Understanding the economic value of cancer research

June 2022

Together we will beat cancer

Reference

This report should be referenced as follows:

'PA Consulting & CRUK. 2022. *Understanding the economic value of cancer research*.'

Authors

Cancer Research UK commissioned PA Consulting to carry out research underpinning this report.

Acknowledgements

The authors would like to acknowledge the experts and contributors who gave their time and knowledge as part of this report. We would like to thank colleagues from Cancer Research UK who conceived the research aims and contributed to the management and delivery of the project: Zoe Martin, Latisha Gordon, Dr Alexandra Feast, Rose Gray, Tony Hickson, Andrew Knowles, Matthew Lawes, Rose Dixon and Rosie Hinchliffe. We would also like to thank Jodie Moffat and Alex Pemberton for their interviews.

Research Funding

Cancer Research UK

Cancer Research UK (CRUK) is the world's largest cancer charity dedicated to saving lives through research. We support research into over 200 types of cancer, and our vision is to bring forward the day when all cancers are cured. Our long-term investment in state-of-the-art facilities has helped to create a thriving network of research at 90 laboratories and institutions in more than 40 towns and cities across the UK, supporting the work of over 4,000 scientists, doctors and nurses. In 2020/21, Cancer Research UK invested £421 million on new and ongoing research projects into the causes and treatments for cancer.

This research was funded by the Policy Development team.

CANCER RESEARCH UK

Contents

Glossary

CRUK	Cancer Research UK
BCR	Benefit cost ratio
ECMC	Experimental cancer medicine centre
EIA	Economic impact assessment
FTE	Full time equivalent
GVA	Gross value added
NCRI	National Cancer Research Institute
QALY	Quality adjusted life years
SIC	Standard Industrial Classification

Figures and Tables

Executive Summary

Together we will beat cancer

Background

Cancer research saves and improves lives. Innovations have led to significant improvements in survival in recent years – but there's still substantial scope for better outcomes. We need to detect cancer in people much earlier, for example. Around 70 per cent of staged lung cancer cases are detected at stages 3 and 4[1], with less than 15 per cent of these patients expected to survive beyond five years[2]. The picture is stark when comparing cancer outcomes in the UK to other similar countries. For some cancers, UK patients' chance of survival is 11 per cent lower than in comparable countries[3]. So, the moral and medical arguments for investing in cancer research are clear.

At its centre, cancer research is the key to improving cancer survival and to improve the quality of life of cancer patients. This remains the primary motivation for continued investment in research but it also brings wider economic and social benefits to the UK. These are less well known but nonetheless important to consider when there are competing priorities.

Cancer Research UK (CRUK) is a key funder of the cancer R&D system in the UK and will be an important part of the research environment for years to come. We are responsible for half of all public and charitable sector cancer research investment in the UK with over £350m spent annually[4]. We commissioned PA Consulting (PA) to explore this question and help make the economic case for investing in cancer research.

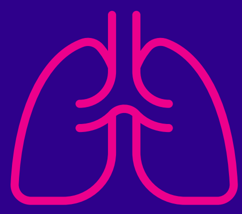
Approach

PA Consulting quantified the economic and societal impact of investment in cancer research in 2020/21 in terms of jobs and gross value added (GVA), a measure of economic output. The benefits that the investment ultimately delivers in terms of extending the healthy life of cancer patients was also calculated.

This report also assesses the role of CRUK in supporting cancer research to deliver benefits, as well as the opportunities for cancer research investment in the future.

The analysis outlined in the report builds on precedence of similar studies (see section 7.4) and aligns to HM Treasury Green Book appraisal guidance. This includes applying input-output multipliers to estimate the direct, indirect and induced economic impacts of cancer research funding.

Further detail on the methodology, data and assumptions underpinning our analysis in the annex of the report.



Over 70%
of lung cancer cases are detected at stages 3 & 4

Less than 15%
of these patients expected to survive beyond five years.

Key findings

1

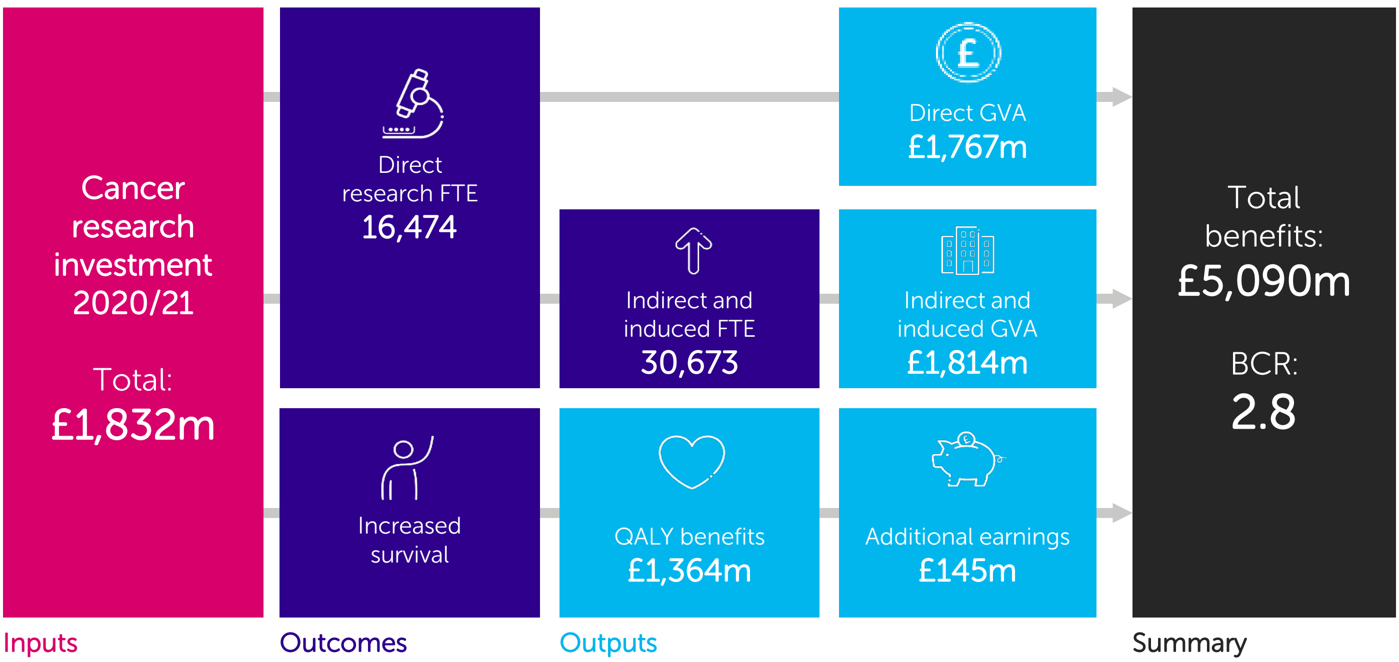
Every £1 invested in cancer research generated £2.80 of economic benefit in 2020/21

Investment in cancer research contributes to the UK economy by supporting jobs within cancer research and creating demand across the wider life sciences and research supply chain. It also generates benefits to the wider economy through the earnings of cancer research workers. In addition, there are secondary economic impacts derived from innovations in cancer care that improve outcomes and enable patients to keep working for longer.

In 2020/21, there was £1.8 billion of investment in cancer research. This investment generated more than £5 billion of economic impact[5] - that's made up of £3.6 billion in GVA from 47,000 jobs, £1.4 billion in monetised patient health benefits, and £145 million in additional earnings from improved patient survival.

These numbers give a benefit cost ratio (BCR) of 2.8 – every £1 invested in cancer research generated £2.80 of economic benefits. To put this into perspective, HM Treasury considers any BCR greater than 1.0 value for money.

Figure 1: Summary of the economic impacts of cancer research investment



Source: Analysis by PA Consulting

Key findings

Creating jobs directly

Of the estimated £1.8 billion investment in cancer research in 2020/21, £815 million, or 44 per cent, represents salaries for 16,474 staff. Almost 14,000 jobs in cancer R&D relate to scientific and technical roles, which tend to be highly skilled and highly paid. Salaries in R&D roles are, on average, 25 per cent higher than the national average. The remaining 2,510 jobs are in supporting and administrative roles. In terms of economic output, cancer research employment translates into a direct impact of £1.8 billion GVA.

Creating jobs and adding value in the supply chain

Cancer research supported 23,250 jobs in its supply chain, generating £1.2 billion in additional indirect GVA in 2020/21.

Additionally, cancer research investment generated 7,423 induced jobs and £572 million of induced GVA[6]. That's 2,370 jobs (£128 million GVA) in the manufacturing and wholesale retail sectors, 1,300 jobs (£69 million GVA) in non-scientific professional sectors, which includes financial and legal services, and 3,680 jobs (£196 million GVA) across the rest of the economy.

These impacts arise when people directly employed by cancer research organisations and indirectly employed by firms in the associated supply chain spend their earnings in their local economy, 'inducing' further economic activity.

In total, PA estimates cancer research investment generates an additional 30,673 indirect and induced jobs, equivalent to a GVA of £1.8 billion.

30,673 indirect and induced jobs = **£1.8bn** equivalent GVA

Induced impacts should be excluded if being considered as part of a business case, given updates to the Green Book guidance in 2020

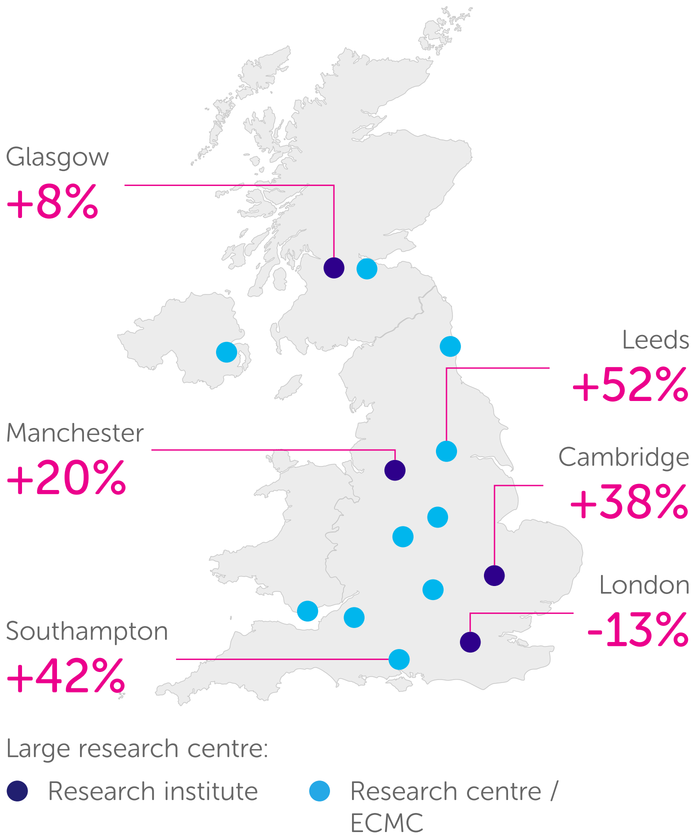
Spreading growth across the country

Full-time salaries in cancer R&D are, on average, 25 per cent higher than the average salary across all jobs in the UK. Cancer research organisations have a presence in all four countries of the UK and all nine regions of England. These range from the largest cancer research institutes to smaller experimental cancer medicine centres (ECMC) and research units within university faculties. This means cancer R&D investment promotes high-skilled and high-paying jobs across the UK.

Saving lives

Improvements in cancer survival can lead to further economic benefits by enabling patients to continue working. PA estimates the health benefit of the cancer research investment in 2020/21 was an additional 22,730 quality adjusted life years (QALYs), which has a societal value of £1,364 million. At the same time, patients could carry on working, leading to an increase in earnings of £145 million.

Figure 2: Comparison of salaries in R&D compared to average regional salaries



Source: Analysis by PA Consulting

Key findings

2

CRUK generated £973 million of economic benefits in 2020/21

CRUK is the largest source of non-commercial funding for cancer research in the United Kingdom. It's the largest independent funder of cancer research in Europe and the world's leading charity dedicated to cancer research[7]. Estimates suggest CRUK is responsible for half of public sector and charitable investment in cancer research and 19 per cent of total cancer research investment in the UK. That means CRUK generated £973 million of economic benefits in 2020/21, made up of 9,010 jobs (£684 million of GVA), £260 million of QALY benefits and £28 million of additional earnings.

CRUK has also been successful in producing spinout companies that can go on to contribute further to the economy. In 2020, ten of the largest CRUK spinouts together spent £421 million in real terms on cancer R&D in the UK. This generated 10,850 jobs and £824 million of GVA in the private sector. PA hasn't included these effects in the GVA impacts of CRUK as these companies exist within the private sector and aren't part of CRUK itself.

CRUK's research impact has also been significant in drug discovery, helping to develop over 50 cancer drugs. 3 in every 4 patients who receive cancer drugs on the NHS are given drugs which are linked to CRUK's research. This is the result of CRUK's discoveries influencing private sector drug development and is one example of how CRUK's activity has a broad impact on patient health beyond its own footprint.

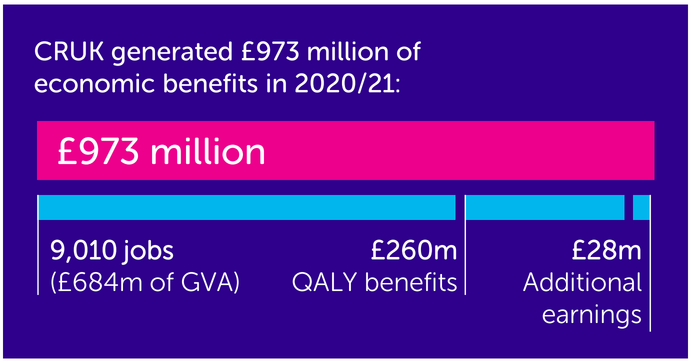
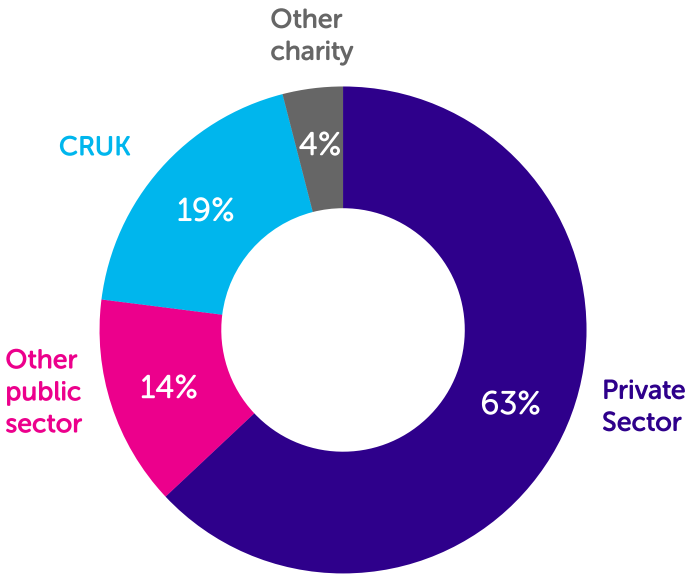


Figure 3: CRUK's expenditure contribution to the cancer research sector



Source: Analysis by PA Consulting

Key findings

3

The return on cancer research will rise as cancer cases will grow by around 40% by 2040

Maintaining historical growth in cancer research investment will see funding top £3 billion in 2040, which will support over 80,000 jobs and generate more than £13 billion in total economic benefits[8]. Forecasts predict cancer cases will grow by around 40 per cent over the next 20 years. This comes as people live longer and become increasingly at risk of developing cancer. This indicates that advancements in early detection and treatment today would go on to positively impact a growing population of potential cancer patients. This increases the return on cancer research investment over and above the broader market.

These benefits however will only be realised by maintaining current growth in public and private investment. Given the evidence that public sector R&D investment 'crowds in' private sector investment[9], ensuring continued public sector investment will be critical to securing the benefits that cancer research investment will bring.

Investing in cancer research saves lives – and delivers economic benefits

Cancer research is crucial to the scientific research and development sector in the UK. As cancer incidences continue to rise, ensuring improvements in detection and treatment keep pace is paramount for a healthy population.

Our results show investing in cancer research can help secure growth across the UK. There's also a commercial opportunity for the UK life science sector to take advantage of new cancer technologies by fostering their development within the UK.

The future impact of cancer R&D relies on continued private and public investment. Such investment will save lives and support economic growth while securing the UK's position as a world leader in science and innovation.

End notes

[1]CRUK data

[2]ONS (2019), Cancer survival in England - adults diagnosed

[3]CRUK (2021) Statistics by cancer type, Age-Standardised Five-Year Relative Survival 2000-2007.

[4]CRUK(2021) Annual Report and Strategy Analysis.

[5]These are base estimates; you'll find sensitivity tests providing low and high estimates in the annex.

[6]Induced impacts should be excluded if being considered as part of a business case, given updates to the Green Book guidance in 2020.

[7]https://www.cancerresearchuk.org/funding-for-researchers

[8]We've assumed the state of the world in 2040 is otherwise the same as it is in 2021. We haven't attempted to project labour market outcomes, inflation, or the future state of cancer.

[9]Haskel J, Hughes A, Bascavusoglu-Moreau E (2014) The Economic Significance of the UK Science Base. A report for the Campaign for Science and Engineering; https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/897470/relationship-between-public-private-r-and-d-funding.pdf;

2. Introduction

2. Introduction

This study has been commissioned by Cancer Research UK to understand the economic value of cancer research in the UK.

2.1 Cancer research saves and improves lives.

Although cancer innovation has led to significant improvements in cancer survival in recent years, there is still much that needs to be done. This includes detecting cancer in people much earlier, such as with lung cancer where over 70% of cases are detected at stages 3 and 4[10] where less than 15% of patients are expected to survive after five years[11]. The picture is even more stark if we compare cancer outcomes of the UK to other countries. For some cancers, UK patients experience a 11% lower chance of survival than in other comparable countries[12].

Higher survival rates and better quality of life in cancer patients is underpinned by cancer research. Delivering innovations in cancer detection and therapies allow us to prevent and more effectively treat cancer. Evolving medical care and challenges such as the coronavirus pandemic demonstrates the importance of new advancements in cancer treatment. New technologies can introduce detection into the home, or improve the tailoring of treatment to reduce the amount of time patients spend accessing the health system.

Continued cancer innovation can only happen with ongoing sustainable funding. However, there is a need to better articulate the value of cancer R&D as a pillar of the UK economy and a driver of public health, particularly at a time when there are competing priorities for funding. Saving and improving lives is a key objective of cancer research, but there is also an economic argument which demonstrates why investment in this area can achieve value for money for the UK taxpayer and support key government objectives. This includes the UK government's ambitions for the UK to become a science superpower, given the accelerating development of medical technologies and growing interest from the private sector in recent years. There are commercial opportunities for the Life Science industry, given that the oncology market is set to see near-double-digit revenue growth in the coming years[13]. Cancer Research UK (CRUK) is a key funder of the cancer R&D system in the UK, providing half of public and charitable funding, and will be an important part of the research environment for years to come.

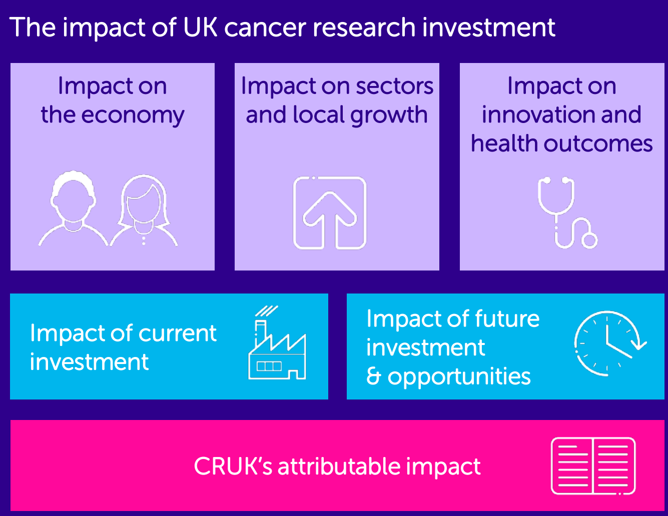
To help make the economic case for cancer research investment, Cancer Research UK commissioned PA Consulting to undertake an analysis of economic impact of cancer research investment to the UK. It seeks to quantify economic impact in terms of jobs and gross value added, as well as the societal benefits generated from the commercialisation of funded research.

2.2 Aims and objectives

To understand the value of cancer research this study seeks to quantify:

1. The impact of UK cancer research investment in generating gross value added (GVA) and jobs
2. The role of this investment in supporting regions and sectors
3. The societal benefits investment in cancer technologies ultimately deliver in terms of saving lives of cancer patients, which in turn generates further economic benefits
4. The role of CRUK in supporting cancer research to deliver these benefits
5. The potential opportunity for cancer investment in the future

Figure 4: Approach to quantifying the benefits of cancer research



A mixed methods approach is employed alongside various sources of evidence to quantify impacts where possible. To ensure the analysis is recognisable to a range of stakeholders, the broad approach builds on precedent of other economic impact assessments (EIAs) in the public domain – section 7.3 provides a comparison of methodology with other EIAs. Recognising the unique nature of cancer research, this analysis also undertakes bespoke health economics analysis that is compliant with HM Treasury Green Book appraisal guidance to articulate the additional benefits cancer research delivers.

Further detail on the methodology is in section 3 and 7.4 of the annex

2.3 Structure of this report

The remainder of this report is structured as follows:

Chapter 3 sets the methodology underpinning the analysis, including a summary of key impacts considered.

Chapter 4 details the quantified economic impact of current cancer research to the UK, including the role of CRUK in supporting these impacts.

Chapter 5 examines the potential future economic impact of cancer research and explores further opportunities that could be realised from additional cancer research investment, for example to close the gap in cancer survival outcomes between the UK and comparable countries.

Chapter 6 provides concluding remarks.

Chapter 7 is the annex to this report, setting out methodology, assumptions and data sources underpinning the analysis. It also contains sensitivity analysis and a comparison of the approach of this analysis to other economic impact assessments.

End notes

[10]CRUK Early Diagnosis Data Hub

[11]ONS (2019), Cancer survival in England - adults diagnosed

[12]CRUK (2021) Statistics by cancer type, Age-Standardised Five-Year Relative Survival 2000-2007.

[13]Global Market Insights – Oncology market

3. Approach to understanding the value of cancer research investment

3. Approach to understanding the value of cancer research investment

The approach in this report addresses the following areas:

- Value of cancer R&D to the UK and scenario planning
- Areas of cancer research megatrends and case studies
- Role of medical charities and CRUK in funding cancer R&D and fostering economic returns

The methodology is underpinned by guidance outlined in HM Treasury Green Book and builds on precedent within the economics field. As such the analysis in this report would be recognisable to public sector stakeholders and other EIA experts. The approach seeks to combine different approaches rather than selecting one over the other. Similarly, data, assumptions and methodology have been triangulated from a range of publicly available sources where possible. Bespoke analysis has been included to reflect the uniqueness of cancer research investment compared to other investment areas. Section 7.3 of the annex compares the methodology used in the analysis with other economic impact assessments.

3.1 Economic impact assessment

The core component of the analysis is the economic impact assessment (EIA) which quantifies the contribution an industrial sector, organisation or region makes to the UK economy. Economic impact assessments offer a structured and consistent approach to wider economic benefits and can enable policymakers to understand the magnitude of the impact of an investment and how it can deliver value for money.

Typically, EIAs quantify economic impacts in terms of employment and gross value added:

- **Full time equivalent (FTE)** is the number of full time jobs that would be supported by an investment. FTE is used instead of a basic headcount so comparisons can be made even if the proportion of partial employment varies between sectors and organisations.
- **Gross value added (GVA)** refers to the contribution of a sector or region to national gross domestic product (GDP) and is a measure of net economic output. It is equal to the value of production minus the value of inputs.

The economic impacts are decomposed into direct, indirect and induced benefits which relate to three separate channels of how economic activity can be generated by the investment. For cancer research investment, these impacts are as follows:

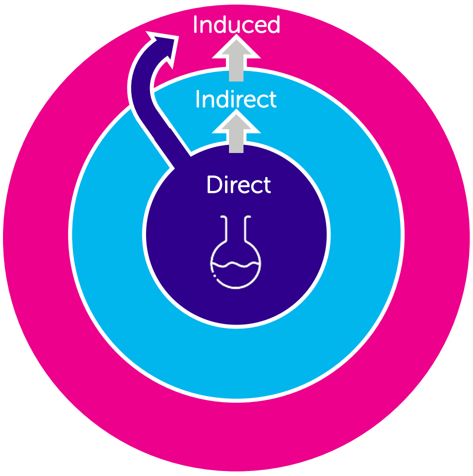
Direct benefits capture the operational expenditure of cancer research organisations on employee salaries and encompass all roles.

Indirect benefits refer to the expenditure of cancer research organisations on goods and services that are used as inputs for their activities. This is the spending that serves as income to suppliers who in turn will demand goods and services from other companies which results in an impact on the entire supply chain.

Induced benefits are derived from the direct and indirect impacts. Those who are employed directly by cancer research organisations or indirectly by firms in the cancer research supply chain receive a wage that is a portion of their employer's income. They use these earnings to purchase goods and services in their local economy which gives rise to an additional ripple effect beyond the cancer research supply chain. Induced benefits are included in this analysis to ensure consistency with other EIAs which are typically not produced for business case submission[14].

The direct economic impact of cancer research investment is calculated from expenditure data for the financial year ending in 2021. Indirect and induced impacts are estimated using economic multipliers obtained from input-output tables provided by government agencies. These describe the flow of goods and services between sectors of the economy and therefore can also be used to identify how specific sectors of the economy are affected by cancer research investment.

Figure 5: Economic impact assessment framework

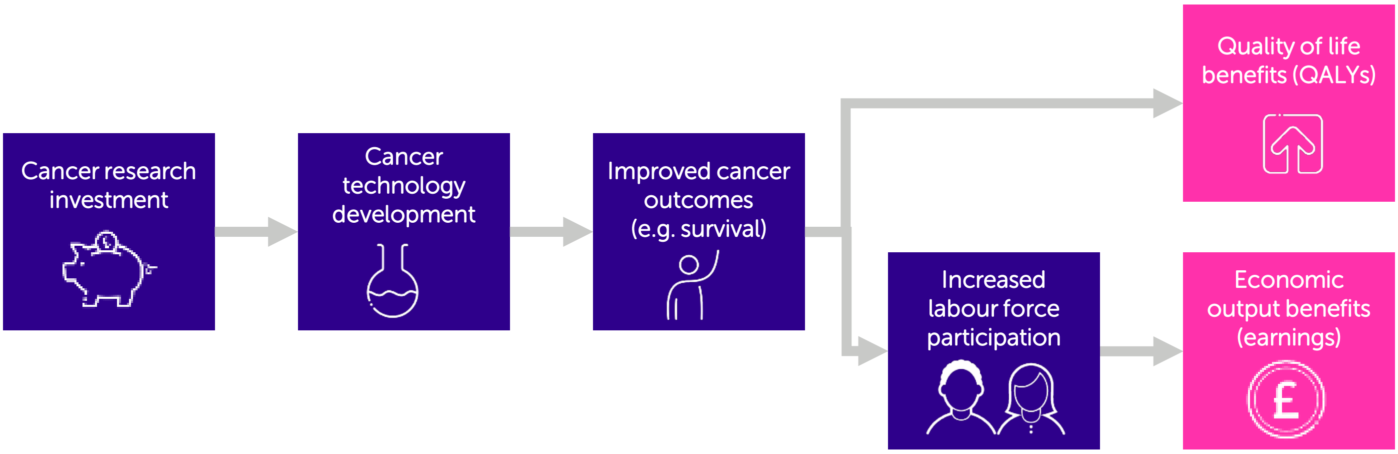


As demonstrated in section 7, the use of economic multipliers to quantify direct, indirect and induced impacts are broadly consistent across other EIAs within the public domain. Most of the differences in methodology stems from other impacts that are additionally captured.

3.2 Health outcomes and earnings benefits

Improved cancer outcomes will enable cancer patients to live longer and heathier lives. These health impacts can be quantified in terms of monetised quality adjusted life years. There could also be economic benefits from cancer patients living longer, given that this will increase their ability to continue participating in the workforce.
This logic is summarised in the following diagram:

Figure 6: Investment to health outcomes framework



Quality adjusted life years

The gain in healthy life years can be expressed as quality-adjusted life years where one QALY (evaluated at perfect quality of life) which has a social monetary value of £60,000 according to willingness to pay estimates from Green Book guidance. The QALYs are derived from estimating the number of cancer deaths that are avoided through improved cancer survival across a subset of the most prevalent cancers. Average years life lost per death, based on data from the World Health Organisation, are used to estimate the total years life lost avoided through reduced mortality, which are converted to QALYs using utility estimates which capture the extent to which the additional life years are of good or 'quality' health. It is implicitly assumed that cancer patients who avoid death through improved survival rate will be subject to the average life expectancy of the rest of the population. The findings are generalised across the entire cancer population.

As this study is concerned with the impact of UK cancer R&D only, adjustments need to be made to account for impacts of cancer technologies from other countries. As a result, it is assumed that 17% of health outcomes are attributable to UK research, in line with previous CRUK-affiliated studies[15] that uses cited references as a proxy for the relative importance of UK research.

As an implicit additionality adjustment, it is assumed that any improved health outcomes from UK R&D will be temporary. This is recognition that the global cancer R&D market is highly competitive, with many countries such as the United States, Germany and China racing to develop the same technologies.

It is therefore likely that any UK success in cancer R&D will bring-forward and accelerate the commercialisation of a technology compared to the counterfactual where other countries may eventually develop such technologies.

Evidence on technology frontiers and diffusion suggest 2.5 years could be the length of time for which benefits would be attributable to the UK. This approach is consistent with other health economics analysis conducted for public sector business cases. Although it is likely that some health outcome improvements could take much longer to arise after the investment, a lack of data makes it impossible to identify an appropriate time lag grounded in evidence.

Economic output benefits

Increased life expectancies will also have secondary effects on the economy where cancer patients are able to spend more time in employment and producing economic output. It is assumed that only those cancer patients of working age will be able to increase their participation of the workforce, equal to the average years of life gained due to avoided cancer mortality, up until retirement age. Lifetime earnings by age are modelled as income varies over the course of a lifetime with earnings at their highest around the ages between 40 and 50. Therefore the cancer incidence by age group is used to find an accurate estimate of additional earnings across all patients. Adjustments are made of for labour force participation, the unemployment rate and retirement age.

The annex provides detail on the methodology and assumptions underpinning the quantification of the QALY and output benefits.

3.3 Future projections

As the methodology to estimate future economic impacts continues to follow the prescribed economic impact assessment approach, the future economic impacts are based on extrapolating historical cancer research investment and estimating the benefits in the same way as described in the previous section (i.e. for current economic impact). To forecast the path of future cancer research expenditure, the average growth rate is extracted from historical data and extrapolated to 2040. This is not a prescription of how much investment should be committed but instead, is an illustrative example of how the wider benefits of cancer research may materialise in the future.

This report will explore the future economic and health impacts of cancer research investment. The economic impacts follow the same breakdown and have the same outputs as in the current expenditure case. Annualised figures are produced for FTE and GVA. Cumulative benefits over multiple years do not have a convenient economic interpretation as GDP, which GVA is a component of, is expressed in annual amounts and employment is based on annual salaries. Values are expressed in 2021 prices for ease of comparability. This analysis does not seek to project any other variables or assumptions, such as GVA, earnings, employment or cancer rates. Therefore, the future projections analysis is otherwise a mirror-image of the current economic impact analysis.

Investment to health elasticities

The translation of investment to health outcomes described in the previous section can be used to estimate health elasticities, which equate to the amount of health and earnings benefits that are attributable to every £1 of UK cancer research investment. This elasticity provides a useful metric that can be applied to projected investment values to understand the potential health benefits in the absence of any evidence on projected cancer survival rates attributable to new cancer technologies.

As an alternative to these estimated health elasticities, this study also takes advantage of similar elasticities from the 'What's it Worth' studies[16] commissioned by the Wellcome Trust, Medical Research Council and Academy of Medical Sciences. CRUK was involved in commissioning the study for cancer research. Taking the cancer specific estimates from the 'What's it Worth' studies, adjusting for the QALY value of £60,000, the studies claim an annualised return of 17.5% in perpetuity. This is applied over a 20-year model horizon to the projected investment to find an alternative estimate for future health outcomes from cancer investment. This health return is estimated the potential health gain from specific health innovations and is applied across the cancer population. In effect, the 'What's it Worth' analysis provides a bottom-up approach to estimating the health impact, whereas the health elasticities estimated in this study take a top-down approach.

Both the health elasticities and 'What's it Worth' estimates are used to estimate the health benefits from projected cancer investment.

End notes

[14] Note that induced impacts should not be included in form of business case or options appraisals following the update to HM Treasury Green Book guidance in 2020.

[15] Glover, M., Buxton, M., Guthrie, S. et al. Estimating the returns to UK publicly funded cancer-related research in terms of the net value of improved health outcomes. BMC Med 12, 99 (2014). https://doi.org/10.1186/1741-7015-12-99

[16] Health Economics Research Group et al. Medical Research: What's it worth? Estimating the economic benefits from medical research in the UK. London: UK Evaluation Forum; 2008

3.4 Data and assumptions

The analysis in this report uses publicly available evidence and evidence where possible. A triangulation approach has been used to determine assumptions and inform modelling decisions. This includes building on precedent of similar studies, evidence, multiple data sources and expert opinion. The approach used throughout the analysis is in line with HM Treasury Green Book guidance and similar studies in the public domain[17] . Assumptions, data sources and rationale are in the annex to this report.

Data obtained from CRUK that are used in the analysis in this report relate to the relative size of CRUK investment in the wider cancer research sector. The methodology, data sources and results have been sense-checked through comprehensive engagement within both Cancer Research UK and PA Consulting, with reference to existing studies and evidence to provide sense-check and context. Experts within CRUK that have been consulted are Dr Jodie Moffat and Dr Alex Pemberton on the areas of early detection and advanced therapeutics respectively.

A mixed methods approach has been used to articulate the value of cancer research investment, for example through the combination of different assumption sources and methodologies. This approach is advantageous by ensuring that no single methodology or source is selected above others that could materially affect the results. This approach also allows the value of cancer research to be articulated in different ways, recognising the inherent difficulties of quantifying a non-standard industrial sector. The case studies make use of quantitative data where available to provide an indication of the future returns of investment in these areas, however the lack of quality evidence makes it difficult to quantify any specific impacts. Sensitivity analysis is also detailed in the annex which tests the impact of any material assumptions that are subject to degrees of uncertainty or different sources, to provide an indication of the potential optimistic and pessimistic range of results.

3.5 Limitations of this study

This report is a technical report which does not seek to provide any policy recommendations. It is intended to provide an economic impact assessment using publicly available evidence where possible to provide quantifiable impacts using methodology that is consistent with other similar studies and can withstand expert scrutiny. There are several limitations to the analysis in this study:

- This study is underpinned by best practice as defined by HM Treasury Green Book guidance, as well as precedent set by other economic impact assessments within the public domain. In alignment to other EIAs induced impacts have been captured, however these effects should be excluded if the impacts in this study are to be part of any form of business case.
- Publicly available evidence and data are used where possible. No attempt has been made to verify the underlying sources.
- Any analysis on the impact of future investment assumes a state of the world similar to that of 'current', such that projections of economic variables and the state of cancer in the UK have not been developed. This is partly to ensure ease of comparability between current and future analysis, as well as consistency with appraisal best practice.
- This study leverages approaches that are broadly consistent with similar studies in the public domain, however differences will exist due to differences in the purpose and approaches, including the extent to which methodologies from other studies are deemed both suitable and robust.
- It is recognised that limitations in the availability of data and evidence have meant that the analysis is inherently imperfect. The analysis builds on precedent and best practice to ensure the approach is both pragmatic and recognisable. In appreciation of the bespoke nature of aspects of this analysis, a variety of different methodologies are employed to triangulate the impact of cancer research, recognising that no one method is perfect.

End notes

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

4. Impact of current cancer research investment

4. Impact of current cancer research investment

4.1 Summarising the economic impact of cancer research investment

Investment in cancer research contributes to the UK economy by supporting jobs within cancer research, creating demand across the wider life sciences and research supply chain, and generating benefits to the wider economy through the additional earnings of cancer research workers.

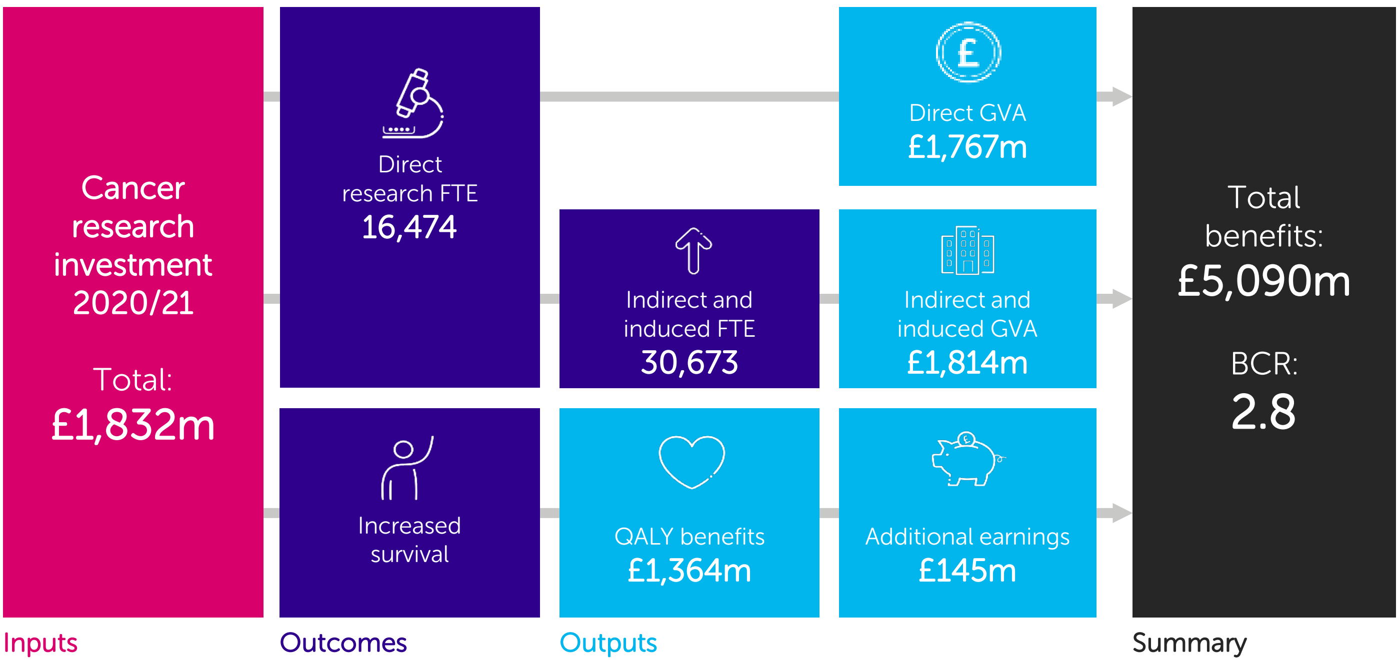
There will also be secondary economic impacts derived from innovations in cancer care made possible by the investment in cancer research, which will improve cancer outcomes and enable patients to participate longer in the workforce.

In total the cancer research sector invested £1,832 million in the 2020/21 financial year. This supported 47,150 full time jobs across the UK and contributed £3,581 million of gross value added to the economy. Improvements to health valued at £1,364 million resulted from cancer research which further added £145 million to the economy through earnings.

Therefore, the total estimated economic impact of 2020/21 cancer research investment is £5,090m. Cancer research investment also supported over 47,000 jobs, the majority of which are high-skilled scientific and technical jobs.

The total economic impact of £5,090 million is similar to that of the Port of London which is the second largest port in the UK[18].

Figure 7: Current economic impact of cancer research



Source: Analysis by PA Consulting

Comparing the monetisable benefits with the initial size of investment **suggests a benefit cost ratio (BCR) of 2.8. This means that every £1 invested in cancer research will generate £2.80 of economic benefits to the UK.** To put this number in perspective, any BCR greater than 1.0 is considered value for money by HM Treasury. The table below provides benchmarks of published benefit cost ratios for R&D, innovation and investment schemes, which can be useful for understanding how the BCR of 2.8 found in this analysis compares. In summary, the BCR found in this analysis is comparable and towards the upper range of publicly available estimates of other science, research and investment schemes. The higher nature of the BCR in this analysis is reasonable given cancer research investment is unique in producing significant economic benefits as well as saving lives, which in itself drives significant societal benefits.

Table 1: Comparison of benefit cost ratio benchmarks

Analysis	BCR	Source
The returns on cancer research (this analysis)	2.8	
R&D Expenditure Credit scheme evaluation	2.4-2.7	HMRC (2020) Evaluation of the Research and Development Expenditure Credit (RDEC)
Social rates of return to R&D	Median 1.85 over 9 estimates	BIS (2014) Rates of return to investment in science and innovation
Review of returns to science, R&D and innovation	Average 1.6 over 102 evaluations Top 5%: 2.9	BIS (2009) Research to improve the assessment of additionality
Aerospace Technology Institute projects (aerospace technologies grant funding)	Median: 2.3 Range: 0.3-5.9	BEIS (2017) EVALUATION OF ATI AEROSPACE R&D PROGRAMME
Advanced Propulsion Centre (automotive technologies grant funding)	R&D multiplier: 1.2 GVA multiplier: 1.7	BEIS (2021) ADVANCED PROPULSION CENTRE, Interim Impact Evaluation
HS2 Phase 1	1.2	DfT (2020) Full Business Case High Speed 2 Phase One

The remainder of this section provides further detail on the economic impact of cancer research investment in 2020/21.

4.2 Direct economic impact

Cancer research investment is characterised by investment that is dominated by charities in the non-commercial sector and life science organisations in the private sector.

Data from NCRI suggests the public and charitable sectors invested £700m in cancer research in 2019/20 . Given a lack of available evidence on the size of investment in the private sector, estimates suggest that the private sector made up 62% of UK medical research in the 2000s which is extrapolated to current cancer research specifically[19]. **This means that total UK cancer research investment was £1,832 million in the financial year 2020/21.**

Of this investment, a total of £815 million, or 44%, was allocated to the salaries which **directly supported 16,474 FTE staff, of which 13,964 were in scientific and technical roles.** The remaining 2,510 FTE jobs are in supporting and administrative roles. In terms of economic output, these FTE jobs translate into a **direct impact of £1,767 million of gross value added (GVA).**

4.3 Economic benefits to the supply chain

Cancer research investment will support the broader research and life sciences supply chain, generating further economic impact in these areas. Cancer research organisations will purchase inputs from suppliers in order to produce research outputs. This means that activity within cancer research supports firms in other sectors in terms of their employment and economic output.

To estimate the supply indirect economic impacts, Type I and Type II multipliers are derived from UK-wide input-output analytical tables, which represent the amount of economic output from subsectors that are feeding into cancer research sector. The multipliers used in this analysis are summarised in the table below. The application of the Type 1 multipliers suggests cancer research supported 23,250 additional FTE jobs in its supply chain and generated £1,242 million of additional GVA in 2020/21 (see Annex 7.4.1 for calculation).

Table 2: Economic multipliers for FTE and GVA

Multiplier type	FTE	GVA
Type I	2.41	1.70
Type II	2.86	2.03

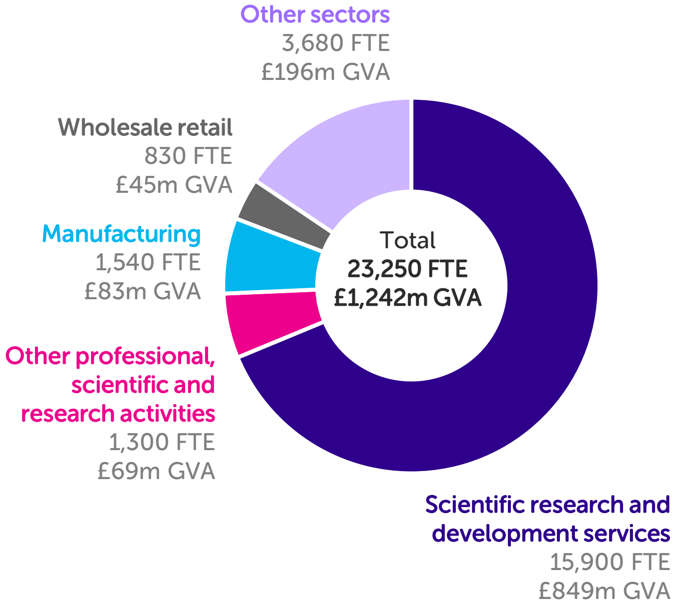
Source: Analysis by PA Consulting

The benefits that arise from activity in the cancer research supply chain can be broken down into sector specific impacts according to the input-output model. The Leontief matrix shows the input requirements per unit of output for each subsector where cancer research would fall under scientific research and development services. The indirect impact can therefore be allocated between sectors according to their relative importance as an input sector.

Scientific research and development services are characterised by a high proportion on inputs being sourced from within the same sector. **The scientific R&D sector accounts for 68% of all supply chain economic activity generated from cancer research, which corresponds to 15,900 FTE jobs or £848 million of GVA.** This could be because the cancer research process relies heavily on intellectual property and patents from other research areas. As a result, the breakdown of the indirect impacts of cancer research is disproportionately weighted towards other parts of the scientific and knowledge economy. This also suggests that investment in cancer research will stimulate activity in the broader R&D sector, which is both high skilled and highly productive compared to other areas of the economy.

Cancer research investment stimulated 2,370 FTE jobs and £128 million of GVA in the Manufacturing and Wholesale Retail sectors, while 1,300 FTE jobs and £69 million of additional output were generated in non-Scientific Professional sectors, which includes financial and legal services. The remaining 3,680 FTE jobs and £196 million of GVA were distributed over the rest of the economy.

Figure 8: Sectoral breakdown of indirect economic benefits



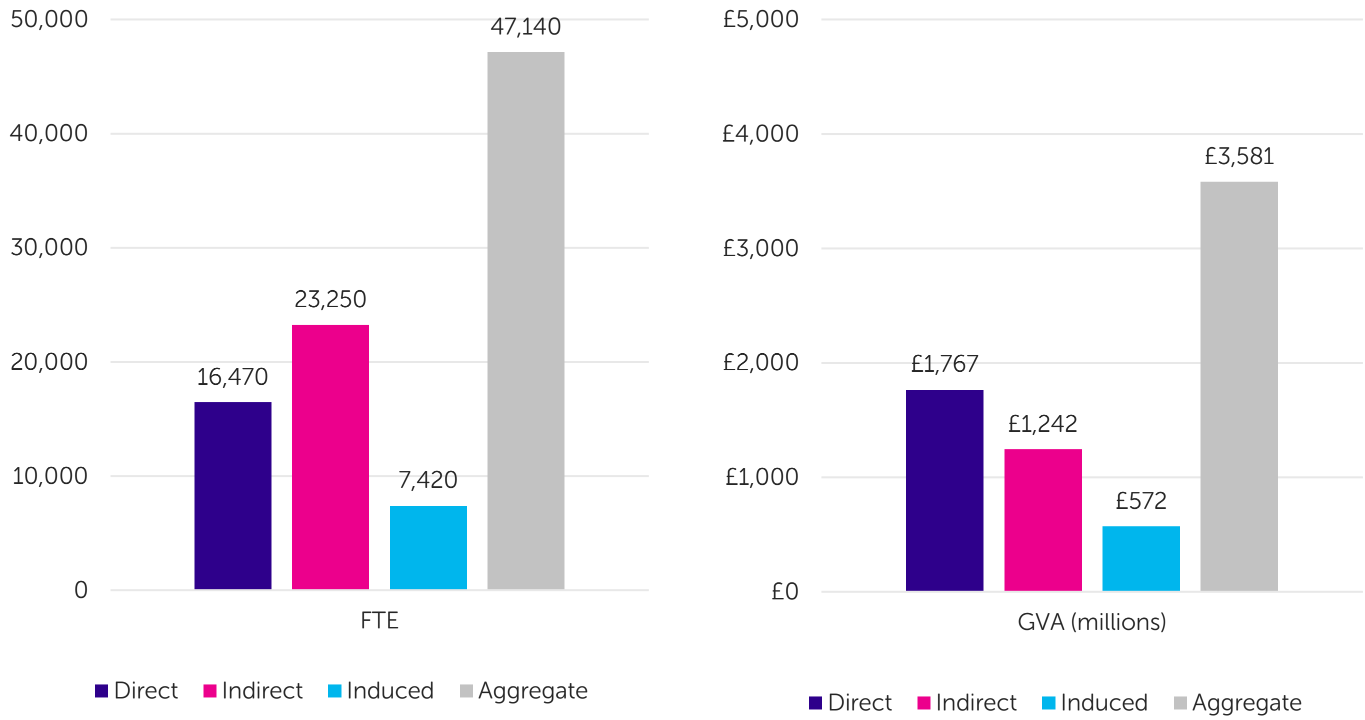
Source: Analysis by PA Consulting

4.4 Economic impacts to the wider economy

Induced economic impacts arise when those who are directly employed by cancer research organisations and indirectly employed by firms in the cancer research supply chain spend their earnings in their local economy, 'inducing' further economic activity. Type I multipliers are used to extract the indirect impact while Type II multipliers are used in conjunction with Type I multipliers to extract the induced impacts. In summary, **cancer research investment generates an additional 7,420 FTE induced jobs and £572 million of induced GVA**[20].

By including all three direct, indirect and induced effects, the **aggregate economic impact of the £1,832m cancer research investment totalled 47,140 FTE jobs with an associated £3,581 million of GVA in the 2020/21 financial year.**

Figure 9: Direct, indirect and induced economic impact of current cancer research investment



Source: Analysis by PA Consulting

4.5 Spreading growth across the UK

Cancer research organisations have a presence in all four countries of the UK and all nine regions of England, as shown in Figure 10. These range from the largest cancer research institutes to smaller experimental cancer medicine centres (ECMC), or research units based within university faculties.

The high productivity nature of the cancer research sector can be seen in regional comparisons of average salaries between roles in R&D and average salaries for all jobs in the area. Looking at the UK as a whole, **full time salaries in cancer R&D are on average 25% higher than the average salary across all jobs in the region.** The largest difference is seen in Yorkshire and the Humber where R&D salaries are 52% greater. The other regions where the difference is more pronounced than the UK overall are the West Midlands, the East, South West and South East of England where R&D salaries have at least a 29% wage premium.

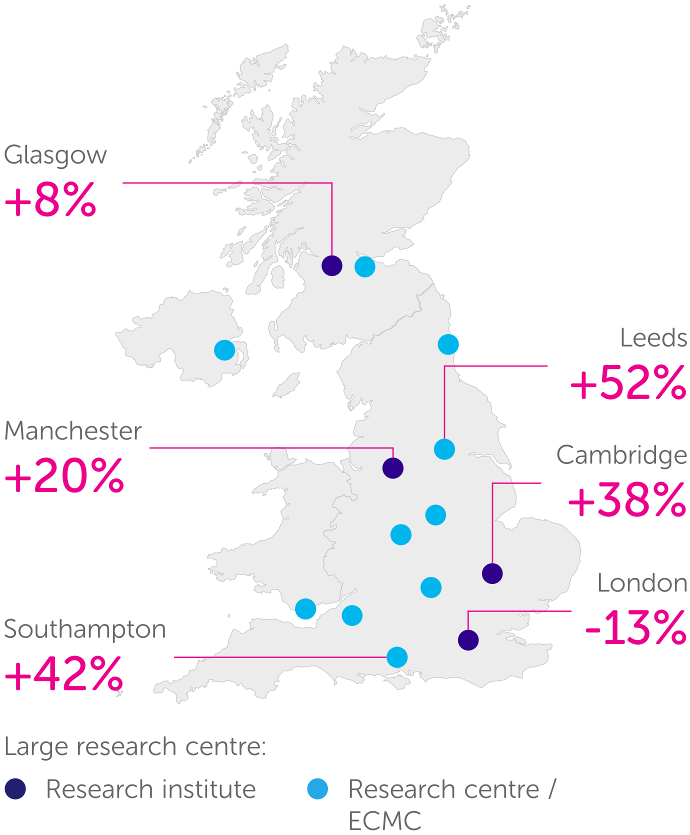
A positive wage premium for R&D jobs is seen in all regions of England except for London where the delta is negative 13%. This is due to the relative prevalence of highly paid roles in professional services in London compared to the UK more generally. This can be seen by the fact that the only roles where salaries are greater than the London average are in information and communication, finance and insurance, real estate, and law.

The presence of jobs in R&D as a result of cancer investment will promote growth in local wages, particularly during periods of low unemployment, therefore demonstrating the positive effect that investment in cancer research has on local economies.

Cancer research activity is concentrated in cities with university hubs, but these are distributed across the UK and devolved nations, and not confined to typical high productivity regions such as London and the South East. This shows that investment into cancer research has a positive economic impact in terms of regional distribution, in addition to its absolute magnitude.

Investment in cancer research will support government priorities to spread high productive and high-skilled growth across the country. Cancer research has presence across the UK and full-time salaries in R&D are on average 25% higher than the average regional salary.

Figure 10: Comparison of salaries in R&D compared to average regional salaries



Source: Analysis by PA Consulting

4.6 Investing in cancer research to save lives

Cancer research is unique to other investment areas as it can lead to significant societal benefits in terms of improving cancer patient outcomes. Improvements in cancer survival can lead to further economic benefits by enabling patients to continue participating in the workforce.

The health benefit that resulted from one year of cancer research investment in 2020/21 is estimated to be an **additional 22,730 healthy life years (QALYs), which has a social value of £1,364m.** The additional life years enables patients to continue participating in the workforce, leading an increase in earnings of £145 million. In total, this means improved societal benefits as a result of cancer research amounted to £1,509 million.

Figure 11: QALY benefits and additional earnings associated with current cancer research

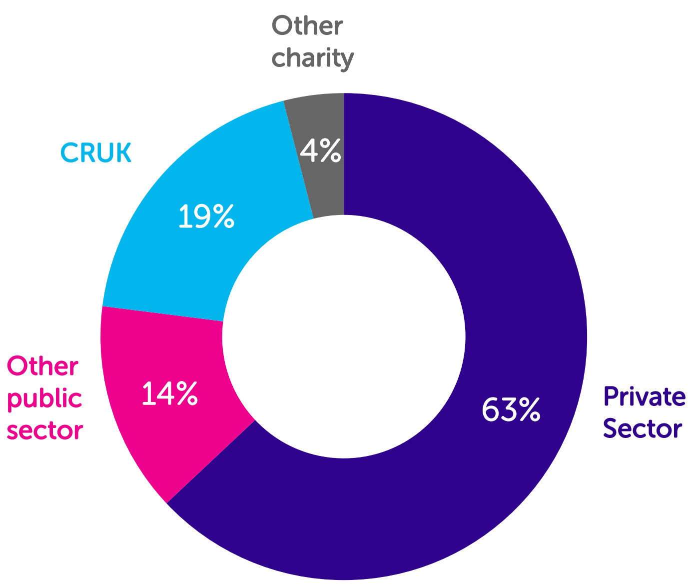
4.7 CRUK's economic impact

CRUK's attributable economic impact

CRUK is the largest source of non-commercial funding for cancer research in the UK, the largest independent funder of cancer research in Europe and the world's leading charity dedicated to cancer research[21]. Based on NCRI data, CRUK is responsible for half of all UK public sector and charitable investment in cancer research. When compared to the whole cancer research sector, it is estimated that CRUK contributes around 19% of all research spending.

The analysis suggests **CRUK was responsible for £973 million of benefits in 2020/21[22]. The economic impact comprised 9,010 FTE jobs and £684 million of GVA benefits. In terms of health benefits, CRUK was responsible for £260 million of QALY benefits and £28 million of additional earnings.**

Figure 12: CRUK's proportion of spending relative to the broader cancer research sector



Source: Analysis by PA Consulting

Although CRUK as a charity does not itself employ a large number of researchers, the direct and indirect impacts of its funding resulted in the employment of 5,710 full time researchers and technicians.

The economic impact of CRUK spinouts

The research funded by CRUK can lead to commercial spinouts and these companies will invest in cancer research independently. Since these companies form part of the private sector, the impact of this spending is already captured by the economic impact assessment that evaluated the sector as a whole. However, since the operations of the spinouts are derived from the activities of researchers that were funded by CRUK, it is reasonable to quantify the positive externalities that CRUK research has on the sector.

In 2020, ten of the largest CRUK spinouts together spent £421 million in real terms on cancer R&D in the UK, which supported 10,850 jobs, equivalent to £824 million of GVA, in the private sector, which CRUK played an important role in realising. This suggests that CRUK's activities have contributed to the success of private sector activity, equivalent to a magnitude that is greater than CRUK's own economic footprint.

These spinout impacts are not reported within the results for CRUK itself (as outlined in the previous subsection) though they can be thought of as a component of the private sector impact. This is because the spinouts are not a part of CRUK itself and are independent companies. The table below shows the separate impacts of CRUK and CRUK spinouts relative to the market as a whole.

Table 3: Economic impact of CRUK and its spinouts

Participants	GVA economic impact
Total market (public + private)	£3,581m
CRUK	£684m
CRUK's spinouts	£824m

Source: Analysis by PA Consulting

It would be misleading to include the economic impact of CRUK's spinout R&D as part of CRUK's own cancer R&D because this would suggest that CRUK is completely responsible for the investment and activities of the spinouts, which cannot be the case given the spinouts are private sector entities. However, it is clear that CRUK has a vital role in supporting UK cancer research, to the extent that its activities enhance growth of the private sector.

CRUK's impact in driving commercialisation of research

CRUK provides funding for cancer research across the research pipeline, including early stage research, which can then be commercialised by the life science industry. CRUK's research impact has been significant in drug discovery. CRUK's research has helped develop over 50 cancer drugs. 3 in every 4 patients who receive cancer drugs on the NHS are given drugs which are linked to CRUK's research[23]. The table below illustrates some of the drugs that have been at least in part derived from CRUK's research.

This suggests that CRUK's R&D activities have contributed to world-leading discoveries which generate substantial commercial benefits to the life sciences industry which supports thousands of jobs in the UK.

While there are clearly economic benefits to this drug discovery R&D, a lack of data on UK manufacturing of such drugs means it is impossible to estimate the economic impact of this commercial success. The below table provides selected examples of drugs which CRUK's research has helped to bring to market, which suggests that CRUK has helped to support at least $47bn of global sales in the drug industry. The overall impact is likely to be much larger if all drugs could be included in the analysis.

CRUK's research has helped develop over 50 cancer drugs. 3 in every 4 patients who receive cancer drugs on the NHS are given drugs which are linked to CRUK's research.

Table 4: CRUK's impact in drug discovery

Drug	CRUK's impact	Global sales (USD)[24]
Mabthera (rituximab)	This is a targeted drug used for certain types of leukaemia and lymphoma (blood cancers), and also some autoimmune diseases. Early work on antibodies in the lab back in the 1980s helped in the development of this drug, and CRUK played a leading role in early clinical trials for the treatment.	$ 4.5bn
Herceptin (trastuzumab)	This is a targeted drug for breast cancers that have high levels of a protein molecule called HER2 on their cells. Early work on HER2 in the lab, by CRUK scientists and others, underpinned the drug's development, and later supported clinical trials for the treatment.	$ 4.0bn
Avastin (bevacizumab)	This is a targeted drug that stops tumours from being able to develop blood vessels, therefore starving them from nutrients and oxygen. This type of treatment is known as an anti-angiogenesis drug, and it's used for many types of cancers (and also to prevent vision loss). CRUK have supported clinical trials for this drug.	$5.3bn
Opdivo (nivolumab)	This is an immunotherapy drug that's currently used for advanced forms of melanoma, non-small cell lung cancer and kidney cancer. CRUK supported a clinical trial looking at combining this drug with another immunotherapy for melanoma, and a number of other clinical trials are currently running to investigate the drug's potential in other cancer types.	$7.2bn
Keytruda (pembrolizumab)	This is an immunotherapy drug that's currently used for some people with non-small lung cancer, melanoma and Hodgkin lymphoma. CRUK have been supporting clinical trials for this drug, for example finding out whether radiotherapy can boost its activity in people with advanced skin cancer.	$14.4bn
Ibrance (palbociclib)	This is a targeted drug for certain types of advanced breast cancer, which blocks 2 molecules that tell cells when to grow. CRUK's early work in the 1980s on how cell growth is coordinated and controlled helped lay the foundations for this drug's development. CRUK is also currently funding a clinical trial looking at whether palbociclib, combined with a hormone therapy drug, could be an effective treatment before breast cancer surgery.	$5.4bn
Xtandi (enzalutamide)	This is a hormone therapy that stops the body making testosterone. It's a treatment for advanced prostate cancer. CRUK have been supporting clinical trials for this drug, such as the currently open RE-AKT trial which is combining enzalutamide with a new drug.	$4.4bn
Zytiga (abiraterone)	This is a hormone therapy that blocks the body from making testosterone. It's a treatment for some men with advanced prostate cancer. CRUK researchers played a leading role in the drug's development, and CRUK have also supported a number of clinical trials for the treatment, including the first in-man studies and current research such as STAMPEDE.	$2.5bn
	Total	$47.7bn

The story of abiraterone (Zytiga)

One of CRUK's success stories is abiraterone acetate (Zytiga), which is an important treatment for advanced prostate cancer. Abiraterone works by blocking the production of male hormones that can fuel the growth of prostate cancers.

CRUK's researchers were first involved in the drug's development in the early 1990s. They identified and tested a compound in the lab, referred to as '3', and were able to show that it could block hormone production. The CRUK Strathclyde Formulation Unit packaged '3' into a pill renamed as abiraterone, which was then tested rigorously in people with cancer in clinical trials.

CRUK supported the initial, early phase I and II clinical studies before the final phase III trials, which were carried out with the help of the pharmaceutical industry. In 2012, CRUK lobbied to make abiraterone available on the NHS and it is now regularly used to treat patients with prostate cancer.

In 2017 results showed that taking abiraterone with hormone therapy and a steroid drug, compared to standard hormone treatment, could dramatically boost survival in some men by 37%. Abiraterone (Zytiga) has proved commercially impactful, generating £2.5bn of sales in 2020.

Cytosponge

Around 9,100 people are diagnosed with oesophageal cancer each year, but often symptoms aren't recognisable until a later stage in the disease.

Some people develop a condition called Barrett's Oesophagus first and, while not everyone goes on to develop cancer, it is an opportunity to investigate further.

The typical test for Barrett's Oesophagus is invasive and expensive, but CRUK-funded researchers at Cambridge have developed a test called Cytospongex that is simpler, quicker and more affordable.

The device can be described as a 'sponge on a string'– the patient swallows a small, coated pill on a string and when it reaches the stomach the pill coating dissolves, and the sponge expands. The sponge can then be pulled back up the oesophagus, collecting cells on the way that are sent for lab analysis. Research shows that this approach can detect ten times more people with Barrett's in a population that is currently taking medicine for heartburn than current GP care. These people may then benefit from regular surveillance, such as with endoscopy, with the aim of spotting cancer earlier.

COVID-19 has accelerated interest in the use of this test and NHS England are investigating its use in the triage of patients waiting for a routine appointment, but further research is ongoing to explore and support its use in the original primary care setting.

End notes

[18]SQW. (2020). Port of London Economic Impact Study.

[19] Sussex, J., Feng, Y., Mestre-Ferrandiz, J. et al. (2014). Quantifying the economic impact of government and charity funding of medical research on private research and development funding in the United Kingdom. BMC Med 14, 32

[20]Induced impacts should be excluded if being considered as part of a business case, given updates to the Green Book guidance in 2020.

[21]https://www.cancerresearchuk.org/funding-for-researchers

[22]In effect, the direct, indirect and induced benefits are linear in magnitude to the size of investment. The benefits from improving lives of cancer patients are assumed equally proportional

[23]Based on data provided by CRUK

[24]Roche 2021 investor update; Bristol-Myers Squibb Reports Fourth Quarter and Full Year Financial Results for 2019; pfizer reports fourth-quarter and full-year 2020 results and releases 5-year pipeline metrics; Johnson and John 2020 annual report; Merck Fourth-Quarter and Full-Year 2020 Financial Results

5. Future impact of cancer research investment

5. Future impact of cancer research investment

This section explores the potential benefits of future investment in cancer research.

Table 5: Economic and health impacts of current and 2040 expenditures

Scenario	Investment[27]	Benefits				BCR
		Annual FTE	Annual GVA	QALYs	Earnings	
Current	£1,832m	47,150	£3,581m	£1,364m	£145m	2.8
2040: Investment-to-health multipliers	£3,131m	80,590	£6,121m	£6,393m	£681m	4.2
2040: What's it Worth study	£3,131m	80,590	£6,121m	£10,316m	£1,099m	5.6

Source: Analysis by PA Consulting

Between 2003 and 2020, public and charitable expenditure on cancer research, as described by the NCRI, grew on average 2.8% per year in real terms. When adjusted for inflation, the sum of investment grew from £434 million to £673 million over seventeen years. Extrapolating this forward to 2040 gives an implied public and charitable investment into cancer research of £1,197 million per year[25]. Assuming the ratio between public and private expenditure is constant over time, the total value of **cancer research investment is estimated to be £3,131 million in 2040 (in 2021 prices).** This is approximately 70% greater than current investment levels. **This level of investment suggests that cancer R&D in 2040 will generate over 80,000 jobs and be supported by cancer research investment which will generate £6,121m in GVA[26]. Total benefits will reach £13,196m once health impacts are included. However, these benefits can only be achievable if growth in current public and private investment is maintained.**

An implicit assumption to this is that investment will continue to result in new technologies and medical advancements that will improve health outcomes. Many of the key technologies that have the potential to bring significant improvements to cancer outcomes are related to early detection and/or therapeutic advances. Advancements in genome sequencing and the use of biomarkers allow for the detection of cancer at earlier stages or reveal underlying risks in those who would not have been tested. Advanced therapies can improve treatment and extend life expectancies of those who already have cancer while also reducing harmful side effects.

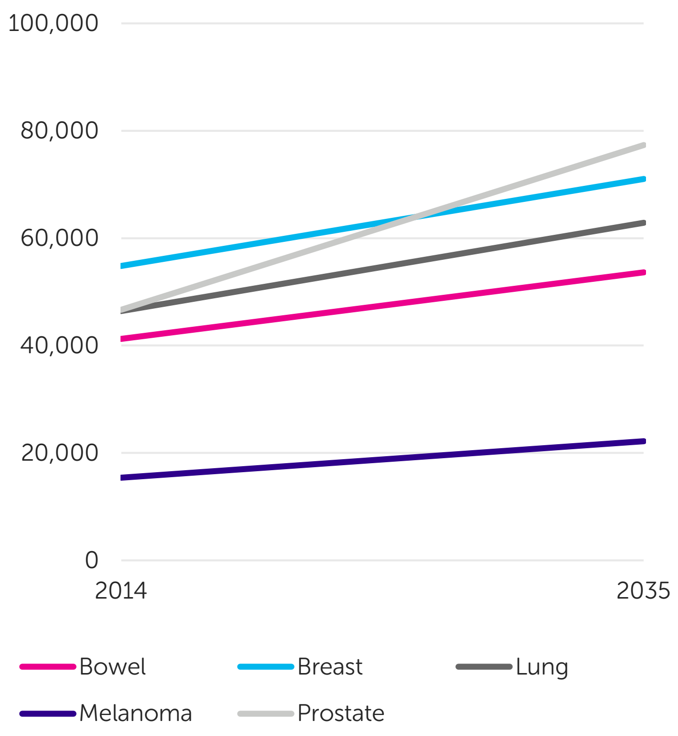
Two different methodologies are used to estimate the health returns for the 2040 analysis, each providing different values for QALYs and earnings. Differences in these methodologies and results are explained in sections 5.1 and 5.2.

Increasing returns to cancer R&D

The returns to cancer research investment becomes greater as the prevalence of cancers grows in the future

Even if cancer research investment continues to deliver the same health returns to patients as it has done in the past, the increasing health burden over time of cancer on the UK population will inevitably increase the total health benefits of cancer research in the future. This is because each innovation produced from cancer research will be able to benefit more and more cancer patients. Figure 13 shows the increasing incidence for the most common cancers in the UK – by almost 40% over 20 years. By 2035, there will be more than 60,000 new cases of breast, lung and prostate cancer each year.

Figure 13: Average number of new cases per year 2014-2035



Source: Analysis by PA Consulting

Advancements in early detection and cancer treatment will therefore benefit an increasing number of cancer patients. The impact of cancer caseload growth can be seen in the benefit cost ratios. Table 6 shows how the BCR's change according to whether growth in cancers is included in the analysis – it shows that the returns to cancer research investment increases with cancer caseload.

Using the investment-to-health multipliers methodology, the return on £1 of investment grows by 67p while for analysis using the What's it Worth study, the additional return is over £1. This demonstrates that even with the strong BCR for cancer research investment right now, this will only increase over time as a result of growing cancer prevalence. As these returns can only be achieved if cancer investment is sustained, the increasing returns of cancer suggests there is an increasing opportunity cost of not investing in cancer research in the future.

Table 6: BCRs for current and 2040 investment with and without cancer incidence growth

Scenario	Zero cancer growth	Expected cancer growth	Effect on BCR
Current investment	2.78	2.78	n/a
2040 investment: Investment-to-health multipliers	3.54	4.21	+0.67
2040 investment: What's it Worth study	4.51	5.60	+1.09

Source: Analysis by PA Consulting

The following sections provide further explanation on the projections for each set of multipliers.

5.1 Scenario: Future investment and investment-to-health multipliers

As discussed in section 3.3, this analysis estimates the health returns of cancer research investment by analysing the historical relationship between cancer survival and cancer research investment in the UK. The resulting multipliers provide an estimate on the QALY return per £1 invested in cancer R&D. These multipliers are applied to projections of future investment to estimate future gains to health. This implicitly assumes the health returns from cancer R&D will be the same in the future as it is in the past. Discussions with experts suggests this could be a reasonable assumption, as there is currently an unprecedented acceleration of cancer technologies which would suggest even greater health returns. These technologies are discussed in section 5.4.

Conducting this analysis for seven cancers in the UK yields the multipliers seen in below. These cancers were chosen based on highest incidence and data availability for analysis. The highest equivalent returns are seen for cancers that are less commonly the target for research and have seen significant increases in survival rates over recent decades, potentially from a low base value. Conversely, cancer types that have seen large improvements in survival rates previously have lower multipliers due to relatively low marginal improvements compared to investment.

Investment to health multipliers for key cancer types


Breast
0.92


Prostate
1.43


Lung
2.57


Colorectal
1.03


Melanoma
1.84

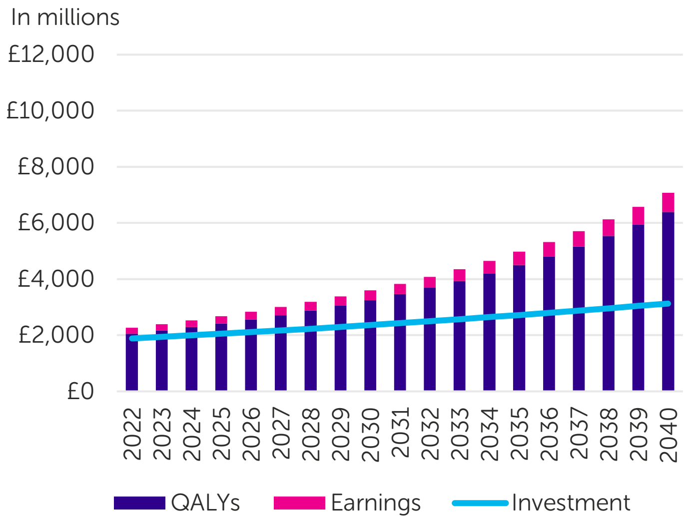

Kidney
8.08


Stomach
1.92

Source: Analysis by PA Consulting

Weighting these multipliers by their relative incidence gives an average multiplier of 1.89 which is then used to the project future health returns of investment. This weighted multiplier has the interpretation that for every £1 of cancer research investment, there is a return of £1.89 in health benefits to society.

Figure 14: Health impact of future cancer research investment: Investment-to-health multipliers



Source: Analysis by PA Consulting

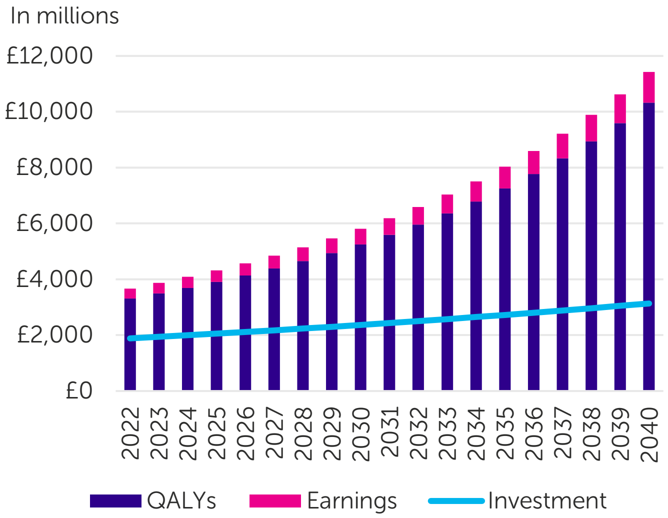
Combined with growing cancer incidence, the annual QALY benefits gained by 2040 have a monetary value of £6,393 million and a further £681 million of benefit is realised through additional earnings by those who would experience longer life expectancies. Looking at health-related benefits alone and excluding GVA, the size of the benefits in 2040 will be 2.3 times larger than the sum of investment.

Figure 14 shows the return to investment over time until 2040. The BCR for health-related benefits already exceeds 1.0 in the current period. As health outcomes improve, the earnings benefit grows in proportion.

5.2 Scenario: Future investment and What's it Worth study

As an alternative analysis to the health multipliers, the What's it Worth studies looked to quantify the return from specific medical innovations for key diseases including cancer. The analysis stated that 'each pound invested in cancer related research by the taxpayer and charities returns around 25 pence to the UK every year'[27]. This multiplier included both an economic spillover component and a health outcomes component – for a comparable analysis to be made, only the health component is used as an alternative method to evaluate future cancer investment. The return becomes 17.5 pence when accounting for these changes and the standardised QALY value. Discounting this over a 20 year horizon provides an effective multiplier of 3.05, which suggests the estimated health benefits of cancer research are substantially larger than in the case with investment-to-health multipliers. The QALY benefits realised in 2040 alone are estimated to reach £10,316 million and earnings gained will reach £1,099 million. Looking at health-related benefits alone and excluding GVA, the size of the benefits in 2040 will be 3.6 times larger than the sum of investment.

Figure 15: Health impact of future cancer research investment: What's it Worth study

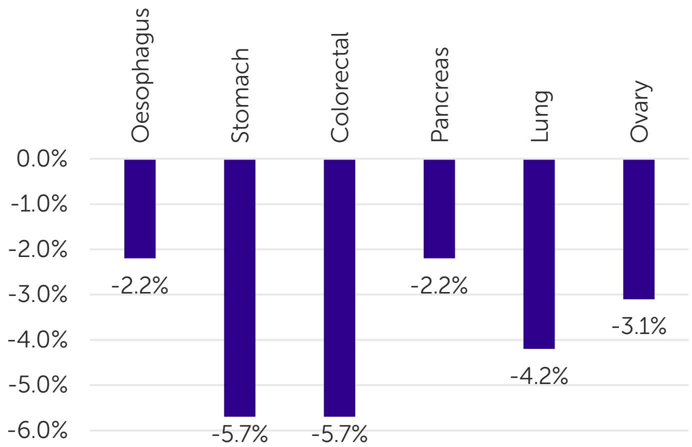


Source: Analysis by PA Consulting

5.3 Realising opportunities through implementation of care

The UK lags certain peer countries in terms of cancer health outcomes. When compared to similar countries in Northern Europe or Anglosphere countries, survival rates for key cancers are lower in the UK[28]. For example, analysis of seven countries: the UK, Ireland, Denmark, Norway, Australia, New Zealand and Canada, showed that the UK is the worst performer in both one year and five year survival rates for stomach, colorectal, and lung cancers. This is combined with an ageing population and results in mortality rates being greater in the UK than two thirds of all countries. This presents the UK with high potential gains to cancer health outcomes compared to other high income countries.

Figure 16: Difference in 5 year survival rates between the UK and the 7 country average



Source: Analysis by PA Consulting

If the UK was to catch up to the best performing countries immediately and the increase in survival rates were to affect the outcomes of all current patients diagnosed with cancer, **an estimated £204 billion of QALY benefits could be realised. This corresponds with an additional £22 billion in additional lifetime earnings. This combines to £226 billion of health-related benefits.** This provides an indicative picture of the potential benefits from improving in cancer care, derived through future cancer innovation, implementing existing technologies and improving general cancer care. Given that many countries are already able to achieve better cancer outcome using existing technologies, this would suggest that the returns from cancer innovations could be much higher if the UK was able to improve their implementation.

5.4 Forthcoming cancer technologies

The global oncology market is growing rapidly. This growth is partly driven by accelerating demand for cancer technologies to help address the growth of cancer cases globally. For example, within the UK, there is expected to be a circa 40% increase of cancer cases over 20 years[29]. This means that commercial investment in cancers will generate an increasing return on investment in the future, even if technologies continue to deliver the same value.

This, along with increasing commercialisation of cancer technologies which seek to deliver better outcomes for patients and the health system, means the global market for cancer profiling technologies is expected to grow from $45.2 billion in 2018 to $90.6 billion by 2023 with a compound annual growth rate (CAGR) of 14.9% [30]. Further, the market for oncology therapeutics is expected to achieve a 12 percent CAGR and reach a global value of $250 billion by 2024[31]. Figure 17 shows how growth rates may vary for different technologies which will reflect the readiness for commercialisation.

Figure 17: Compound annual growth rates for key cancer technology markets

8%	12%	19%
Cancer Vaccines (2021-26)	Oncological biomarkers (2020-27)	Genome sequencing (2018-25)

Early detection and screening technologies can unlock substantial value for health systems by reducing the risk of cancers detected at late stage, where treatment costs are more expensive and patient outcomes much worse. Given the growth in the number of cancers globally, it is unsurprising that the market for early detection and screening technologies are seeing unprecedented growth. For example, the global cancer diagnostics market size is expected to reach USD 249.6 billion by 2026, suggesting an annual growth rate of 7%. This is the result of continual introduction of innovative products[32].

It is common for technologies to be relevant for more than one research area. Advancements made in early detection can also have implications for therapeutic advances. Even if not directly linked, the detection and classification of tumours can be enablers and inform advanced therapy techniques. Below we provide some examples of cancer technologies relevant to early detection and diagnosis, and therapeutic advances to illustrate the benefits of continued cancer research in the future. Improved detection will catch cancer at earlier and less serious stages and more effective treatment will reduce cancer progression. These will reduce mortality and improve quality of life which provides the basis for why current investment would have quantifiable benefits in the future.

Logic models are used to demonstrate the causal relationship between variables and are useful when intermediate steps make the relationship more complex. For the technologies shown in Figure 18, logic models are used to link cancer advancements with quantifiable economic outcomes. The causality flows from an input, or technology, that has an associated clinical activity which improves operational processes. This improvement will have positive outcomes that are quantifiable and provide a rationale for the use of economic impact assessment in health.

5.4.1 Genome sequencing

A recent study in England demonstrated the potential benefits of genome sequencing to existing cancer patients. Tumour and blood samples from 36 children with cancer were sequenced and analysed to inform their treatment . This process revealed several potentially important variants [33].

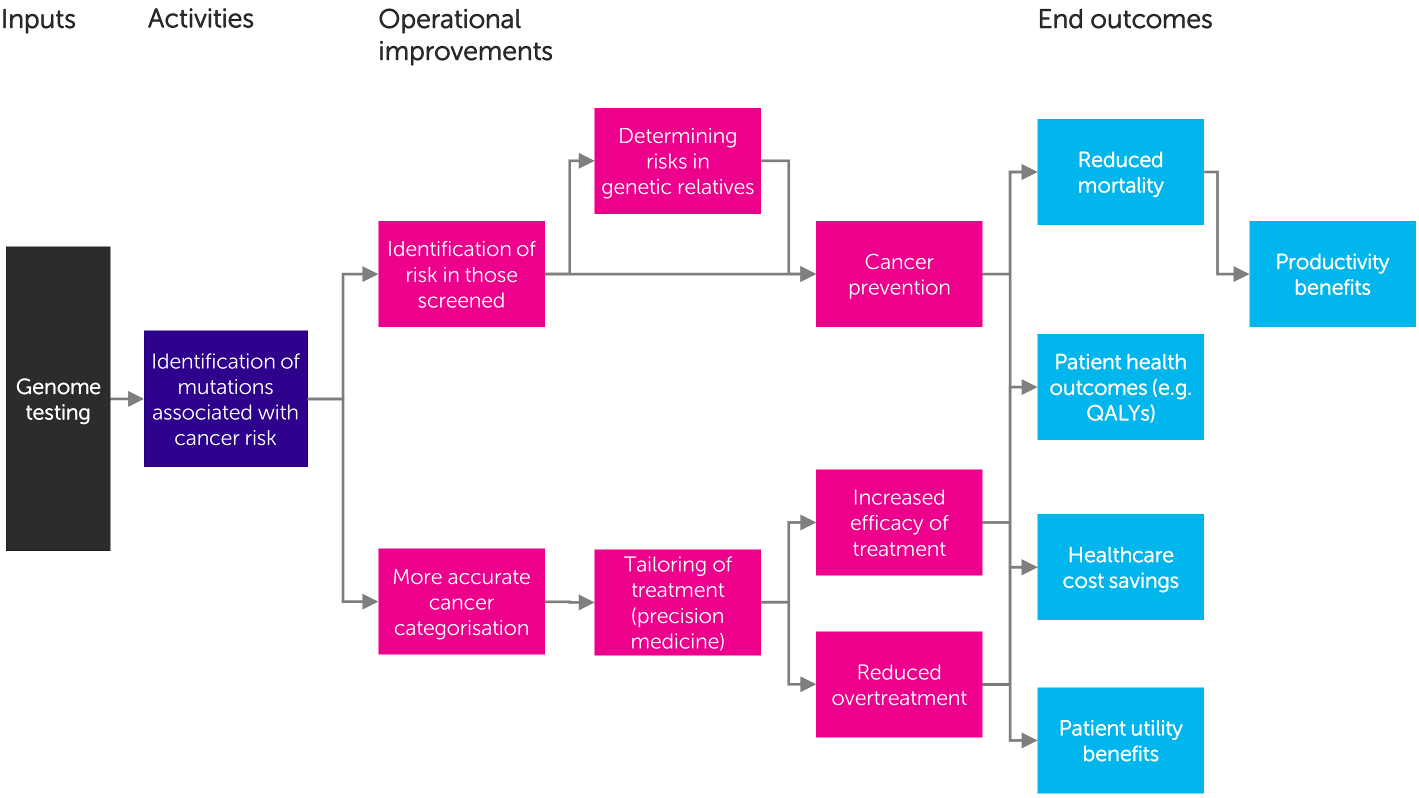
- In two cases, the information refined the children's' diagnosis, and in four cases, it changed their diagnosis.
- In eight cases, it revealed new information about children's prognoses (the likely course of their disease).
- In two cases, it showed possible hereditary causes of the cancers.
- In seven cases, it revealed treatments that might not have been considered but were likely to be effective for treating the children.

This demonstrates that genome sequencing of cancer patients could improve both the efficacy and efficiency of treatment, which in turn could generate financial and economic benefits to the wider health system.

Genome testing of cancerous cells can also enable identification of cancer heterogeneity and can help tailor treatment to the patient, leading to better health outcomes and reduced overall treatment. Lung cancer is the second most diagnosed cancer, but the leading cause of cancer deaths worldwide. Approximately 40-50% of lung cancers exhibit a targetable gene mutation such that appropriate targeted treatment can result in increased survival. Having a better understanding of these mutations can improve the cost-effectiveness of cancer treatment. Greater preventative measures and targeted treatment will reduce cancer prevalence and improve the prognosis of patients. This will produce QALY benefits through lower mortality and better quality of life, and increase lifetime earnings.

The high cost of genome sequencing has been a significant barrier to wide-spread adoption by healthcare systems. However, these costs are expected to continue declining as they have in recent years – from $10,000 in 2010 to under $1,000 today. The increasing viability of genome sequencing is expected to drive significant growth in the value of the market in the future, reaching $25.5bn in 2025 and registering a CAGR of 19.0% from 2018 to 2025. This suggests significant market share can be unlocked for organisations which are able reduce the cost of genome sequencing the fastest.

Figure 18: Genome sequencing logic model

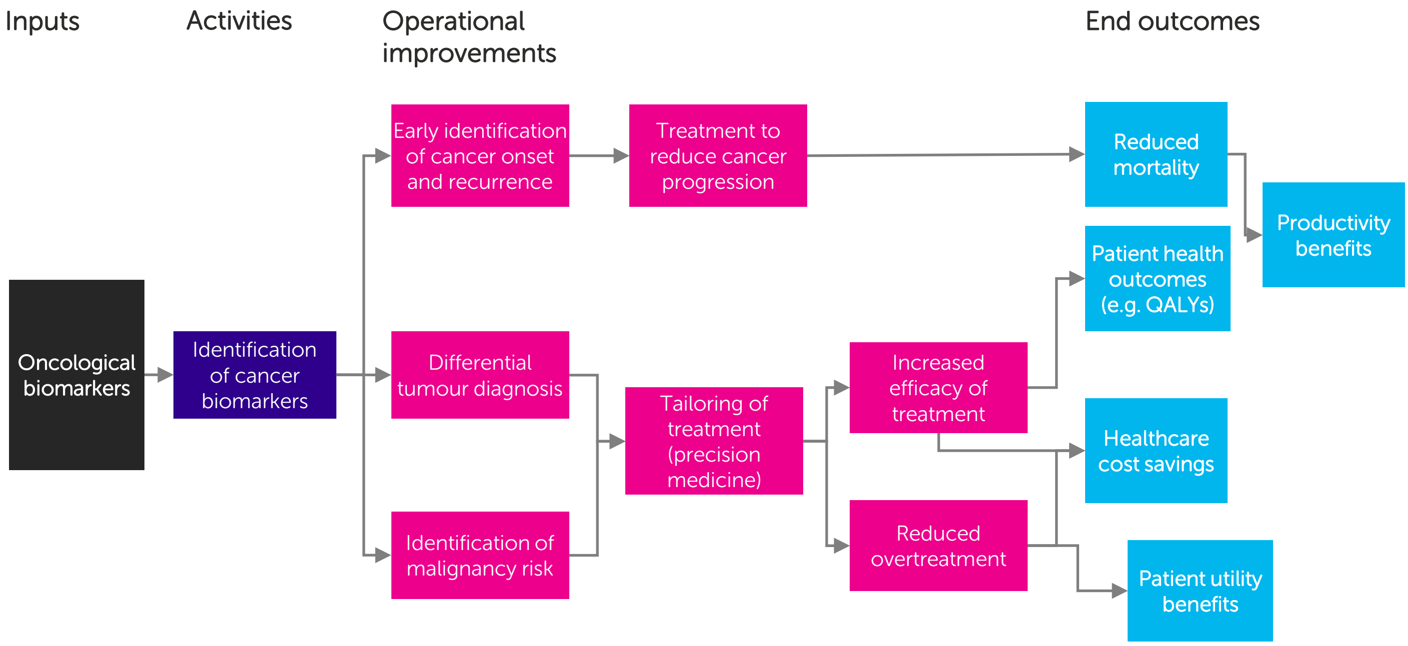


5.4.2 Oncological biomarkers sequencing

Cancer biomarkers are molecules that signal the presence of cancers that can be detected through novel detection methods such as through blood testing and breath. The detection of cancer biomarkers can lead to earlier diagnosis of cancers than conventional methods, which in turn can prompt earlier treatment before full cancer onset. Greater preventative measures and targeted treatment will reduce cancer prevalence and improve the prognosis of patients. This will produce QALY benefits through lower mortality and better quality of life, and increase lifetime earnings.

Biomarker tests can help tailor treatment according to detected cancer characteristics, therefore increasing both efficacy and efficiency of the selected treatment. Biomarker tests can also rapidly improve the success rate of clinical trials by helping to focus only on those cancers in patients which are likely to be more responsive to the treatment. The cancer biomarkers market was valued at $10.9bn in 2019 and is projected to reach $27.0bn by 2027, achieving a CAGR of 11.8% from 2020 to 2027.

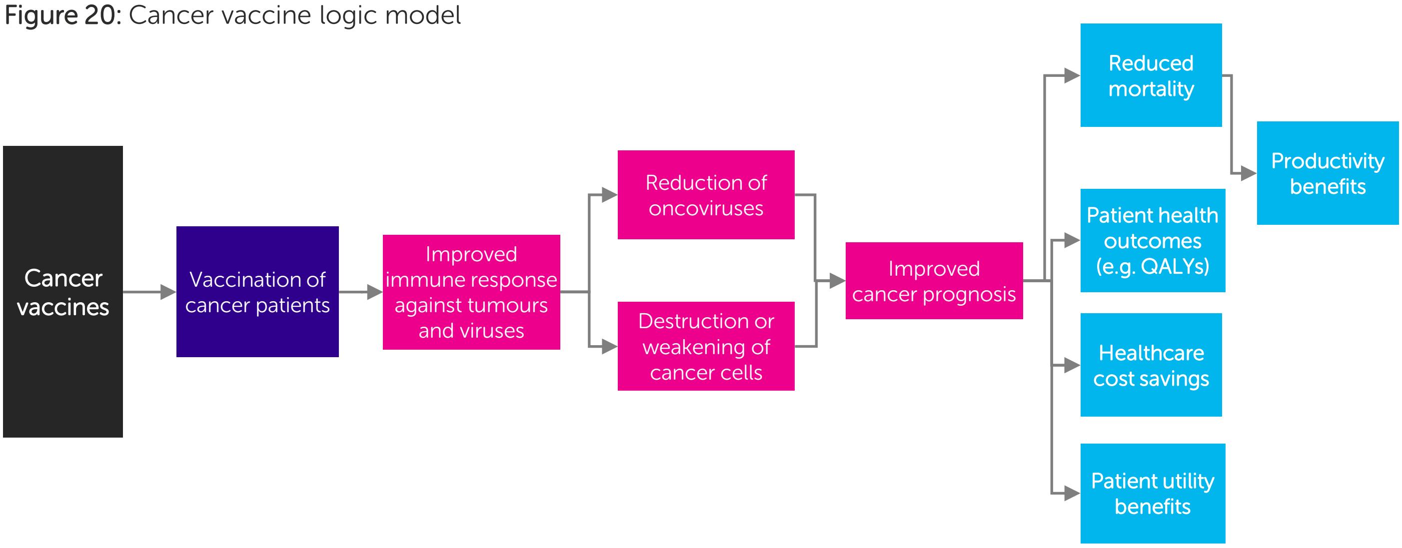
Figure 19: Oncological biomarker logic model



5.4.3 Cancer vaccines

Therapeutic cancer vaccines aim to reduce and eliminate tumours and prevent their recurrence by stimulating an immune response. Protein, DNA and, most recently with the aid of nanoparticle delivery, RNA vaccine delivery platforms have all been proven in the context of infectious diseases like COVID-19. Delivering impact for cancer patients will be facilitated by identifying ways to target cancer-cells specifically. This pathway and its benefits remain to be demonstrated but cancer vaccines as an area of research is attracting significant interest. The cancer vaccine market is expected to experience an 8% compound annual growth rates from 2021 to 2026.

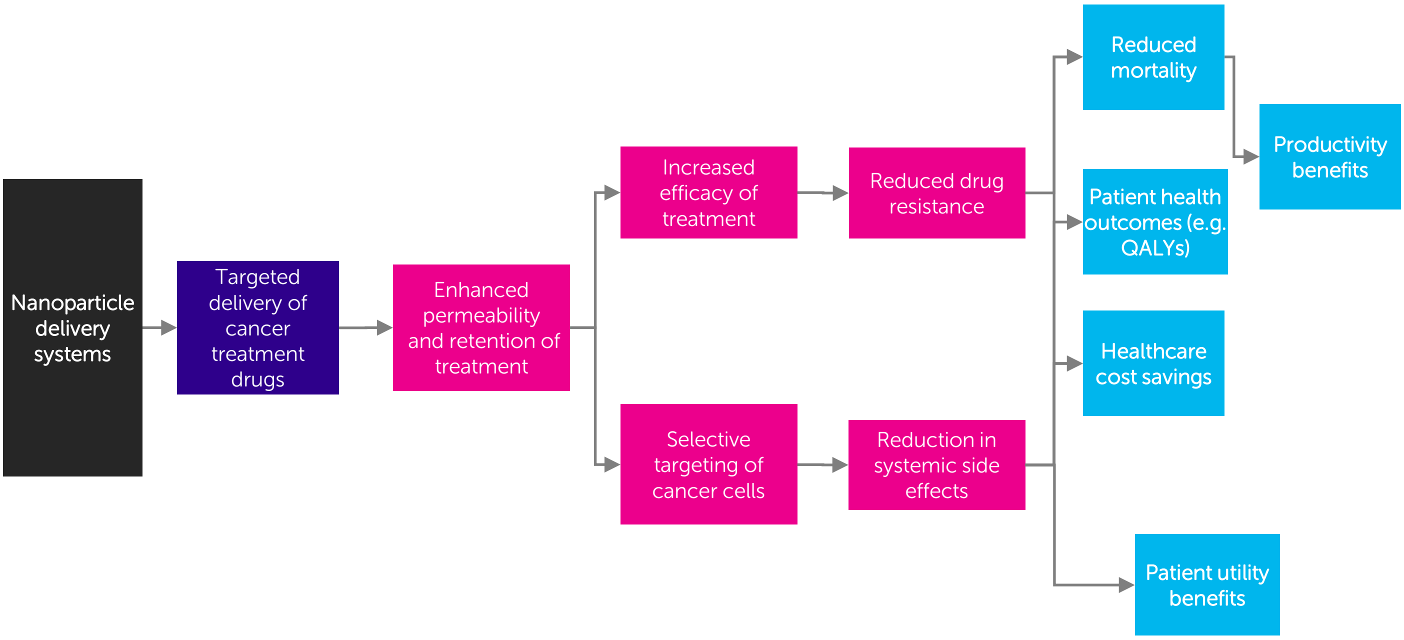
Figure 20: Cancer vaccine logic model



5.4.4 Nanoparticle delivery systems

Nanoparticles can be used to aid the delivery of drugs to cancerous cells. Nanoparticle-based delivery hypothetically offers the potential for greater stability and/or more precise targeting of non-conventional drugs to where they are most effective. This expands the number of potential treatment approaches – for example, making RNA-based therapies feasible – and can serve to limit toxic side-effects of treatment, for example by reducing drug exposure to non-cancerous tissue. It is hoped that nanoparticle delivery systems could increase the efficiency and efficacy of both new and existing cancer drugs, which could generate savings to the healthcare system and lead to better patient outcomes. More effective cancer treatment when combined with nanoparticle delivery systems will have QALY benefits.

Figure 21: Nanoparticle delivery system logic model



5.4.5 Big data, AI and machine learning technologies

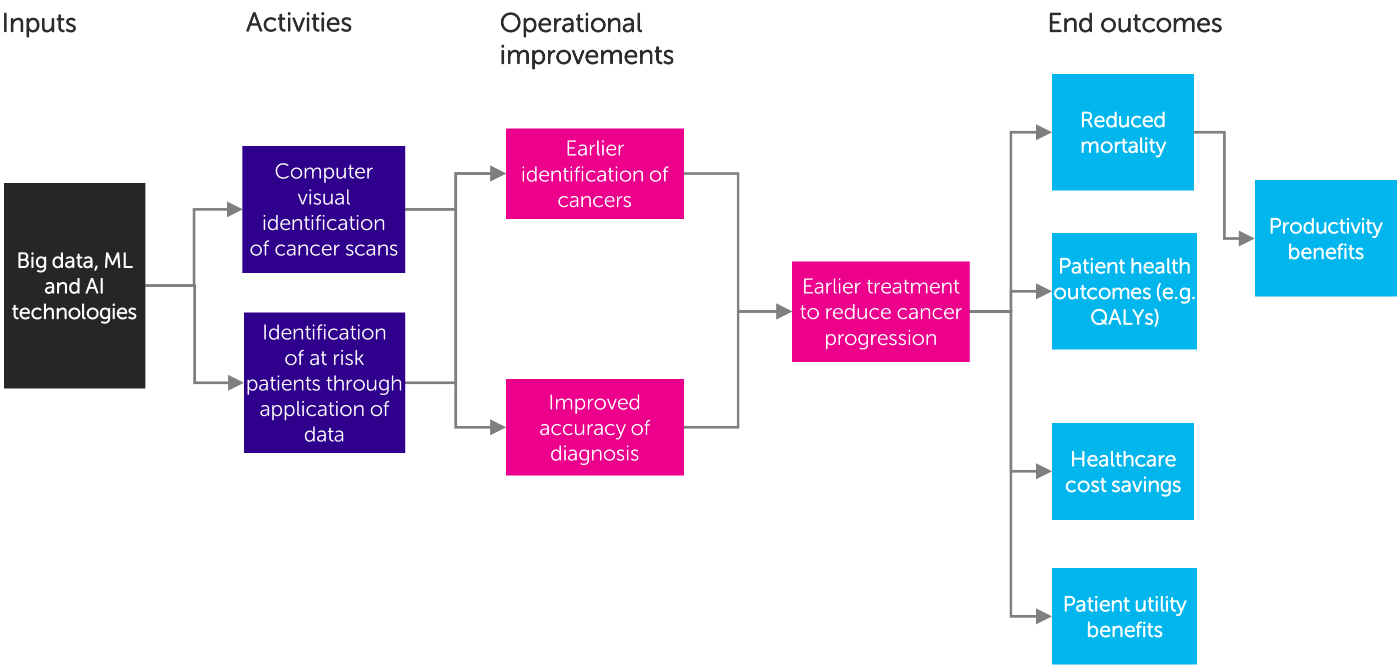
Big data, machine learning and AI approaches can be used to recognise cancer cells in images more accurately and reliably than human visual analysis. As a result, cancers can be detected earlier and therefore treated earlier. Big data can also be used to stratify patients based on cancer risk and potentially identify cancer patients from patient records, which in turn can realise patient benefits and wider economic outcomes.

Although AI has demonstrated comparable performance to that of an expert in common application fields across a range of biomedicine, there are several challenges that are inhibiting the full benefits of AI in cancer innovation to be realised. Firstly, AI requires substantial amounts of high quality data which currently do not exist and are time consuming to collect. Data sharing agreements can play an important role in addressing the challenge above. Similarly, although the amount of available being collected is greater than ever, the collection, structure and assessment of data is non standardised.

Despite AI regularly achieving high performance in medical research, the adoption of AI in real cases is limited due to the lack of transparency in understanding why the AI machine reaches the conclusions it does (the black box problem). This, along with lack of collaboration between clinicians and data scientists makes it harder to achieve buy-in for a technology that can have substantial impact on course of treatment[34].

The application of big data, AI and machine learning has a long way to go before it can be widely used in cancer medicine, however the economic returns are potentially large if it results in substantial improvements in early detection and stratification of cancers.

Figure 22: Big data, machine learning and AI logic model



End notes

[25]Investment is in 2021 prices to enable ease of comparability and to be consistent with HM Treasury Green Book guidance.

[26]It is assumed that the state of the world in 2040 is otherwise the same as it is in 2021. No attempt has been made to project labour market outcomes, inflation, or the future state of cancer.

[27]Wellcome Trust. Medical Research: What's it worth? A briefing on the economic benefits of musculoskeletal disease research in the UK. Accessed at: https://acmedsci.ac.uk/file-download/54792223

[28]Arnold, M., et al. (2019). Progress in cancer survival, mortality, and incidence in seven high-income countries 1995–2014 (ICBP SURVMARK-2): a population-based study. The Lancet Oncology, 20(11), 1493-1505.

[29]CRUK. (2021). All Cancers, Observed and Projected Age-Standardised Incidence Rates, by Sex, UK, 1979-2035

[30]https://www.bccresearch.com/market-research/biotechnology/cancer-profiling-and-pathways.html

[31]https://www.mckinsey.com/industries/life-sciences/our-insights/delivering-innovation-2020-oncology-market-outlook

[32]https://www.grandviewresearch.com/press-release/global-cancer-diagnostics-market

[33]"Clinical utility of whole genome sequencing for children with cancer" by Patrick Tarpey et al, part of the treatment theme, available on Monday 8 November 2021

[36]Dan Shao, Yinfei Dai, Nianfeng Li, Xuqing Cao, Wei Zhao, Li Cheng, Zhuqing Rong, Lan Huang, Yan Wang, Jing Zhao, Artificial intelligence in clinical research of cancers, Briefings in Bioinformatics, Volume 23, Issue 1, January 2022, bbab523, https://doi.org/10.1093/bib/bbab523

6. Conclusion

6. Conclusion

This report has illustrated the core economic impact of investing in cancer research.

Improving cancer survival and quality of life is underpinned by cancer research but this report demonstrates how cancer research investment also supports high paying jobs across the UK and plays an important role in the wider R&D industry. Cancer technologies are accelerating in their development, presenting commercial opportunities for the UK life science sector. These new technologies will be crucial in the fight to improve cancer outcomes. Although part of the solution is also about improving care using existing technologies, the Covid-19 pandemic highlights the importance of continuous innovation to ensure patients with cancer are treated faster, closer to home. Beyond treatment and care, as research improves our understanding of cancer, more progress can be made in cancer prevention.

As the burden of cancer on health increases into the future, ensuring that improvements to cancer detection and treatment continue is paramount to a healthy population. The UK as a research centre is key to the development of technologies that have the potential to increase survival rates and improve quality of life for those with cancer.

CRUK is in a unique position to make the health and economics case to stakeholders in an effort to secure future cancer research funding. Saving and improving lives is the objective of cancer research, but this report shows that there are significant economic benefits that should be recognised.

£1,832m
Cancer research spending in the UK in 2020/21

47,000
jobs supported

£5,090m
added to the economy

£1,364m
A single year of investment translates into health benefits worth through longer life expectancies and avoided deaths

25%
premium on wages. Activity in cancer research is distributed across the UK and provides high skill employment to local economies.

£3,131m
of investment by 2040 would support:

80,000
jobs and add

£13,196m
to the economy.

6.1 Areas for further research

There are several areas of potential refinement to the analysis in this study should better data and evidence become available. Opportunities for further analysis is presented in the remainder of this section.

Private sector investment

The exact investment from the private sector will also benefit the analysis. Since this data is not readily available, a simple market share of the private sector was taken from Sussex et al (2016)[37] which relates to the medical research sector in general. If cancer R&D investment from pharmaceutical companies were known and included in the model, then the true size of the entire sector can be estimated. A time series of private sector investment would also help inform the growth of how total cancer investment may grow in the future, thus refining the 2040 projections.

FTE and GVA multipliers

The core of the economic impact assessment relies on appropriate use of multipliers to estimate indirect and induced economic impacts. These multipliers can be refined by looking at sectors at a more granular level. The current multipliers treat R&D as a homogenous group despite the varying characteristics of different research areas. If multipliers were available for the biotechnology research sector (SIC code 72110) this would produce a more accurate estimate of indirect and induced effects for cancer research specifically. Currently, such evidence does not exist.

Supply chain analysis

The sector breakdown of impact is based on input-output analysis of the R&D sector as a whole and does not distinguish between medical and non-medical research. This approach was taken because of a lack of granular data on the inputs and outputs of cancer research institutions. To provide a more representative picture of the supply chain, financial and expenditure data at the supplier level of cancer research institutions would give a more granular breakdown of sectors that are affected by investment in cancer research. If available, qualitative information could inform the analysis of how the economic impacts are distributed across the different sectors of the economy for cancer research specifically.

Employment and salary

A more granular breakdown of employment and salaries in cancer research would also improve the results of the economic impact assessment. The analysis currently assumes that jobs fall either into research or administrative activities while in reality, there are likely other categories of jobs that should be represented that are excluded or inappropriately classified as simply research or administration. This approach was taken due to a lack of readily available data on salaries and roles across cancer research organisations. Obtaining such data would give a more accurate representation of the FTE impact of cancer research expenditure.

CRUK spinouts

A further refinement can be made by including all CRUK spinouts in the analysis. Only publicly available data on R&D was used which excludes many of the smaller spinout companies. In addition, if these companies have operations outside of the UK, then detailed information on the location of R&D activities would be useful. This can give a more accurate representation of the externalities generated by CRUK funding.

Alternative economic benefits

Productivity spillovers are not addressed in this analysis. This is due to a lack of data and robust research on the quantification of spillovers in a relevant sector. Private sector expenditure is also included in this analysis and as such the typical spillover of public sector investment crowding in private sector investment would not apply in a static model. If data on the crowding in effect was available, then projections of private sector investment may increase as the stock of public sector investment rises. This would also be considered an externality that may be attributed to public sector sources such as CRUK and government funding.

[37]Sussex, J. et al. (2016). Quantifying the economic impact of government and charity funding of medical research on private research and development funding in the United Kingdom.

7. Annex

7.1 Collated results with scenario analysis

The table below provides ranges to the results described in the main body of this report, based on pessimistic and optimistic scenarios for those assumptions which are subject to degrees of sensitivity.

The base case represents the core results presented in the main report.

Metric	Low	Base case	High
Current economic impact 2021			
Total investment	£1,831m	£1,831m	£1,831m
GVA – direct	£1,767m	£1,767m	£1,767m
GVA – indirect	£1,242m	£1,242m	£1,242m
GVA – induced	£0m	£572m	£572m
QALY benefits	£1,091m	£1,364m	£2,728m
Additional earnings	£116m	£145m	£290m
CRUK share of benefits	£805m	£973m	£1,261m
Total benefits	£4,216m	£5,090m	£6,599m
Benefit cost ratio	2.3	2.8	3.6
Future economic impact 2040			
Total investment	£1,831m	£3,131m	£3,131m
GVA – direct	£1,767m	£3,020m	£3,323m
GVA – indirect	£1,242m	£2,123m	£2,336m
GVA – induced	£0m	£977m	£1,075m
QALY benefits	£1,943m	£6,393m	£12,786m
Additional earnings	£207m	£681m	£1,363m
CRUK share of benefits	£986m	£2,521m	£3,991m
Total benefits	£5,159m	£13,196m	£20,882m
Benefit cost ratio	2.8	4.2	6.7

Source: Analysis by PA Consulting

Low scenario is defined on the basis of pessimistic outcomes of key assumptions subject to degrees of uncertainty:

- Induced multiplier effects are removed from the analysis, making the GVA benefits null.
- 20% additionality adjustment is applied to the investment to health multipliers, to account for some uncertainty in impact
- Annual cancer research investment by both public and private sector remains static in real terms until 2040

High scenario is defined on the basis of optimistic outcomes of key assumptions subject to degrees of uncertainty:

- Productivity (GVA per hour) grows by 10% in real terms by 2040
- Technology diffusion takes 5 years rather than 2.5 years
- Current GVA and FTE - there is no basis for an optimistic value so remains unchanged.

7.1.1 Indirect and induced GVA

The calculation of indirect and induced GVA is typically done using multipliers. An alternative methodology is to take estimates for indirect and induced FTE and apply a relevant measure of labour productivity which converts labour input into economic output. The table below shows the GVA estimates for 2019/20 expenditure if an economy-wide labour productivity was used in conjunction with the cancer research FTE jobs.

GVA	Multiplier approach (base case)	Productivity approach
Direct	£1,767m	£1,767m
Indirect	£1,242m	£1,588m
Induced	£571m	£507m
Total	£3,581m	£3,863m

Source: Analysis by PA Consulting

7.2 Comparison with benefit cost ratios benchmarks

The below table provides benchmarks of published benefit cost ratios for R&D, innovation and investment schemes, which can be useful for understanding how the BCR of 2.8 found in this analysis compares. In summary, the BCR found in this analysis is comparable and towards the upper range of publicly available estimates of other science, research and investment schemes. The higher nature of the BCR in this analysis is reasonable given cancer research investment is unique in producing significant economic benefits as well as saving lives, which in itself drives significant societal benefits.

Analysis	BCR	Source
This analysis	2.8	
R&D Expenditure Credit scheme evaluation	2.4-2.7	HMRC (2020) Evaluation of the Research and Development Expenditure Credit (RDEC)
Social rates of return to R&D	Median 1.85 over 9 estimates	BIS (2014) Rates of return to investment in science and innovation
Review of returns to science, R&D and innovation	Average 1.6 over 102 evaluations Top 5%: 2.9	BIS (2009) Research to improve the assessment of additionality
Aerospace Technology Institute projects (aerospace technologies grant funding)	Median: 2.3 Range: 0.3-5.9	BEIS (2017) EVALUATION OF ATI AEROSPACE R&D PROGRAMME
Advanced Propulsion Centre (automotive technologies grant funding)	R&D multiplier: 1.2 GVA multiplier: 1.7	BEIS (2021) ADVANCED PROPULSION CENTRE, Interim Impact Evaluation
HS2 Phase 1	1.2	DfT (2020) Full Business Case High Speed 2 Phase One

Source: Analysis by PA Consulting

7.3 Comparison of approach with other EIAs

A comparison has been made between the analysis in this study and an EIA produced for the University of Oxford[38]. While comparable in most respects, differences in the headline numbers have been raised – with Oxford University generating over twice the level of benefits per pound invested than cancer research investment. This chapter summarises how and why the methodologies between the two EIAs differ to explain differences in economic impact.

	Investment / expenditure	Total benefits	Benefit cost ratio (BCR)
Impact of cancer research investment (this study)	£1.8bn	£5.0bn	2.8
Impact of Oxford University	£2.6bn	£15.7bn	6.1
Impact of Nottingham University	£0.5bn	£1.1bn	2.2

Source: Analysis by PA Consulting

7.3.1 Summary of findings

The general methodology is similar between the analyses for CRUK and other comparable EIAs. The approach is based on an annual expenditure figure that is used to find employment figures (FTE) and output (GVA). Multipliers are then applied to estimate indirect and induced benefits to produce an aggregate economic impact. This is in line with EIAs conducted by other companies and public sector bodies.

The notable differences between our analysis and other assessments stem from:

i. Differences in the magnitude of investment

The economic impact of a sector or organisation is directly proportional to the size of that sector or organisation, for example in terms of revenue, expenditure or investment.

Differences in the size of the investment will therefore affect the size of the benefits. Note that the magnitude of the investment will not affect the benefit cost ratio.

Differences in factors explaining differences in the BCRs are explained in the following sections.

ii. GVA multipliers

The use of GVA multipliers is the cornerstone of economic impact assessments since they allow for estimates of indirect and induced impacts to be made. Their application is critical to the overall economic impact of a given sector and will influence the size of the benefit cost ratio.

The table below compares the ratio of investment to aggregate GVA benefits, when focussed solely on direct, indirect and induced impacts, excluding other potential economic impacts (spillovers, exports, spin-outs, etc.). As shown in the last column, the BCRs are broadly similar which suggests that the methodologies are in line with each other.

Subject	Expenditure in year	Aggregate GVA	BCR (GVA only)
Cancer research sector	£1.8bn	£3.6bn	2.0
Oxford University[39]	£2.7bn	£3.4bn	1.2
York University[40]	£302m	£556m	1.8
Pharmaceutical industry in Europe[41]	£99bn	£206bn	2.1

Source: Analysis by PA Consulting

Given the similarities in the GVA multipliers, any substantial differences in the BCR must be explained the addition of other impacts analysed beyond the GVA multipliers and magnitude of investment.

iii. Impact of spinouts

The inclusion of spinouts will substantially increase the BCR because the economic impact of spinouts will be attributed to the studied organisation However the 'investment' or expenditure of these spinouts cannot be attributed to CRUK given that spinouts will be funded through other means (e.g. the private sector). As a result, analysis on spinouts is reported separately and should not be considered in addition to the presented benefits.

iv. Productivity spill-overs

Differences in the application of productivity spillovers from research investment explains most of the difference in the BCRs between our analysis and a small number of other impact assessments. These spillover benefits rely on a study looking at the effects of UK Research Council spending (Haskel, 2010)[42].

It is believed that this approach is not credible because of:

1. Improper application of assumption

The Haskel (2010) study finds a spillover multiplier of 12.7 for UK Research Council investment only and cannot be reasonably assumed to extend to all other areas of funding as done in some other economic impact assessments.

2. Precedent

There is generally a lack of precedent of using spillovers in this way in other published economic impact assessments, particularly by other organisations. Analyses that does feature this methodology do not do so consistently.

3. Evidence base

As discussed in a UK government research study BIS (2014)[43] , productivity spillovers are notoriously difficult to quantify. Given the lack of evidence on this area, it is recommended productivity spillovers are not quantified.

Given the above, attempting to quantify productivity spillovers would be counterproductive to achieving a credible economic impact assessment that would withstand scrutiny. It therefore has been excluded from this analysis.

7.4 Assumptions and detailed methodology

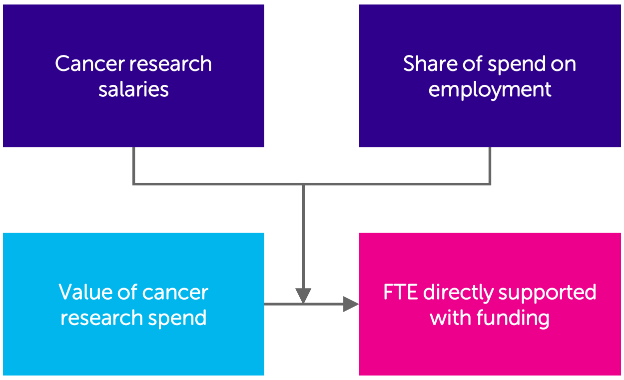
EIA assumptions

Metric	Value	Source
Public and charitable cancer research investment	£700m	NCRI database
Private sector share of cancer research industry	62%	Sussex, J. et al. (2016). Quantifying the economic impact of government and charity funding of medical research on private research and development funding in the United Kingdom.
CRUK share of cancer research industry	50% of public and charitable sector	CRUK Market Insights and NCRI data
Full time salaries	Researcher - £51k Admin - £43k	ONS Annual Survey of Hours and Earnings
Employment shares	Researcher – 79% Admin – 21%	Hutton, G. (2021). Research & Development Spending. ICR Annual Report and Francis Crick Annual Report
Salary expenditure proportion	44%	ICR Annual Report and Francis Crick Annual Report
Working hours per year	1,710	National Public Holidays
GVA per FTE	Researcher - £118k Admin - £47k	ONS labour productivity by industry division
FTE multipliers	Type I – 1.49 to 2.58 Type II – 1.66 to 3.09	ONS FTE multipliers and effects Scottish government input-output analytical tables
GVA multipliers	Type I – 1.70 Type II – 2.03	ONS input-output analytical tables Scottish government input-output analytical tables
Sector distribution of indirect effects	Various	ONS input-output analytical tables
Inflation forecast	4.0% in 2021 declining to 2.0% in 2025	OBR Economic and Fiscal Outlook

Source: Analysis by PA Consulting

7.4.1 Direct economic benefits

The calculation of direct FTE from the initial cancer investment sum is as follows:



1. Categorise cancer research employees as being in either research or administrative roles.
2. Find average salaries for research roles and administrative roles.
3. Estimate how headcount is divided between research and administrative roles.
4. Find the proportion of cancer research expenditure that is used for wages and apply it to the initial investment sum to obtain the value of investment that goes to employment.
5. Estimate FTE in research by dividing the employment investment by the summed product of salaries and headcount share by role.

$$\text{Direct FTE} = \frac{\text{Cancer investment spend on employment}}{\sum(salary_{role} \times \text{share of headcount}_{role})}$$

Role specific FTEs are found by simply multiplying the total FTE with the headcount shares established in step two.

Direct GVA is derived from the direct FTE that was just calculated.

1. Find productivity estimates for the different roles.
2. Convert productivity estimates from GVA per hour to GVA per FTE.
3. Multiply the role FTE by the respective productivity.

$$\text{GVA} = \sum FTE_{role} \times productivity_{role}$$

7.4.2 Indirect and induced economic benefits

Calculating indirect and induced economic benefits relies on the use of economic multipliers. UK Type I multipliers are available from the ONS and describe how expenditure affects the supply chain across the UK. The ONS does not publish UK Type II multipliers while Scotland Type II multipliers are available from the Scottish government. The Scottish Type II multipliers are used to scale up the UK Type I multipliers.

Indirect and induced FTE are calculated as follows.

$$\text{Indirect FTE} = (\text{Direct FTE} \times \text{Type I multiplier}) - \text{Direct FTE}$$

$$\text{Induced FTE} = (\text{Direct FTE} \times \text{Type II multiplier}) - \text{Direct FTE} - \text{Indirect FTE}$$

Similarly, indirect and induced GVA is calculated using the same method.

$$\text{Indirect GVA} = (\text{Direct GVA} \times \text{Type I multiplier}) - \text{Direct GVA}$$

$$\text{Induced GVA} = (\text{Direct GVA} \times \text{Type II multiplier}) - \text{GVA} - \text{Indirect GVA}$$

An alternative way to calculate indirect and induced GVA is to replicate the process for finding direct GVA and to derive them from FTE estimates. An estimate of economy-wide productivity converts employment into output.

$$\text{Indirect GVA} = \text{Indirect FTE} \times \text{economy productivity}$$

$$\text{Induced GVA} = \text{Induced FTE} \times \text{economy productivity}$$

Health outcomes assumptions

Metric	Value	Source
Cancer health state utility values	Breast – 0.74	Peasgood, T., Ward, S. and Brazier, J. (2010). A review and meta analysis of health state utility values in breast cancer.
	Prostate – 0.89	Lane, A. et al. (2016). Patient-reported outcomes in the ProtecT randomized trial of clinically localized prostate cancer treatments: study design, and baseline urinary, bowel and sexual function and quality of life.
	Lung – 0.67	Paracha, N. et al. (2018). Systematic review of health state utility values in metastatic non-small cell lung cancer with a focus on previously treated patients.
	Colorectal – 0.87	Hompes, S. et al. (2015). Evaluation of quality of life and function at 1 year after transanal endoscopic microsurgery.
	Melanoma – 0.79	Hatswell, A. et al. (2014). Patient-reported utilities in advanced or metastatic melanoma, including analysis of utilities by time to death.
	Kidney – 0.74	Klinghoffe, Z. et al. (2013) Cost-utility analysis of radical nephrectomy versus partial nephrectomy in the management of small renal masses: adjusting for the burden of ensuing chronic kidney disease.
	Stomach – 0.64	Carter, G. et al. (2015). Health state utility values associated with advanced gastric, oesophageal, or gastro-oesophageal junction adenocarcinoma: a systematic review.
Monetised QALY value	£60,000	HM Treasury Green Book
Health discount rate	1.5%	HM Treasury Green Book
UK research attribution rate	17%	Glover, M. et al. (2014). Estimating the returns to UK publicly funded cancer-related research in terms of the net value of improved health outcomes.
What's it Worth return on cancer investment	17.5%	Glover, M. et al. (2014). Estimating the returns to UK publicly funded cancer-related research in terms of the net value of improved health outcomes.
What's it Worth time horizon	20 years	
Time of technological diffusion between countries	2.5 years	Gotkis, P. and Vezzani, A. (2016). Technological diffusion as a recombinant process: Evidence from patent data.

Source: Analysis by PA Consulting

7.4.3 QALYs – investment-to-health multipliers

A change in survival rates can be quantified in terms of QALYs which in turn can be monetised for the purposes of a cost benefit analysis. For a specific cancer type:

1. Identify the increase in survival rate over a specified period of time.
2. Multiply by the number of cases that would be affected by UK research to find the number of deaths that have been avoided as a result of UK cancer research.
3. Multiply the number of deaths avoided by the average years of life lost for the specified cancer to obtain the number of life years gained.
4. Using health state utility values, life years can be converted into QALYs and when further multiplied by the social value of a QALY gives the total benefit of improved health outcomes.

This exercise is completed for the historical analysis with observed changes in survival rates between 2004 and 2018. The resulting QALY benefit is compared to the cumulative cancer research investment over the same time period to obtain a multiplier between investment and QALYs. This investment-to-health multiplier is applied to investments over other time periods, either single-year or over multiple years, to estimate QALY benefits.

Multipliers are derived for seven cancer types: breast, prostate, lung, colorectal, melanoma, kidney and stomach. These are then weighted according to the type's relative prevalence to give a representative weighted average multiplier that is applied to the investment for all cancer research.

7.4.4 QALYs – What's it Worth

The series of What's it Worth studies found annualised returns to health research investment. Return values of 16.1% and 18.9% were found for QALY values equal to £50,000 and £70,000 respectively so taking the arithmetic mean of the returns gives an estimate for 17.5% return for a QALY of £60,000. In this analysis, the annualised return is capped at 20 years and discounted at 1.5% per year as per Green Book guidance giving a multiplier, with a similar interpretation to the investment-to-health multiplier, of 3.05. Calculation of QALYs then follow the same process as described in 7.4.3.

7.4.5 Earnings benefits

Deriving QALYs requires an estimate of the number of life years gained. The increase in lifetime earnings can be calculated by multiplying the gain in life years with a representative annual salary. This representative salary is estimated by constructing a weighted average of yearly earnings gained by cancer type. Cancers with greater incidence at lower ages have greater cumulative lifetime earnings and therefore higher average yearly earnings.

7.4.6 Sectoral breakdown and the Leontief matrix

Apportioning indirect impacts is done using the Leontief matrix (alternatively called the Leontief Inverse) which describes the indirect relationships between sectors of the economy. If final demand for a sector's output increases, then intermediate demand for the sector's inputs will also increase which is a secondary effect. This in turn increases the intermediate demand of inputs to produce goods that are used to supply the original sector which is a third order effect. This continues as an infinite geometric sum and is expressed in the coefficients in the Leontief matrix Determining the relative size of the R&D expenditure impact on sectors on involves dividing the total final demand impact by the impacts on specific sectors, having incorporated the intermediate effects.

Together we will beat cancer