nine months.

A106. The initial three months are then backdated so money is only forgone temporarily. As this short period is less than one year, we do not apply a discount rate to the first three months' benefits when they do arrive on the basis that the effects of discounting are expected to be negligible.

[133] Source: Income Related Benefits Estimates of Take-Up in 2009-10 by expenditure, which contains a comparison against 2008-09 figures, published by DWP and available at http://research.dwp.gov.uk/asd/income_analysis/feb2012/tkup_first_release_0910.pdf

[134] Source: DWP *for Housing Benefit:* https://www.gov.uk/government/statistics/number-of-housing-benefit-claimants-and-average-weekly-spare-room-subsidy-amount-withdrawal*; for Council Tax Benefit:* https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/208272/hbctb_release_may13.xls, Table 13 "All Recipients, inflated to 2013 prices using CPI.

A107. DLA consists of two components based on applicants' ability to care for themselves (Care Component) and their degree of mobility (Mobility Component). The average rate of DLA received according to DWP during 2013/14 was £80pw.[135]

A108. As mentioned above, it is assumed that 83% of cancer patients will be eligible for DLA.[136]

Attendance Allowance (AA)

A109. This benefit replaces DLA at age 65. To be eligible, applicants must have needed help for at least 6 months. The average AA payment in 2013/14 according to DWP was £68pw.[137] As with DLA, it is assumed 83% of cancer patients will be eligible for it.

Industrial Injuries Disablement Benefit (IIDB)

A110. IIDB presented a problem to estimate in the Costs of Work-related Cancer model as it was already accounted for in the aggregate in the Costs to Britain estimate. To identify the proportion of total IIDB claims that were related to cancer attributable to work, estimates from HSE of the number of new claims from 2009 to 2011 related to cancer are used in the model.[138]

A111. This will necessitate the removal of cancer-related IIDB claimants from Costs to Britain estimate to prevent double-counting.

Mesothelioma Benefits

A112. There are two compensation schemes for mesothelioma sufferers: The Pneumoconiosis Etc. (Workers Compensation) Act 1979 and the Diffuse Mesothelioma Payment.

A113. Both are recorded in the cancer model as benefits payments, as they are paid by the government.

A114. The Pneumoconiosis Etc. (Workers Compensation) Act 1979 is only payable if you are in receipt of Industrial Injuries Disablement Benefit and applies to dust related disease caused by your employment.

A115. Data was obtained from DWP about what proportion of payments under the Pneumoconiosis Etc. (Workers Compensation) Act 1979 relate to mesothelioma. In 2012/13 the total payment was £32 million and so this has been inflated to 2013 prices and added to the benefits received by fatal cancers.

A116. The Diffuse Mesothelioma Payment covers those people exposed in the UK but not entitled to a payment under the Pneumoconiosis Etc. (Workers Compensation) Act 1979, for example they came into contact with asbestos from a relative or their exposure was while self-employed.

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[135] Sourced from DWP: http://83-244-183-180.cust-83.exponential-e.net/100pc/dla/ccdate/ctdurtn/a_cawklyamt_r_ccdate_c_ctdurtn.html

[136] Source: Income Related Benefits Estimates of Take-Up in 2009-10 by expenditure, which contains a comparison against 2008-09 figures, published by DWP and available at http://research.dwp.gov.uk/asd/income_analysis/feb2012/tkup_first_release_0910.pdf

[137] Source:

http://tabulation-tool.dwp.gov.uk/100pc/aa/ccdate/ccaaawd/a_cawklyamt_r_ccdate_c_ccaaawd.html

[138] Taken from HSE Statistics website: http://www.hse.gov.uk/statistics/tables/iidb01.xls. This is the latest period for which estimate are available.

A117. Data was obtained from DWP which gave total payments made under the Diffuse Mesothelioma Payment scheme for the last four years.[139] The average payment per year was estimated to be £9 million (2013 prices). This has been added to the benefits received by those who suffer fatal cancers.

Lost Pension Income

A118. For those people who die of cancer in the model, they are forgoing state pension income that they would otherwise have received from the point at which they die (if over 65 at the time of fatality) or retirement (if under 65 at the time of fatality) until the end of their natural life expectancy. This will be a contributing factor to total lost income.

A119. This is a departure from the Costs to Britain estimate, which does not take account of effects after the age of 65. As all other cost impacts in the model were only analysed up to the age of retirement, it was justified to not include any pension effects in Cost to Britain. In addition, fatal cancers accounted for only a small percentage of the total incidence, and so any loss in future pension income for them was not material to the total cost estimates.

A120. In the Costs of Work-related Cancer model, as the majority of people are of pensionable age, it was decided that the pension costs could not be omitted. In addition, with fatal cancers making up over half of total incidence, the cost impact would be material and should be accounted for.

A121. Estimates of average pension income were sourced from the Department of Work and Pensions (DWP).[140] The rates given encompass basic and additional state pensions, widow's pension and widowed parent's allowance; income related benefits (pension credit, housing benefit, council tax benefit and social fund grants) and tax credits; disability benefits; winter fuel payments; and carer's allowance. The rates given by DWP are different depending on whether the recipient is single or part of pensioner couple – the amount received for a couple is between £40 and £77 per week greater than that received by a single person depending on whether the head of the unit is below or above the age of 75. In order to appropriately weight the couple and single rates to give a single average rate for the model, average rates of marriage in the general population for the retired population have been applied. It is considered appropriate to use general population rates of marriage as the general population is assumed to be eligible for state pension.[141]

A122. It should be noted that any loss to the individual related to unclaimed pension will be an equal gain to Government as they will make a saving from not paying the pensions of those who have dies of work-related cancer. Please see Section 5.5.3 for more discussion on this issue.

Occupational and Statutory Sick Pay (OSP & SSP)

A123. If output is maintained at the same marginal cost of production, the net cost to the employer is any sick pay that it also has to pay to the absent employee (plus any costs of 'production

[139] Data available see: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/197721/iidb_quarterly_jun12.xls

[140] Sourced from the 2012/13 Pensioners' Income Series. Estimates have been inflated to 2013 prices using series K54U. Source: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/325315/pensioners-incomes-series-statistics-july-2014.pdf

[141] This has been sourced from the ONS England and Wales Mid-Year Population Estimate for 2010. Source: http://www.ons.gov.uk/ons/dcp171778_244768.pdf

disturbance'). This is a money outflow from the employer that becomes an equal and opposite money inflow to the affected individuals.

A124. Almost 90% of employers provide occupational sick pay (OSP) at the full rate of basic pay (but excluding overtime and bonuses) for an average of 15 weeks, according to the Chartered Institute of Personnel and Development (CIPD).[142] Of these, 87% pay it for the first three days of absence. Part salary is then paid for an average of an additional 16.4 weeks. Some firms impose a qualifying period before a new employee becomes eligible for OSP payments, but the effect of these variations has not been quantified in the cost model. In addition, approximately 13% of incidence cases are suffered by the self-employed and so receive no employer sick pay.[143]

A125. Sick pay costs borne by employers are not normally recompensed by the Government, and payments to absent employees continue to attract employers' class 1 National Insurance contributions at a rate of 12.8%. However, if in a tax month, the total SSP paid to all employees (including the underlying SSP that is part of any OSP payments) is more than 13% of the total gross employers' plus employees' class 1 National Insurance contributions for the same tax month, the excess can be reclaimed from HM Revenue and Customs under the Percentage Threshold Scheme (PTS). The proportion of PTS payments estimated to relate to absences caused by occupational injury or illness has been estimated in Costs to Britain. As no satisfactory method could be found to estimate the proportion related to work-related cancer specifically, and given the small size of this cost, it has been omitted from Costs of Work-related Cancer.

<u>Income tax and NI savings</u>

A126. Absences from work will be associated with a loss of earnings to individuals, as discussed in Section 5.2.2. However, loss of gross pay will also be accompanied by a reduction in the amount of income and National Insurance tax that the individual has to pay. Any income tax or NI savings to the individual represent a benefit to individuals but a reduction in receipts to the Exchequer of an equal and opposite amount.

A127. In addition, employers also pay NI on any sick payments to individuals. This represents a transfer between employers and Government.

A128. Total income and NI tax savings to individuals are estimated to be around £208 million. This represents a cost to Government of equal value, minus £3 million of NI paid on OSP/SSP by employers, equivalent to a reduction in income tax and NI receipts of £205 million.

[142] CIPD, 2007, 'Absence Management' annual survey report available on-line at: http://www.cipd.co.uk.

[143] According to the Labour Force Survey, approximately 13% of occupations are self-employed. This fraction has been steady over recent years, so for consistency with Costs to Britain, the 13% is carried into the cancer model, too. Source: Labour Force Survey: Employment status by occupation and sex, Office for National Statistics, http://www.ons.gov.uk/ons/rel/lms/labour-force-survey-employment-status-by-occupation/labour-force-survey--employment-status-by-occupation-and-sex--april---june-2006/occupation-and-sex-april-june-2006.xls

Appendix 5: Healthcare costs

A. Results of the medical costs study lit review

A129. This table shows the results of the literature review. All values have been converted into 2011/2012 GPB using the March HCHS Index values for the relevant years. HCHS values were not available for March 1991, 1992, 2000, or 2011, and so any conversions for these years used the closest available year. For those studies that were not UK based, the currencies were first converted using PPP-adjusted GDP values as reported by the World Bank.[144] Studies that have '**' shown in the value column are studies that appear to be relevant to the UK, but that the author could not access given existing journal subscriptions. The value associated with 28 should be treated with caution, as described in the source paper. A more detailed excel version of this table is available upon request.

#	Study	Cancer	Orenstein Category	H&SE Cancer	Value	Country of Origin	Year of Original Currency
1	[Sanger et al., 2005]	Bladder	A	Bladder	£9,667	UK	2000-2002
2	[Neymark and Torfs, 1997]	Bladder	A	Bladder	**	UK	**
3	[Lafond, 2011] (re: UK Department of Health (2011)}	Lung	A	Lung	£6,612	UK	2009
4	[Waterson et al., 2006]	Mesothelioma	A	Mesothelioma	£11,746	UK (Scotland)	2000
5	[Morris et al., 2009]	Skin	A	Melanoma (but not eye-based)	£3,671	UK (England)	2002
6	[Morris et al., 2009]	Skin	A	NMSC	£1,669	UK (England)	2002
7	[Kim et al., 2011]	Pooled Lip, tongue, oral cavity, pharynx, larynx	A/B	N/A	£25,020	UK	2009
8	[Kim et al., 2011]	Larynx	A	Larynx	£31,238	UK	2009
9	[Kim et al., 2011]	Pharynx	B	Nasopharynx	£27,839	UK	2009

144 http://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD?page=2

#	Study	Cancer	Orenstein Category	H&SE Cancer	Value	Country of Origin	Year of Original Currency
10	[Kim et al., 2011]	Oral Cavity	B	N/A	£27,282	UK	2009
11	[Bending et al., 2010]	Colon	B	N/A	£10,609	UK (England, Wales)	2005
12	{[Bending et al., 2010]	Rectal	B	N/A	£14,824	UK (England, Wales)	2005
13	[Bachmann et al., 2003]	Stomach	B	Stomach	£9,197	UK (SW England, S Wales)	1996/1997
14	[Bachmann et al., 2003]	Oesophageal	B	Oesophagus	£13,119	UK (SW England, S Wales)	1996/1997
15	[Bachmann et al., 2003]	Pancreatic	B	Pancreas	£11,676	UK (SW England, S Wales)	1996/1997
16	[Lafond, 2011] (re: UK Department of Health (2011)	Breast	C	Breast	£13,443	UK	2009
17	[Wolstenholme et al., 1998]	Breast (Overall Mean)	C	Breast	£6,404	UK (Central England)	1991
18	[Wolstenholme et al., 1998]	Breast (Stage I)	C	Breast	£4,929	UK (Central England)	1991
19	[Wolstenholme et al., 1998]	Breast (Stage II)	C	Breast	£5,508	UK (Central England)	1991
20	[Wolstenholme et al., 1998]	Breast (Stage III)	C	Breast	£5,398	UK (Central England)	1991
21	[Wolstenholme et al., 1998]	Breast (Stage IV)	C	Breast	£9,083	UK (Central England)	1991
22	[Wolowacz et al., 2005, Karnon et al., 2007]	Breast Cancer	C	Breast	**	UK	**
23	[Remak and Brazil, 2004, Dahlberg et al., 2009]	Breast Cancer (Stage 4)	C	Breast	£15,130	UK	2004

#	Study	Cancer	Orenstein Category	H&SE Cancer	Value	Country of Origin	Year of Original Currency
24	[Karnon et al., 2007]	Breast Cancer	C	Breast	£20,138	UK	2004
25	[Karnon et al., 2007]	Breast Cancer	C	Breast	£29,045	UK	2004
26	[Karnon et al., 2007]	Breast Cancer	C	Breast	£29,045	UK	2004
27	[Roehrborn and Black, 2011]	Prostate Cancer	C	N/A	£7,023	UK (Scotland)	2006
28	[Redaelli et al., 2004, Tennvall et al., 1994]	Leukaemia (Acute Myeloid)	A	Leukaemia	£1,048,928***	Sweden	1992
29	[Redaelli et al., 2004, Stafelt and Brodin, 1994]	Leukaemia (Acute Myeloid)	A	Leukaemia	£192,061	Netherlands	2001
30	[Reis et al., 2006]	Plasmocytoma (Proxy for Bone)	A	Proxy for bone cancer, and therefore for Multiple Myeloma	£10,044	Germany	2000
31	[Mantovani et al., 2008, Shih et al., 2011]	Renal Cell Carcinoma (localized)	A	Kidney	£22,435	Italy	2005
32	[Mantovani et al., 2008, Shih et al., 2011]	Renal Cell Carcinoma (metastatic)	A	Kidney	£24,619	Italy	2005
33	[Blomqvist et al., 2000]	Brain	B	Brain	£16,408	Sweden	1996
34	[Ferrandina et al., 2010]	Cervical (Mean)	B	Cervix	£29,227	Italy	2008
35	Ferrandina et al., 2010]	Cervical (Early stage CC)	B	Cervix	£16,231	Italy	2008
36	Ferrandina et al., 2010]	Cervical (Locally Advanced CC)	B	Cervix	£37,779	Italy	2008
37	[Reis et al., 2006]	Non-Hodgkin's Lymphoma	B	NHL	£3,857	Germany	2000
38	[Reis et al., 2006]	Non-Hodgkin's Lymphoma	B	NHL	£7,351	Germany	2000

#	Study	Cancer	Orenstein Category	H&SE Cancer	Value	Country of Origin	Year of Original Currency
39	[Tingstedt et al., 2011]	Pancreatic	B	Pancreas	£10,305	Sweden	2009
40	[Müller-Nordhorn et al., 2005]	Pancreatic	B	Pancreas	£34,015	Germany	2000-2002
41	[Reis et al., 2006]	Hodgkin's Disease	C	LH	£4,309	Germany	2000

The following table provides quality-related attributes by which the studies were assessed.

Quality-Related Study Attributes of Note

Quality-Related Study Attributes	
Age of Data	Studies utilizing more recent data are generally preferable to studies that use older data
Data Precision	Studies that utilize patient-level data are preferable to studies that use less precise data
Paper Content	Studies that clearly report exactly where their data came from, and what their data consist of are preferable to studies that do not do this. However, it would be incorrect to assume that all studies with poor reporting are of a low quality, and the corresponding authors should be contacted for clarification prior to making a final assessment of the quality of a study
Duration of Time Considered	Studies that followed patients for longer periods of time are preferable to studies that followed patients for shorter periods of time. The studies most relevant to the lifetime costs of disease are those studies that follow patients for the full duration of their disease. A second best are studies that model the lifetime costs of disease using disease and treatment pathway information.
Types of Costs Counted	Studies that include a greater variety of cost types are preferable to studies that include a more limited selection of cost types. Ideally, the costs included should cover medical tests, treatments, staff time, administration, and additional cost of hospital stays. Studies that maintain a large number of cost categories across different disease stages are preferred to those that simply their cost structure as they increase the number of disease stages considered.
Data Source	Studies that utilize data from the whole of the UK are preferable to studies that utilize data from other countries (though data from other countries with nationalized health care systems are preferred to data from countries without nationalized health care systems).
Scale of Data Resolution	Studies that utilize data from the whole of the UK (or another country) are preferable to studies that utilize data from only a portion of the UK (or another country)
Data Reporting	Studies that can break down costs by disease stage are preferable to studies that cannot do this. Patient-specific data is the best in this regard, and so studies that utilize this type of data are preferred over studies that utilize mean unit costs.

Table 29: Comparison of treatment costs coverage for four main cancer types

Cancer type	GP Visits and referral	Testing/Biopsy	Treatment (factors could include - 1. chemo, surgery etc. 2. Material 3. Hospital Admin 4. Time cost of medics 5. Overhead costs 6. Porterage + Nursing care)	Palliative care	Aftercare/Homecare if state paid and hospices	Outpatients follow up checks	Autopsy after death	Reconstructive surgery (where appropriate)
Lung[a]	Explicitly not included	Diagnostic Costs included	Surgery, Chemo and Radiotherapy costs included and 'Inpatient' costs are specified. This could contain general hospital costs and staffing, however what is included cannot be confirmed.	Not mentioned	Explicitly not included	Outpatient referrals included	Not mentioned	Not relevant therefore not included
Breast[b]	Included	Diagnosis costs included (stated in original Wolstenholme study used to calculate Secondary care costs in Dolan study)	Chemo, Radiotherapy and Surgery included. Inpatient stay included but no details as to what costs are included, therefore cannot determine if any of the above costs are accounted for.	Included	Included although said to be a conservative estimate as some patients will have more than one hospice visit.	Follow up checks included (stated in original Wolstenholme study used to calculate Secondary care costs in Dolan study).	Not mentioned	Included
Mesothelioma[c]	Explicitly not included	All different treatment types, as well as all direct costs associated with hospital admissions are included (all of the above)	Range of unit costs for day case and inpatients with good coverage.	Included (hospital based)	Not included as only concerns hospital costs	Day cases included	Not mentioned	Not relevant therefore not included

Non-melanoma skin cancer[d]	Included at 2.7% of total cost per patient.	Not mentioned in study or in the DH NHS reference costs document used to inform costs. Possibly be included in treatment costs.	All of the above are accounted for	Not mentioned	Community nursing services/ Health visitor services included (DH NHS reference costs)	Included	Not mentioned	Procedures Involving Repair of Skin by Flap or Graft included (DH NHS reference costs)

[a] Fleming, I., Monaghan, P., Gavin, A., & O'Neill, C. (2008). Factors influencing hospital costs of lung cancer patients in Northern Ireland. The European Journal of Health Economics, 9(1), 79-86

[b] Dolan, P., Torgerson, D. J., & Wolstenholme, J. (1999). Costs of breast cancer treatment in the United Kingdom. The breast, 8(4), 205-207

[c] Watterson, A., Gorman, T., Malcolm, C., Robinson, M., & Beck, M. (2006). The Economic Costs of Health Service Treatments for Asbestos-Related Mesothelioma Deaths. Annals of the New York Academy of Sciences, 1076(1), 871-881.

[d] Morris, S., Cox, B., & Bosanquet, N. (2009). Cost of skin cancer in England. The European Journal of Health Economics, 10(3), 267-273

B. Validating NHS costs using NHS programme budgeting data

A130. As described in Section 6.1, we use a 'bottom up' approach to estimating the total cost to the NHS of treating work-related cancers, based on unit lifetime treatment costs for various cancer types identified during an independent literature review conducted for HSE.[145] These are then multiplied by the number of attributable registrations to obtain aggregate treatment costs.

A131. This approach allows us to estimate of aggregate healthcare costs for all cancers, while also providing unit treatment costs per cancer type that can be factored into appraisal values for use in policy appraisal (see Sections 9.4 and 11.2).

A132. In order to validate these estimates, HSE analysts undertook analysis using a 'top down' approach to valuing annual treatment costs, using NHS Programme Budgeting data. The results of this supplementary analysis are broadly commensurate with the total costs estimated using the lifetime treatment costs identified as part of the literature review, suggesting the approach presented in the main body is reasonable.

A133. The following section describes this analysis.

NHS Programme Budget Data

A134. NHS programme budgeting data provides information on aggregate spend under various programme categories reflecting the whole treatment pathway, one of which is cancer.[146] The data shows that total spend relating to cancer in 2010-11 was almost £5.8 billion in 2013 prices.

A135. We explored the possibility of using this source to derive NHS costs arising from work-related cancer via discussions with NHS England and the Health and Social Care Information Centre (HSCIC). Following these discussions, the data was discounted as a primary source of estimates for the present study because of difficulties in deriving unit treatment costs – in particular per cancer type – which are important for use in impact assessments and other economic analyses.

A136. However, the data presents the opportunity to triangulate the estimate of total costs we derive in Section 6.1, by applying estimates of the proportion of cancers attributable to work (attributable fractions) to the budget data on cancer expenditure.

A137. The approach is broadly as follows:

- group the cancer types used in this study into the broader categories from the NHS England programme budgeting data for 2010 (see Table 30);
- estimate the proportion of work-related cancers in each category using the attributable fractions described in Section 3 (see Table 31) ;

[145] For a small number of cancers, lifetime treatment costs are taken from UK Department of Health data.

[146] See https://www.england.nhs.uk/resources/resources-for-ccgs/prog-budgeting/ for further information, including definitions of care settings and programme categories.

- apply these proportions to the estimates of total expenditure in each category to estimate total NHS expenditure on *work-related* cancers (see Table 32).[147]

A138. Programme budgeting data in this format was only available for England, not for Scotland and Wales. In order to estimate the proportion of expenditure relating to work-related cancers across the whole of GB, the cost estimates from England were scaled up using the proportion of total work-related registrations in GB that arose in England (i.e. around 85%).

Adjusting expenditure data under 02x 'Cancer and Tumours (other)'

A139. One of the main challenges in using this data for the purposes of this study is the subcategory 02x 'cancers and tumours (other)', which accounts for over half of total NHS cancer expenditure (£3.1 billion in 2013 prices). Discussions with NHS England highlighted that this category captures a wide range of costs and cancer types not accounted for in the 02a-i categories.

A140. Most importantly, 02x includes a range of 'unbundled care' i.e. treatment not assigned to a particular cancer type, such as chemotherapy, radiotherapy and high cost drugs, which will account for a large proportion of cancer treatment. It also includes some costs related to less common cancers that are unlikely to be related to work. Unfortunately, no further breakdown of 02x was available to distinguish these costs.

A141. NHS programme budgeting guidance shows that unbundled care is allocated to 'Other secondary care'. We therefore adjust the secondary care expenditure under 02x to include only 'other secondary care' and exclude other 02x secondary care categories, as the latter are more likely to relate to other non-work-related cancers. Based on discussions with NHS England, we also exclude from 02x 'GP, Dental and ophthalmic' expenditure but retain other 02x primary expenditure (since this includes expenditure on prescription drugs) and also retain expenditure relating to 'community care' and 'health and social care provided in other settings', since NHS guidance suggests that cancer-related community and hospice care expenditure is typically allocated to 02x. We then take the simple approach of apportioning the remaining costs in the 02x category by the estimated proportion of total population cancers that are work-related: around 4%. This inevitably allocates some cancer costs that are not work-related; however, we expect the adjustments made above to minimise this issue and for the purposes of this exercise – to 'sense check' our main results – it is sufficient.

Results

A142. The results are presented in Table 32 (page 123). Using the approach outlined, this gives £121 million expenditure on work-related cancers for England, or around £8,900 per average case of cancer. Using the proportion of overall work-related GB registrations from England as a proxy for the total GB treatment costs, this gives a value for total NHS costs of treating work-related cancers in GB of around £142 million in 2013 prices.[148]

A143. The total NHS treatment costs using our primary 'bottom up' approach described in Section 6.1 were around £132 million, providing reassurance that the bottom-up approach is

[147] Note a number of inclusions and exclusions of cost components described below in Table 32.

[148] The NHS budget data was in 2010 prices, and so has been inflated to 2013 prices using the Hospital & Community Health Services (HCHS) Pay and Prices index, available here: http://www.pssru.ac.uk/project-pages/unit-costs/2014/

commensurate with the NHS budget and gives a reasonable approximation of costs arising from work-related cancers.

A144. Section 6.1 highlights that some studies used to derive the per cancer type treatment costs applied in the main report did not cover the full treatment pathway, particularly community / hospice care. Removing these elements from the programme budgeting data (settings defined as ‘Community care’ and ‘Health and social care provided in other setting’), results in an estimate of £114 million in 2013 prices using the NHS programme budgeting data, which is still comparable with our main estimate.

A145. As highlighted in the main report, the NHS programme budgeting data gives the annual costs of treating *all* cancers, i.e. both new and existing cases of cancer in 2010, as opposed to the lifetime treatment costs of incident (i.e. new) cases in a given year. This is more in line with a prevalence-based approach to estimating the proportion of attributable cancers, and thus not directly comparable with the incidence approach used to estimate new work-related cancer registrations.

A146. However, when one considers that the NHS expenditure data relates to treatment costs of cases of cancers that will be in varying stages of treatment (i.e. different disease stages), and that the number of work-related cancers is relatively stable in the short term, then the two approaches should in theory be similar in providing an estimate of the annual treatment costs relating to work-related cancers, so the comparison is valid.

NHS Programme Budgeting Expenditure Data Analysis Tables
Table 30: Grouping of cancer types used in this study by NHS programme budget categories

Cancer types	Work-related cancers in England	NHS programme budget categories
Bladder	491	Urological cancers
Bone	0	Essentially zero for work-related cancer
Brain	13	Cancer and tumours other
Breast	1,879	Breast cancers
Cervix	15	Gynaecological cancers
Kidney	3	Urological cancers
Larynx	49	Head or neck cancers
Leukaemia	41	Haematological cancers
Liver	6	Cancer and tumours other
Lung	4,755	Lung cancers
LH	0	Haematological cancers
Melanoma eye	6	Cancer and tumours other
Mesothelioma	2,088	Lung cancers
Multiple Myeloma	10	Haematological cancers
Nasal / sinonasal	136	Head or neck cancers
Nasopharynx	15	Head or neck cancers
NHL	149	Haematological cancers
Oesophagus	178	Upper gastro intestinal cancers
Ovary	29	Gynaecological cancers
Pancreas	1	Upper gastro intestinal cancers
NMSC	3,697	Skin cancers
STS	30	Cancer and tumours other
Stomach	119	Upper gastro intestinal cancers
Thyroid	1	Head or neck cancers
ALL	**13,713**	

[1]Lympho- haematopoietic (LH). [2]Non-Hodgkin's lymphoma (NHL). [3]Non-melanoma skin cancer (NMSC). [4]Soft Tissue Sarcoma (STS).

NHS Programme Budgeting Expenditure Data Analysis Tables
Table 31: Grouping cancer registrations by 02a - 02x to determine proportion of work-related cancers in each category.

Programme budget category 02		Work-related cancers best estimate England	All (population) cancers England	% work-related related	% cancer cases in each category of total (ALL cancers)	% cancer cases in each category of total (ALL cancers excl 02x)
a	Head or neck cancers	201	17,240	1.2%	4%	5%
b	Upper gastro intestinal cancers	298	24,954	1.2%	6%	7%
c	Lower gastro intestinal cancers	0	35,060	0.0%	9%	9%
d	Lung cancers	6,843	70,126	9.8%	18%	19%
e	Skin cancers	3,697	93,799	3.9%	24%	25%
f	Breast cancers	1,879	41,612	4.5%	11%	11%
g	Gynaecological cancers	45	16,160	0.3%	4%	4%
h	Urological cancers	494	53,848	0.9%	14%	14%
i	Haematological cancers	201	23,106	0.9%	6%	6%
x	Cancer and tumours other	55	15,870	0.3%		
	TOTAL	**13,713**	**391,775**	**3.5%**	96%	100%

NHS Programme Budgeting Expenditure Data Analysis Tables

Table 32: Total 2010/11 NHS expenditure apportioned according to the proportion of work-related cancers in each category (2013/14 prices)

Aggregate PCT level expenditure Programme budgeting category		**Total primary care[a] £m**	**Total secondary care[b] £m**	**Other[c] £m**	**Total[d] £m**	**% total GB cancer cases work-related[e]**	**Total expenditure in England (work-related) £m**	**% of total GB work-related cancers in England[f]**	**Total expenditure in GB £m**
02a	Head or neck cancers	£0.03	£118.69	£23.55	£142.27	3%	1%	£1.66	85%
02b	Upper gastro intestinal cancers	£0.01	£184.24	£22.28	£206.53	5%	1%	£2.46	85%
02c	Lower gastro intestinal cancers	£0.05	£333.96	£34.94	£368.95	9%	0%	£0.00	85%
02d	Lung cancers	£0.01	£162.03	£29.13	£191.17	4%	10%	£18.66	85%
02e	Skin cancers	£0.01	£116.82	£11.30	£128.13	3%	4%	£5.05	85%
02f	Breast cancers	£140.29	£375.64	£42.77	£558.69	13%	5%	£25.23	85%
02g	Gynaecological cancers	£0.97	£119.30	£16.54	£136.80	3%	0%	£0.38	85%
02h	Urological cancers	£83.72	£258.90	£29.01	£371.64	9%	1%	£3.41	85%
02i	Haematological cancers	£1.41	£437.91	£34.15	£473.46	11%	1%	£4.11	85%
02x	Cancers and tumours (Other)[g]	£226.16	£837.18	£664.37	£1,727.70	40%	4%	£60.47	85%
	TOTAL 02a-02x	**£452.65**	**£2,944.65**	**£908.03**	**£4,305.34**			**£121.43**	

Notes: [a] includes 'GP, dental and ophthalmic' and 'Primary prescribing and pharma services'

[b] includes 'Inpatient: Elective and Daycase', 'Inpatient: Non-elective', 'Outpatient' and 'Other secondary care'

[c] includes 'Ambulance', 'Accident & Emergency', 'Community Care', 'Care provided in other setting', and 'Non-health / social care'

[d] includes [a], [b], and [c]; does not include 'Prevention and Health Promotion' spend

[e] see Table 31

[f] 85% is based on total work-related cancers in England as a proportion of total GB work-related cancers. It is applied across all categories as a simplifying assumption and does not reflect that there may be small differences in proportions between categories.

[g] For 02x, 'Total primary care' excludes 'GP, dental and ophthalmic' and 'Total secondary care' excludes all secondary care except 'Other secondary care'.

See guidance available at https://www.england.nhs.uk/resources/resources-for-ccgs/prog-budgeting/ for definitions of care and programme categories.

Published by the Health & Safety Executive 10/16

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Costs to Britain of Work-Related Cancer

Understanding the economic and wider impacts of work-related cancer is important to inform HSE's regulatory decision making and engagement with stakeholders on the case for proportionate risk management in the workplace. Monetised estimates are used by HSE in Regulatory Impact Assessments and other evaluations and economic analyses.

This report presents new research which estimates in monetary terms the total annual economic burden of new cases of work-related cancer in Great Britain (GB) in 2010. It is the first attempt at such an estimate and provides the most comprehensive indicator of the overall burden on society available. The analysis accounts for a broad range of impacts from work-related cancer and how the costs fall to different groups: individuals, employers, government, and society as a whole. Costs are estimated for the 24 work-related cancer types identified in the HSE Cancer Burden Study, which was published in 2010, based on both the known and the probable carcinogens classified by the International Agency for Research on Cancer.

The results suggest that the total economic costs of new cases of work-related cancer in GB in 2010, arising from past working conditions, were around £12.3 billion. Individuals bear the vast majority of the costs of work-related cancer.

RR1074

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