The likely impact of earlier diagnosis of cancer on costs and benefits to the NHS

Summary of an Economic Modelling Project
carried out by *Frontier Economics*
on behalf of the Department of Health
the National Awareness and Early Diagnosis Initiative (NAEDI)
January 2011

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Prepared by DH Cancer policy team

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Executive Summary

The Cancer Reform Strategy (CRS), published in December 2007, highlighted that cancer survival in England compares poorly with that of comparable countries. One reason for this is that symptomatic patients in England are believed to present to the health service when their disease is more advanced, which has an impact on the potential for successful treatment, on patient outcomes, and on resources.

The specific questions addressed by this piece of work are:

- How would the costs to the NHS change if certain cancers (see below) were detected and diagnosed appreciably earlier than is currently the norm (i.e. according to current survival curves)?
- How would the benefits to individuals change if certain cancers (see below) were detected and diagnosed appreciably earlier than is currently the norm?

The work has focussed on five cancers: breast, colo-rectal, lung, prostate and skin (melanoma). The modelling seeks to examine the impact that earlier detection and diagnosis would have on survival curves and on downstream costs and benefits. For example, what would be the impact on treatments costs and overall costs if more patients are diagnosed at stages I and II rather than III and IV. Does earlier diagnosis simply shift costs to earlier stages or does it avoid particular costs entirely?

The key feature of these models is that all inputs and activity are modelled by stage of diagnosis.

Consequently, the key assumptions or drivers in the models include the following:

- Current costs of life-time treatment by stage of diagnosis
- Costs of diagnosis (costs of tests, and assumptions about diagnostic pathways)
- Current survival rates by stage
- Distribution of incidence by stage in base-line
- Future distribution of incidence by stage (assumptions vary)
- Annual discount rate of 3.5% applied to future costs and benefits to calculate present values.

For these cancers generally, the modelling found that earlier diagnosis is generally cost-effective, but not cost-saving. If people are diagnosed earlier, either through screening programmes or through their general practice, the main benefit is a substantial improvement in health outcomes. There is not a cost reduction, rather an increase in NHS costs (large increase in testing costs generally offset by a modest reduction in treatment costs). The modelling does not include the costs of the NAEDI interventions themselves, but these are expected to be very modest compared to testing and treatment costs.

<u>Colorectal Cancer</u>

Based on optimistic assumptions, it would be possible to achieve the 1-year EUROCARE-4 good practice survival rate of 79%. Initially the additional costs of diagnosis would be around £272m, which reduces over time, and offset by a modest saving in treatment costs of £14m.

However, the model suggests a population benefit of 41,000 life-years gained, and an average cost per life saved of £6,241. This suggests that earlier diagnosis would be very cost-effective.

Breast Cancer

Based on very optimistic assumptions, an improvement could be achieved in the 1-year survival rate from the current 93.8% to 95.2%. It does not appear to be possible to achieve the best European rates, based simply on earlier diagnosis and assuming current survival rates by stage. In other words, achieving best European rates appears to require **an improvement in breast cancer survival rates by stage**. Initially the additional costs of diagnosis would be around £85m, which reduces over time, and offset by a modest saving in treatment costs of £9m. However, the model suggests a population benefit of 319,000 life-years gained, and an average cost per life saved of £2,329. This suggests that earlier diagnosis would be very cost-effective.

Lung Cancer

Based on very optimistic assumptions, an improvement could be achieved in the 1-year survival rate from the current 28% to 33.3%. It does not appear to be possible to achieve the best European rates of 37%, based simply on earlier diagnosis and assuming current survival rates by stage. In other words, achieving best European rates appears to require **an improvement in lung cancer survival rates by stage**. Initially the additional costs of diagnosis would be around £95m, which reduces over time, and additional treatment costs of £9m. This result is a consequence of the shape of the cost curve by stage for lung cancer, which assumes that treatment costs are higher if patients are diagnosed earlier. However, the model suggests a population benefit of 42,000 life-years gained, and an average cost per life saved of £2,376, again very cost-effective.

Prostate Cancer

Based on optimistic assumptions and the more conservative model of patients that present symptomatically, it would be possible to achieve the 1-year EUROCARE-4 good practice survival rate of 96%. Initially the additional costs of diagnosis would be around £101m, and a substantial increase in treatment costs of £376m, due to the large increase in patients diagnosed annually. The model suggests a population benefit of 62,000 life-years gained, and an average cost per life saved of £7,691, higher than the other cancers, but still cost-effective.

Skin Cancer (Melanoma)

Based on optimistic assumptions, it would be possible to achieve the 1-year EUROCARE-4 good practice survival rate of 98%. Initially the additional costs of diagnosis would be around £3m, with a slight reduction in treatment costs of £1m. The model suggests a population benefit of 22,000 life-years gained, and an average cost per life saved of £31, highly cost-effective.

Introduction to NAEDI

The Cancer Reform Strategy (CRS), published in December 2007, highlighted that cancer survival in England compares poorly with that of comparable countries. One reason for this is that symptomatic patients in England are believed to present to the health service when their disease is more advanced, which has an impact on the potential for successful treatment, on patient outcomes, and on resources.

The National Awareness and Early Diagnosis Initiative (NAEDI) was launched in November 2008, and is a partnership between the Department of Health, the NHS, and Cancer Research UK. It seeks to meet the commitments to earlier cancer diagnosis made in the CRS. The CRS is currently being reviewed by Professor Sir Mike Richards, the National Cancer Director.

NAEDI is a programme of work that seeks to understand and improve public awareness of the signs and symptoms of cancer; encourage people with symptoms to seek help earlier; and support earlier diagnosis in primary care. Based on analyses of 5-year survival rates in Europe, it has been estimated that up to 10,000 deaths could be avoided per year in England by bringing survival rates up to the best rates in Europe[1]. There is a need to expand on this headline figure to examine the economic case for NAEDI, taking into account not only mortality but wider benefits for patients, and impact on costs.

NAEDI has four key outcome focused workstreams[2]:

i) Achieving early presentation by public and patients: Earlier (and more appropriate) presentation of potential cancer patients with symptoms to primary care.
ii) Optimising clinical practice and systems: Overcoming clinical and system barriers to prompt onward referral within and between primary and secondary care.
iii) GP access to diagnostics: Earlier diagnosis of cancer through primary care, including improving access to diagnostic tests to help GPs confirm or rule out suspicion of cancer.
iv) Research, evaluation and monitoring: Inform and underpin effective NAEDI activity through quality, investigator-led research and ensure appropriate evaluation.

Especially given the economic outlook for the NHS after 2010, it is imperative to be able to demonstrate to what extent earlier diagnosis of cancer can bring about cost efficiencies and health benefits in the mid-term (as well as long term). Economic modelling should be able to indicate broadly the impact of investment in methods to diagnose cancer 'earlier'. It should also be able to indicate which particular investments will be most effective and cost effective in future, if there is sufficient early evidence about NAEDI interventions. Ideally we would begin to understand this, even as NAEDI evolves, so that efforts can be concentrated on the most fruitful and sustainable activities.

[1] Mike Richards presentation, NAEDI launch November 2008. Figure derived from unpublished research by Michel Coleman. Professor Coleman estimated the number of deaths per annum that could be avoided, if patients diagnosed in the UK in the years 1995-1999 had survival rates comparable with the best in Europe. Estimates range between 5,000 and 10,000 deaths avoided.

[2] More information on the various work streams is available at: http://info.cancerresearchuk.org/spotcancerearly/naedi/013772/

NAEDI activity covers the cancer pathway up to treatment, beginning with the 'potential' cancer patient/ member of the public, who may or may not be exhibiting signs/ symptoms of cancer. We are interested in understanding better how to promote the benefits of early diagnosis of cancer, how to encourage people to come forward and engage with the health system, often despite a deep fear of cancer, and also how to raise awareness without unduly raising anxiety.

We are interested in the reasons for delays in primary care as well as the interface between primary and secondary care; patient, professional and system. The following diagram illustrates the diagnostic pathway, showing the main elements of potential delay in diagnosis.

Figure 1: Illustration of potential delays in the cancer pathway

Stages of Delay	←First appearance of symptoms	← First Presentation in Primary Care	←GP-initiated investigation	←Investigation results returned	←Referral	←Patient first seen in secondary care	←Diagnosis	←Treatment received
Definition of Delay	Patient Delay	Primary Care Delay			Referral Delay	Secondary Care Delay		
	Pre-hospital delay						Treatment Delay	
			Primary Care System Delay					
	Time to diagnosis							
	Time to treatment							

Purpose of models

Question

The specific questions addressed by this piece of work are:

- How would the costs to the NHS change if certain cancers (see below) were detected and diagnosed appreciably earlier than is currently the norm (i.e. according to current survival curves)?
- How would the benefits to individuals change if certain cancers (see below) were detected and diagnosed appreciably earlier than is currently the norm?

Scope of work

The work has focussed on five cancers: breast, colo-rectal, lung, prostate and skin (melanoma).
The modelling seeks to examine the impact that earlier detection and diagnosis would have on survival curves and on downstream costs and benefits. For example, what would be the impact on treatments costs and overall costs if more patients are diagnosed at stages I and II rather than III and IV. Does earlier diagnosis simply shift costs to earlier stages or does it avoid particular costs entirely?

The scope of the modelling is NHS funded patients that reside in England, and the data sources are where possible based on this population group.

Costs are limited to costs to the NHS (including diagnostics, screening, treatment, end-of-life care, etc). Ideally, we would have included costs to other public services and to society generally, but we have not been able to identify studies of these costs, in relation to **stage of diagnosis**. As much as possible, the modelling has tried to quantify any cost changes, but some indirect impacts (e.g. on waiting lists) have been noted qualitatively.

Similarly, benefits are limited to patient benefits in terms of improved survival, i.e. the change in life-years. Ideally it would have also included changes in morbidity (i.e. quality of life), and disbenefits (eg anxiety due to false positives) to patients, families and carers, and to the economy (eg higher productivity), based on the clinical evidence of the impact of earlier intervention. However, again there appears to be a lack of data on such benefits and disbenefits, in relation to **stage of diagnosis**.

Frontier Economics were commissioned to develop models for the five selected cancers, as outlined above[3]. The main sources of data for the models were estimates in the literature, and expert clinical opinion where estimates were not available from the literature.

[3] Two variations were produced for the prostate model, namely a model based on symptomatic patients only and a model based on both symptomatic and asymptomatic patients. This paper reports on the symptomatic model. We have not included the alternative model, which assumes also raised awareness for asymptomatic patients, as this is less realistic at the present time.

The key outputs expected from the project were:

- A framework/structure for a model which could be used for looking at other cancers and possibly other diseases (although the actual parameters/assumptions would need to be tailored for each cancer).
- Provisional conclusions on the economic case for the earlier detection and diagnosis of cancer, using models for the specific cancer included.
- Flexible models that would be able to include future data on NAEDI interventions.

NAEDI is also concerned with the relative cost-effectiveness of different strategies or interventions for improving early diagnosis. Ideally, we would like to answer the question of what we need to do to save 10,000, 20,000 etc lives. This question has not been addressed in the work to date. However, it should be possible to use the models developed by Frontier to answer these questions when information becomes available from the various NAEDI pilots. (See section below on further work).

Outline of models

Structure of models and key drivers

The key feature of these models is that all inputs and activity are modelled by **stage of diagnosis**. This was deliberate in order to provide answers to the key policy questions, which were about the impact of diagnosis at an earlier stage.

Consequently, the key assumptions or drivers in the models include the following (they apply to all models unless otherwise specified):

- Current costs of life-time treatment by stage of diagnosis (apart from Melanoma, Frontier did not carry out original research on life-time costs, but used existing estimates from the literature)[4]
- Costs of diagnosis (costs of tests, and assumptions about diagnostic pathways)
- Current survival rates by stage
- Distribution of incidence by stage in base-line
- Future distribution of incidence by stage (assumptions vary)
- Annual discount rate of 3.5% applied to future costs and benefits to calculate present values.

The following table shows a summary of the high-level features of the models.

Table 1: Summary of Model Features

Cancer Type **Issue**	***Colorectal***	***Breast***	***Lung***	***Prostate***	***Skin***
Alternative Versions?				Symptomatic, Asymptomatic[5]	
Patient streams	3: Screened, Symptomatic, Raised awareness	3: Screened, Symptomatic, Raised awareness	2: Symptomatic, Raised awareness	2: Symptomatic, Raised awareness	2: Symptomatic, Raised awareness
Assumes constant overall population incidence	Yes	Yes	Yes	No[6]	No[6]

[4] Costs have been updated for inflation to 2009.

[5] As noted earlier, the Asymptomatic model is not discussed in this report.

[6] Evidence suggests that increased awareness and increase use of diagnostics will increase the numbers of people diagnosed with prostate and skin cancer.

Approach to Modelling

The general approach is to produce projections under a set of assumptions relating to current presentation and screening rates, referred to throughout as Business as Usual (BAU). The model is then rerun making alternative assumptions about awareness and screening rates, referred to as the Policy Intervention scenario. The impact of earlier diagnosis is measured by comparing the two scenarios, i.e. BAU and Policy Intervention.

In the models, the patients are split into up to three groups:

- Those who are diagnosed through screening (where relevant[7])
- Those who present to their GPs with symptoms (referred to as 'symptomatic patients'); and
- Those who are made aware of risks and symptoms through NAEDI and therefore present to their GPs at an earlier stage (referred to as 'high awareness group').

The following section explains the rationale for this split and its impact on the modelling in more detail.

Business as usual (BAU) scenario

Currently people are diagnosed with cancer through two main routes:

- they either present to their GP with symptoms; or
- if national screening programmes are available, patients may be diagnosed through screening (referred to as the 'screened population').

The differences between these two groups are as follows:

- Symptomatic patients (those diagnosed with cancer after presenting to their GP with symptoms) tend to be diagnosed at a later stage than those who are screened. Hence, their distributions of incidence by stage and average survival rates are worse.
- Diagnosis process and costs may also be different for these two groups. For example, FOBT is used in colorectal cancer screening, but not for those who present with symptoms.

In the 'Business as Usual' case, the split of patients between these two groups is kept constant at its current level. The policy scenario (NAEDI) is then compared to this BAU basecase.

Policy case

[7] A screening program is currently in place for colorectal cancer (for 60-69 year olds) and for breast cancer (for 50-70 year-old women, with an extension to 47 -73 year olds in the near future). There is no screening program for lung cancer, prostate cancer and skin cancer.

Groups of patients in the policy case

The goal of NAEDI is to inform the population about the risks of developing a cancer and the signs that should alert them as potential cancer symptoms. Knowing risks and symptoms would lead people to present earlier to their GP for a check than they would have done otherwise. Earlier presentation would result in diagnosing people at earlier stages, leading to higher survival rates.

There are a number of alternative assumptions that could be used for the future distributions of cancer incidence. For example, when we have evidence of NAEDI interventions and their impact on incidence, we could examine the impact of those interventions on costs and outcomes.

The current approach has been to compare costs in the BAU case to a scenario which assumes that England could aim to reach Europe's "best practice" survival rates[8]. By "best practice" we mean the group of comparable countries in Europe with the highest survival rates. The model is iterated (by varying the distribution of cancer incidence by stage) until "best practice" survival rates are achieved.

An awareness campaign can be more or less effective, with effectiveness varying between 0% and 100%. NAEDI's effectiveness of, say, 70% means that:

- 70% of those at risk (called target population) are made aware of the risks and symptoms and therefore present earlier to their GP; while

- 30% of the same group are not aware of the risks and therefore present at a later stage.

It is worth emphasising that both groups are diagnosed after visiting their GP, i.e. the 'high awareness group' is a subgroup of the symptomatic population, but with better chances of survival as they are diagnosed at an earlier stage.

The assumptions regarding the distribution by stage at diagnosis for the '**high awareness group'** are as follows:

- If a screening program is in place for the cancer modelled, it is assumed that the distribution by stage for the 'high awareness group' is the same as for the screened group; and

- If there is no screening in place, the US data (e.g. SEER for lung cancer, pilot program for prostate cancer) and informed hypotheses (in the case of melanoma) are used to model the incidence by stage for this group.

[8] Frontier ran several alternative scenarios re survival rates, but only one scenario is included in this report.

The effectiveness rate is calibrated in each model to ensure that European "best practice" survival rates are achieved.[9]

Another important assumption is regarding the number of people visiting their GP as a result of the awareness campaign. It is expected that a higher number of people would visit GPs and go through initial tests, but with a less than proportionate increase in the number of people referred and subsequently diagnosed. Consequently, this change in the ratio of people tested for one referred, and in the ratio of referrals per diagnosis, has an impact on total diagnostic costs.

Number of patients in each group in the policy case

Part of the modelling work focused on evaluating the effectiveness of the awareness campaign needed in order to reach Europe's best practice survival rates.

In the case of lung cancer, prostate cancer and skin cancer, there is no screening program. The only means in the NAEDI models to reach Europe's best practice survival rates is to run an effective awareness campaign, with a more effective campaign implying more effort and higher costs, but also higher survival rates.

In the modelling, effectiveness is expressed as a percentage of the target population. For example, suppose that the awareness campaign for prostate cancer has to be effective for 50% of relevant population groups. This means that at least 50% of the population originally diagnosed after presenting with symptoms should be diagnosed earlier, following the awareness campaign.

In the case of colorectal and breast cancers, the DH/NHS has two principal interventions to use to reach Europe's best practice survival rates:

- Either it can increase those accessing diagnostic tests, eg as a result of increasing awareness; or

- It can increase the effectiveness of the screening program (or both).

Indeed, not all those who are invited for screening currently attend their appointments. For example, only 77% of 60-69 year-old women get tested as part of the screening program. Increasing this proportion would allow more people from this group to be diagnosed earlier and to have better chances of survival.

The effectiveness of these two interventions is measured as percentages of the relevant population groups.

[9] Note that in two models (breast and lung) we do not achieve the European best practice survival rates even if NAEDI is assumed to be 100% effective. The constraining factors are (i) incidence by stage for the screened population for breast cancer patients and (ii) poor survival rates by stage for lung cancer patients. Our interpretation of this result is that NAEDI on its own may not be sufficient and other improvements (e.g. in treatment of lung cancer patients) may be needed to improve the average survival rates. This is discussed further in the results section.

Finally, we calculate the costs of diagnosis and treatment under the policy scenario and, if relevant, following the improvement in the screening programs, and compare the resulting costs against the BAU costs.

Currently the costs of the campaign itself are not included in the modelling, but could be readily added to the models in future, when evidence becomes available.

Some Health Warnings

It should be noted that the models are not detailed dynamic financial models of costs or detailed models of patient pathways. They take typical pathways and costs as set out in the assumptions, and model those assuming alternative screening and awareness rates.

So the models are not appropriate for eg resource planning or examining detailed changes in patient pathways. However, they are suitable for the questions posed, i.e. the likely impact on costs and benefits of earlier diagnosis.

The transition assumed in the models for the change from the current situation to a new long-term equilibrium is arbitrary and essentially optimistic. In practice, the changes modelled would be expected to take much longer than as shown in the Annexes.

The models do not take account of possible supply constraints, eg they do not test the number of tests needed against NHS capacity.

It should be noted that the estimation of benefits in the modelling is approximate. Ideally, the modelling would have estimates of changes in Quality Adjusted Life Years (QALYs), but there is little evidence available of benefits by stage in QALY terms. The modelling is therefore likely to understate benefits, as it doesn't include those patients that have an improvement in Quality of Life, but not an increase in life expectancy. So the modelling simply measures benefits in life-years resulting from longer life expectancy associated with diagnosis at an earlier stage.

On the other hand, the estimated benefits in life-years might also include lead-time bias. The survival time for people with screen-detected disease is longer simply because they are detected at an earlier point in the natural history of the disease. The benefits will therefore be overstated to the extent that there is lead-time bias.

Key Sources of Data

Key inputs relate to the costs of diagnosis, the costs of treatment, and pathway probabilities.

Costs of diagnosis

Table 2 summarises the main costs of diagnosis used in the models, showing both the original costs as documented in the source studies, and updated for inflation to estimated 2009 costs.

Table 2: Unit Costs of diagnosis

Unit Costs	Original costs of diagnosis[10]		Costs of diagnosis, updated for inflation	
Cancer Type	**Initial Test**	**Further Tests**	**Initial Test**	**Further Tests**
Colorectal cancer	11.7	411.6	14	477
Breast cancer	45.5	323.0	46	342
Lung cancer	63.0	379.0	65	439
Prostate cancer	46.0	315.2	47	354
Melanoma cancer	92.8	177.1	107	180

More details on unit costs by type of cancer, including sources, are provided in the Annex 2[11].

Costs of treatment

Table 3 summarises the costs of treatment, by stage, for each of the five cancer models (by type). The costs are estimated for 2009, and represent life-time treatment costs for patients diagnosed by stage of cancer. Further detail and sources are provided in Annexes 3-7.

Treatment costs are generally highest for colorectal cancer, followed by breast, prostate, lung, and melanoma. However, the shape of the cost curve varies by type of cancer:

- Colorectal cancer has an inverse U-shaped curve, and the highest cost is associated with diagnosis at stage C.
- Breast cancer treatment cost continues to increase from early to late diagnosis, based on the Nottingham Prognostic Index[12].
- Similarly, melanoma cancer costs increase from Stage 1 to IV.

[10] Costs as shown in source documents

[11] Note that the detailed tables show costs as quoted in the original studies, while the models use these costs updated for inflation.

[12] The Nottingham Prognostic Index is not the ideal staging method to use for breast cancer. However, life-time treatment costs by stage of diagnosis are only available for this staging method.

- The costs for lung cancer treatment reduce for stages III and IV.
- Prostate cancer costs reduced for the advanced and metastatic stage.

Table 3: Lifetime Treatment Costs by Stage of Cancer

CANCER TYPE AND STAGE	COST[13]
Colorectal Cancer	
Stage A	£9,121
Stage B	£13,918
Stage C	£21,604
Stage D	£13,344
Unknown	£14,496
Breast Cancer	
Excellent prognosis	£8,767
Good	£9,945
Moderate	£11,098
Poor	£13,173
Lung Cancer	
Stage I	£7,135
Stage II	£7,135
Stage III	£6,720
Stage IV	£4,689
Prostate cancer	
Localised	£8,982
Locally advanced and metastatic	£5,905
Melanoma cancer	
Stage 1	£1,373
Stage 2	£3,340
Stage 3	£4,822
Stage 4	£5,302
Unknown	£4,872

Sources: Colorectal cancer, based on SCHARR and updated by Frontier Economics (FE); Breast cancer, based on SCHARR and updated by FE; Lung cancer, based on Fleming et al (2008); Prostate cancer, based on *The economic consequences of prostate and bladder cancer in the UK* (2004) and updated by FE; Melanoma cancer, based on FE analysis.

Summary of Pathway Probabilities

[13] Costs are estimated for 2009 by Frontier Economics, based on source studies (see Annexes 3-8). Costs are estimated lifetime costs by stage of diagnosis.

Another set of key inputs is the probabilities for patients tested of further testing and of diagnosis. These are summarised in the following table. The probabilities for symptomatic patients and screened patients are assumed to be unchanged for both Business As Usual and the Policy Scenario. The probabilities for the aware patients only apply in the Policy Scenario.

Table 4: Number of people tested for one diagnosed with cancer

	Tests	Colorectal cancer	Breast cancer	Lung cancer	Prostate cancer symptom-matic	Melanoma
Symptomatic patients (unaware)	People tested through initial test who then need other tests	NA	1 in 3 (4)	1 in 7 (3)	1 in 3 (7)	1 in 5 (3)
	People tested through other tests who are diagnosed with cancer	1 in 20 (2)	1 in 7 (2)	1 in 3 (3)	1 in 5 (7)	1 in 2 (9)
Screened patients	People tested through initial test who need other tests	1 in 20 (1)	1 in 20 (5)	NA	NA	NA
	People tested through other tests who are diagnosed with cancer	1 in 20 (1)	1 in 7 (6)	NA	NA	NA
Aware patients	People tested through initial test who need other tests	NA	1 in 8 (3)	1 in 18 (3)	1 in 3 (7)	1 in 5 (10)
	People tested through other tests who are diagnosed with cancer	1 in 20 (3)	1 in 7 (2)	1 in 3 (3)	1 in 5 (7)	1 in 2 (10)

Sources

(1) "Bowel cancer screening" The Facts NHS Cancer Screening Programme
(2) Frontier assumption that this rate is equal to the one among screened population
(3) Frontier assumption given other rates
(4) "The accuracy of "one-stop" diagnosis for 1110 patients presenting to a symptomatic breast clinic"
(5) Cancerhelp.org
(6) Statistic provided by expert (Julietta Patnik)
(7) "Symptomatic diagnosis of prostate cancer in primary care: a structured review", William Hamilton and Deborah Sharp
(8) "Population-based prostate-specific antigen testing in the UK leads to a stage migration of prostate cancer"
(9) 2006 study from Sheffield (Westbrook et al 2006) quoted in " Skin conditions in the UK: a health care needs assessment" from Julia Shoffield
(10) Frontier range of lower-bound to upper bound scenarios

Summary of results

Scenario: Target survival one year European good practice

The following sets of results are based on running the models to try and achieve European good practice 1-year survival rates. (More detailed information on the results is provided in Annexes 3-7).

Table 5: SCENARIO: TARGET SURVIVAL ONE-YEAR EUROPEAN GOOD PRACTICE

	Colorectal	Breast	Lung	Prostate (sympto-matic)	Melanoma
ASSUMPTIONS: SCREENING & AWARENESS					
Screening assumption (Current in brackets)	75% of 60-69s[14] (40%)	100% of 50-70s[15] (77%)	NA	NA	NA
Awareness assumption – Campaign efficiency for relevant pop groups	60%	100%	100%	50%[16]	65%
RESULTS					
Current England & Wales 1-year relative survival rate	72%	93.8%	28%	92%	96.4%
Target survival 1-year EUROCARE-4 (Good Practice)[17]	79%	97%	37%	96%	97.8%
Max achievable relative survival 1-year	**79%**	**95.2%[18]**	**33.3%[19]**	**96%**	**98%**
England & Wales 5-year relative survival rate (latest)	50%	82.0%	8%	77%	87.4%
Highest 5-year relative	59.4%	90.4%	16.2%	88.1%	NA

[14] Extension to ages 70-75 is being rolled out from April 2010

[15] Extension to ages 47-73 during 2010-12

[16] % of symptomatic population tested

[17] As identified in CRS 2nd Annual Report

[18] Unable to reach Eurocare-4 good practice through earlier diagnosis only, due to current distribution of screened patients.

[19] Unable to reach Eurocare-4 good practice due to current survival rates by stage.

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	Colorectal	Breast	Lung	Prostate (sympto-matic)	Melanoma
survival rate in Europe (Eurocare-4, 1995-99)					
Change in number of patients tested[20]	FOBt: +958,000 Oth: +864,000	Mam: 1864555 Oth: +187,870	X-ray: +557,571 Oth: +79,653	PSA: +1742835 Oth: 576,985	Biopsy: +15,263
Change in numbers of patients diagnosed	stays at 29,569[21]	stays at 41,250[18]	stays at 26,551[18]	from 30,000 to 70,589	from 9,354 to 16,985[22]
Expected years of life gained each year[23]	41,409	318,736	42,083	61,925	22,202
Impact on cost of diagnosis[24]	from £297m to £569m =£272m	from £216m to £301m =£85m	from £71m to£166m =£95m	from £74m to £175m =£101m	from £13m to £16m =£3m
Impact on cost of treatment[25]	from £452m to £438m =-£14m	from £401m to £392m =-£9m	from £163m to £168m =£5m	from £247m to £623m =£376m	from £20m to £19m = -£1m
Average Cost per year of life saved[26]	£6,241	£2,329	£2,376	£7,691	£31

[20] Additional number in 1st year, and increase declines during transition

[21] Except for short-term surge.

[22] Peak of 16,985 which gradually reduces over time

[23] in steady state

[24] Impact on costs after transition period, i.e. when steady-state reached

[25] Impact on costs after transition period, i.e. when steady-state reached

[26] In steady state, i.e. after transition period

Conclusions

For these cancers generally, the modelling found that earlier diagnosis is generally cost-effective, but not cost-saving. If people are diagnosed earlier, either through screening programmes or through their general practice, the main benefit is a substantial improvement in health outcomes. There is not a cost reduction, rather an increase in NHS costs (large increase in testing costs generally offset by a modest reduction in treatment costs). The modelling does not include the costs of the NAEDI interventions themselves, but these are expected to be very modest compared to testing and treatment costs.

Colorectal Cancer

Based on optimistic assumptions, it would be possible to achieve the 1-year EUROCARE-4 good practice survival rate of 79%. Initially this would require an extra 875,000 patients to be tested annually, although this number declines over time, as patients are diagnosed earlier. In the long-term, the number of patients diagnosed does not change, but of course has an improved distribution. Initially the additional costs of diagnosis would be around £272m, which reduces over time, and offset by a modest saving in treatment costs of £14m. However the model suggests a population benefit of 41,000 life-years gained, and an average cost per life saved of £6,241. This suggests that earlier diagnosis would be very cost-effective.

Breast Cancer

Based on very optimistic assumptions, an improvement could be achieved in the 1-year survival rate from the current 93.8% to 95.2%. It does not appear to be possible to achieve the best European rates, based simply on earlier diagnosis and assuming current survival rates by stage. In other words, achieving best European rates appears to require **an improvement in breast cancer survival rates by stage**.

Alternatively it would require a **distribution by stage** better than that achieved by the screening programme, which currently acts as a constraint in the model. In other words, in the models currently, for patients presenting outside the screening programme, we assume that we are unlikely to do better than the screening programme in terms of the percentages diagnosed at an early stage (eg Stages 1 or 2).

Initially the model requires an extra 1.9m patients to be tested annually, although this number declines over time, as patients are diagnosed earlier. In the long-term, the number of patients diagnosed does not change, but of course has an improved distribution. Initially the additional costs of diagnosis would be around £85m, which reduces over time, and offset by a modest saving in treatment costs of £9m. However the model suggests a population benefit of 319,000 life-years gained, and an average cost per life saved of £2,329. This suggests that earlier diagnosis would be very cost-effective.

Lung Cancer

Based on very optimistic assumptions, an improvement could be achieved in the 1-year survival rate from the current 28% to 33.3%. It does not appear to be possible to achieve the best European rates of 37%, based simply on earlier diagnosis and assuming current survival rates by stage. In other words, achieving best European rates appears to require **an improvement in lung cancer survival rates by stage**.

Initially the model requires an extra 558,000 patients to be tested annually, although this number declines over time, as patients are diagnosed earlier. In the long-term, the number of patients diagnosed does not change, but of course has an improved distribution. Initially the additional costs of diagnosis would be around £95m, which reduces over time, and additional treatment costs of £9m. This result is a consequence of the shape of the cost curve by stage for lung cancer, which assumes that treatment costs are higher if patients are diagnosed earlier. However the model suggests a population benefit of 42,000 life-years gained, and an average cost per life saved of £2,376, again very cost-effective.

Prostate Cancer

Based on optimistic assumptions and the more conservative model of patients that present symptomatically, it would be possible to achieve the 1-year EUROCARE-4 good practice survival rate of 96%. Initially this would require an extra 1.7m patients to be tested annually, although this number declines over time, as patients are diagnosed earlier. In the long-term, the number of patients diagnosed is modelled to increase from around 30,000 to 71,000 annually, and with an improved distribution. Initially the additional costs of diagnosis would be around £101m, and a substantial increase in treatment costs of £376m, due to the large increase in patients diagnosed annually. The model suggests a population benefit of 62,000 life-years gained, and an average cost per life saved of £7,691, higher than the other cancers, but still cost-effective.

Skin Cancer (Melanoma)

Based on optimistic assumptions, it would be possible to achieve the 1-year EUROCARE-4 good practice survival rate of 98%. Initially this would require an extra 15,000 patients to be tested annually. In the long-term, the number of patients diagnosed is modelled to increase from around 9,354 to 17,000 annually, and with an improved distribution. Initially the additional costs of diagnosis would be around £3m, with a slight reduction in treatment costs of £1m. The model suggests a population benefit of 22,000 life-years gained, and an average cost per life saved of £31, highly cost-effective.

Next steps/further work

This project has demonstrated that, subject to data limitations, it is possible to develop economic models of earlier diagnosis of certain cancers. However, the feasibility does depend on fairly robust estimates of costs, particularly the life-time treatment costs **by stage of diagnosis**, and key probabilities (eg the probability of diagnosis given certain tests).

Limitations of the models were discussed above (p12).

APPLICATION OF MODELS TO NAEDI INTERVENTIONS

A limitation of the models is that they do not currently include the costs of the NAEDI interventions themselves, i.e. those projects that will improve awareness of cancer and/or improve screening uptake rates. So currently costs in the models are a little understated.

The models would be more robust if they were to include information on the costs and impacts of NAEDI-specific projects, when the evidence from pilot projects becomes available. That would also make them more powerful and useful to commissioners.

USE OF MODELS BY PCTS AND OTHER NHS ORGANISATIONS

The models have only been developed to test the impact of earlier diagnosis at a national level. It would be possible to assess the impact at a local level, provided that the models could be populated with data for local population sizes, and assuming that the national-level assumptions for costs and probabilities were valid at a local level.

ANNEX 1: Relative survival rates of cancer patients used in Frontier modelling work - Explanatory note provided by Frontier Economics

This is an explanatory note to provide details on the average relative survival rates used as inputs in Frontier Economics' models, estimating impacts of earlier diagnosis on NHS costs and survival rates for four types of cancer.

Frontier Economics has modelled the impact of earlier diagnosis of five types of cancer (colorectal, breast, lung, prostate and melanoma of the skin) on survival rates and NHS costs in England and Wales. More specifically, we estimated the gap between average survival rates in England and Wales and highest survival rates in Europe, and assessed the costs and efficiency improvements needed to reach these higher rates, where possible.

Among the models' main inputs are one-year and five-year survival rates by stage at diagnosis. There are several data sources on the survival rates. Some of them have been provided by the DH; others have been recommended by cancer experts.

In this note, we explain how we selected inputs for our models.

One year relative survival rates

The following table shows one-year survival rates from different sources.

Table 1. England and Wales one-year relative survival rates

	Source	Colorectal cancer	Breast cancer	Lung cancer	Prostate cancer	Melanoma of the skin
Data provided by DH	Eurocare (1995-1999)	69.9%	93.2%	25.2%	88.5%	95.9%
	Rachet et al*, (2006)	75%	97%	28%	96%	96.8%
	CRS relative survival, England (2006)	75%	94%		94%	
	ONS (2006)	73%	95%		92%	
Other sources	Statistics.gov.uk (2001-2006)	69.5% (colon), 76.5% (rectum)	94.9%	28.4%	92%	97.3% (women), 94.9% (men)
	NCIN (1996-2006)	72% (by stage)				96.4%
	Cancer research UK		93.8% (by stage)	By stage		
	NHS				By stage	
	Levell et al, 2009[27]					By stage
Input for models		*72.0%*	*93.8%*	*28%*	*92%*	*96.4%*

The survival rates by cancer vary across sources. The last row of the table shows the data we selected and used as inputs in our models.

One crucial factor affecting our choice was the availability of relative survival rates by stage.

- For colorectal and breast cancer, NCIN and Cancer Research UK provide data by stage. Given that the derived average relative survival rates (72% for colorectal cancer and 93.8% for breast cancer) for these sources were consistent with the other data sources, we selected these data as inputs.

- On lung and prostate cancers, the survival rates by stage from Cancer Research UK and from the NHS did not match the average survival rates data from other sources. For lung cancer, we also did not have data on survival rates for un-staged patients. Hence, we first assumed that the survival rate for un-staged patients was equal to the average survival rate of stages III and IV (this assumption is consistent with observed survival rates for un-

[27] "Melanoma epidemic: a midsummer night's dream?" Levell, Beattie, Shuster and Greenberg, (BJD, 2009)

staged patients with other types of cancer). We then rescaled survival rates by stage from Cancer Research UK, so that the average survival rate was consistent with the other data sources. We used the Government Statistics average relative survival rates for lung cancer of 28% as the figure to match.

- For prostate cancer, we adjusted survival rates by stage (from the NHS) for both localised and locally advanced cancers to reach the average survival rate from the Government Statistics, i.e. 92%.

- For melanoma, we used the average survival rate of 96.4% provided by NCIN. We then used survival rates by stage from Levell et al (2009)[28]. As for lung and prostate cancer, the survival rates by stage did not match the average figures. Because the 1-year survival rates for people diagnosed at stage 1 to stage 3 are very similar (from 91% to 96%), we adjusted the 1-year survival rate of stage 4 patients for survival rates by stage to match the average.

Five years relative survival rates

The following table (also presented in our results slidepack), shows average five-year survival rates by source. The last row of the table shows the average survival rates used in our models.

- NCIN provides data by stage on colorectal cancer, which is consistent with most other sources on average survival rates. Consequently, we used this source.

- For breast cancer, the majority of sources quote a five-year survival rate of around 82%. We used survival rates by stage from Cancer Research UK and adjusted them so that the average survival rate was equal to 82%.

- For lung cancer, all sources present relative survival rate of around 8%. We used the same process as for the one-year survival rate to make our data by stage (from IASLC Lung cancer staging project) consistent with this average.

- For prostate cancer, we used the same data sources as for the one-year survival rates, and adjusted them through the same process.

- For melanoma, we used the Rachet et al. (2006) estimate of average survival rate, confirmed by UK statistics. The information by stage is based on CancerHelp information, consistent with Levell et al (2009).

Finally, we note that Rachet et al. (2006) estimates on survival rates are slightly higher than ours. This is because Rachet et al. use projected survival rates while we use actual (observed) data. Note that the five-year survival rates used in the DH "Cancer Reform Strategy 2009" are also projections (based on Rachet et al.).

[28] "Melanoma epidemic: a midsummer night's dream?" Levell, Beattie, Shuster and Greenberg, (BJD, 2009)

Table 2. England and Wales five-years relative survival rates

	Source	Colorectal cancer	Breast cancer	Lung cancer	Prostate cancer	Melanoma of the skin
Data provided by DH	Eurocare (1995-1999)	50.0%	79.7%	7.7%	69.8%	84.9%
	Rachet et al*	54%	86%	8%	86%	87.4%
	CRS relative survival, England (2006)	55%	82%		83%	
	ONS (2006)	52%	82%		77%	
Other sources	Statistics.gov.uk (2001-2006)	49.9% (colon), 53% (rectum)	82%	7.8%	77%	89.6% (women), 81.1% (men)
	Cancer research UK	50% (by stage)	By stage			By stage
	NCIN (1996-2006)	50.7% (by stage)				
	IASLC Lung cancer staging project			By stage		
	NHS				By stage	
	Levell et al., 2009[29]					By stage
	Cancerhelp.org					By stage
Input for models		*50.7%*	*82%*	*8%*	*77%*	*87.4%*

[29] "Melanoma epidemic: a midsummer night's dream?", Levell, Beattie, Shuster and Greenberg, (BJD, 2009)

ANNEX 2: Unit Cost Assumptions in Each of the Cancer Models

Colorectal cancer

For colorectal cancer, the main source for the costs of diagnosis, and of treatment, has been the SCHARR study on "Colorectal cancer screening options appraisal", as presented in the following table:

Table A2.1: Unit costs of diagnosing colorectal cancer

Population	Action	Unit cost	Source
Symptomatic patients and high awareness group	Colonoscopy / flexible sigmoidoscopy	£188.40	SCHARR, "Colorectal cancer screening options appraisal", 2004
	New attendance outpatient clinic	£75.89	
	2 follow up visits	£127.31	
Screened patients additional cost of screening	FOBt	£11.74	

Source: SCHARR (2004). Costs in table from the original study, i.e. not updated for inflation.

Breast cancer

As for colorectal cancer, the main source for costs of diagnosing breast cancer is a SCHARR study. This study does not explicitly refer to outpatient attendances; however these costs are likely to be included in the costs of mammography, ultrasound and biopsy.

Also, SCHARR assumes that only a share of those tested will go through biopsy. We use a similar assumption when dividing the staging process into two steps: the initial two-view mammography and further tests (including biopsy). **Table A2.2** presents the unit costs of diagnosing breast cancer.

Table A2.2: Unit costs of diagnosing breast cancer			
Population	**Action**	**Unit cost**	**Source**
Symptomatic patients, high awareness group and screened patients	Mammography	£42 – £45.50	SCHARR (2006-07) – NHS Breast Screening Program (2009)
	(if initial mammography positive) Further mammography	£70	SCHARR, "An initial assessment of the merits of extending routine breast screening to women aged 47-49 years", July 2008 (2006-07 costs)
	(if initial mammography positive) Biopsy	£253	
Source: NHS Breast Screening Program (2009), SCHARR (2008)			

Lung cancer

As discussed above, typical pathways of diagnosing lung cancer are similar to those of other cancers, so that the number and costs of outpatient attendance are expected to be similar. Because of these similarities, we use the unit costs of diagnosis from the SCHARR study on colorectal cancer, adjusting these costs for cancer-specific tests (i.e. X-rays and CT scans for lung cancer).

Table A2.3: Unit costs of diagnosing lung cancer			
Population	**Action**	**Unit cost**	**Source**
Symptomatic patients and high awareness group	Chest x-ray	£56	NHS Unit cost data (2008)
	(if chest x-ray positive) CT scan	£171.82	SCHARR, "Colorectal cancer screening options appraisal", 2004
	(if chest x-ray positive) New attendance outpatient clinic	£75.89	
	(if chest x-ray positive) 2 follow up visits	£127.31	
Source: NHS Unit cost data, SCHARR (2004)			

Prostate cancer

For prostate cancer as for lung cancer, scarcity of data on costs of diagnosis led us to use unit costs from the SCHARR study on colorectal cancer, as well as NHS unit cost data, to derive the total cost of diagnosis for prostate cancer.

Table A2.4: Unit costs of diagnosing prostate cancer

Population	Action	Unit cost	Source
Symptomatic patients, high awareness group and screened patients	PSA test	£46	NHS unit cost data (2008)
	(if initial PSA test positive) second PSA	£46	
	(if initial PSA test positive) Ultrasound scanner	£63	
	(if initial PSA test positive) New attendance outpatient clinic	£75.89	SCHARR, "Colorectal cancer screening options appraisal", 2004
	(if initial PSA test positive) 2 follow up visits	£127.31	

Source: NHS Unit cost data, SCHARR (2004)

Melanoma cancer

For melanoma cancer, again unit testing costs are based on unit costs from the SCHARR study on colorectal costs.

Table A2.5: Unit costs of diagnosing melanoma cancer

Population	Action	Unit cost	Source
Symptomatic patients, high awareness group and screened patients	Unit cost of 1-2 outpatient appointments	£107	SCHARR, "Colorectal cancer screening options appraisal", 2004
	Secondary care visits and biopsy	£180	

Source: SCHARR (2004)

Adjusting for inflation

For the models, the costs detailed above have been adjusted for inflation. The following table summarizes the initial unit costs per cancer, as well as the final adjusted costs used in the modelling.

Table A2.6: Costs adjusted for inflation

		Costs of diagnosis from studies	Costs of diagnosis including inflation
Colorectal cancer	Initial test	£11.7	£14
	Further tests	£411.6	£477
Breast cancer	Initial test	£45.5	£46
	Further tests	£323.0	£342
Lung cancer	Initial test	£63.0	£65
	Further tests	£379.0	£439
Prostate cancer	Initial test	£46.0	£47
	Further tests	£315.2	£354
Melanoma	Initial test	£92.8	£107
	Further tests	£177.1	£180

Sources – Frontier estimates, based on sources as per Tables above.

The inflation rates used are shown in the following table:

Table A2.7: Inflation rate for health products

	2005	2006	2007	2008	2009
Inflation	2.90%	2.80%	3.40%	3.10%	2.70%

Source: http://www.statistics.gov.uk/statbase/TSDSeries1.asp

ANNEX 3A: COLORECTAL CANCER MODEL - ASSUMPTIONS

The tables in this Annex are extracts from the model spreadsheets, in order to provide greater detail for those readers interested in the detailed assumptions. The actual spreadsheet model is available on request.

General inputs and costs of treatment

Time Discount rate, for calculation of present values	3.5%

Cost of treatment	Total cost (2009 prices)[30]
Stage A	£9,121
Stage B	£13,918
Stage C	£21,604
Stage D	£13,344
Unknown	£14,496

Cost of Diagnosis[31]

Cost of FOBt	£13.60
For those positive at screening, cost of colonoscopy / flexible sigmoidoscopy	£476.69[32]

Survival rates and mean survival years[33]

	Mean survival years	5-year survival	#s surviving	1 year survival rate	#s surviving
Stage A	11	93%	3,408	95%	3,474
Stage B	11	77%	5,527	92%	6,568
Stage C	8.7	47%	3,311	80%	5,636
Stage D	1.4	7%	165	37%	923
Unknown	2.5	25%	2,345	52%	4,782
Total / Average	5.80	50%	14,755	72%	21,382

[30] *Source: Frontier based on ScHARR.* This is including the cost of further tests (staging) for people diagnosed of colorectal cancer.

[31] Source: ScHARR.

[32] This includes 1 GP consultation, 3 attendances at outpatient clinic, and the colonoscopy/flexible sigmoidoscopy cost.

[33] *Source: ScHARR (one year) and Cancer Research UK (5 years).*
Average survival rates checked against the following sources:
Source: Eurocare IV England + Wales 1995-1999 - Relative survival rates
Source: http://info.cancerresearchuk.org/cancerstats/types/bowel/survival/index.htm#one, 2004-2006

BAU number of diagnosed per year

Total population diagnosed under BAU - 2004[34]	29,569

SCREENING			
Current population screened			
Total number of 60-69 years old in England + Wales		5,474,000[35]	
Efficiency: Total % of 60-69 years old screened		40%	60%
Screening frequency: every		2	years
Efficiency: Total % of 60-69 years old screened per year		20%	30%
Number of people having FOBt per year		1,094,800	
% FOBt that are positive (i.e. screened who need to have colonoscopy / flexible sigmoidoscopy)		5%[36]	
Number of people having colonoscopy / flexible sigmoidoscopy		54,740	
% of FOBt who are diagnosed with cancer		0.25%	
Yearly number of diagnosed through screening		2,758	
Distribution of diagnosed when screened			
Source: Steele et al - UK Colorectal Screening Pilot Group		BAU number of diagnosed when screened - 1st year	
Stage A	48%	1,324	
Stage B	25%	690	
Stage C	26%	717	
Stage D	1%	28	
Unknown	0%	0	
Total	**100%**	**2,758**	

[34] *Source: ScHARR*

[35] *Source: http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=15095*

[36] *Source: "Bowel cancer screening" The Facts NHS Cancer Screening Programme*

POPULATION PRESENTING WITH SYMPTOMS			
Current population diagnosed outside screening process			
Number of 70+ diagnosed after presenting with symptoms per year		17,792	
Number of below 60 diagnosed after presenting with symptoms per year		4,881	
Number of 61-69 diagnosed after presenting with symptoms per year		4,138	
Total diagnosed after presenting with symptoms per year		**26,811**	TRUE
Distribution of diagnosed when presenting with symptoms[37]			
		BAU number of diagnosed when presenting with symptoms	
Stage A	9%	2,333	9%
Stage B	24%	6,488	24%
Stage C	24%	6,327	24%
Stage D	9%	2,467	9%
Unknown	34%	9,196	34%
Total	**100%**	**26,811**	66%
Total number of people presenting with symptoms			
Total number of 70+ years old in England Wales		6,308,342[38]	
Total number 50-60 years old in England-Wales		6,602,650[39]	
Number of people who are going through colonoscopy/ flexible sigmoidoscopy to be or not diagnosed		536,212	
% people going directly through colonoscopy/ flexible sigmoidoscopy who are diagnosed with cancer		5%	
Yearly growth in total number of people presenting with symptoms		0%	

Distribution of diagnosed under BAU - total		
Stage A	**3,657**	12%
Stage B	**7,178**	24%
Stage C	**7,044**	24%
Stage D	**2,494**	8%
Unknown	**9,196**	31%
Total	**29,569**	100%

People having FOBt	**1,094,800**
People having colonoscopy / flexible sigmoidoscopy	**590,952**

[37] *Source: National Cancer Intelligence network - number of diagnosed for colorectal cancer (1996-2006)*

[38] *Source: http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=15095*

[39] *Source: http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=15096*

Policy effects

Starting year of the policy	2012

Cost of policy

Cost of FOBT (2 tests)	£13.60
For those positive at screening, cost of colonoscopy / flexible sigmoidoscopy	£476.69

Effect 1 - increase in efficiency for currently screened population

Additional population screened every 2 years	35%
% additional population screened every year	18%
% of FOBt whose result are positive and thus have colonoscopy / flexible sigmoidoscopy	5.0%
% of screened that are diagnosed with cancer	0.25%
Additional people having FOBt per year	957,950
Additional people having colonoscopy / flexible sigmoidoscopy per year	47,898
Additional number of 60-69 years old who will be diagnosed through screening the first year of the policy	2,414

Effect 2 - targeting new population to increase awareness

% of this population who will be sensitivised through awareness campaign	60%
Number of people from this group who will be diagnosed following awareness campaign	13,604
% of FOBt tested that are diagnosed with cancer	0.0%
Additional people tested with FOBt per year	0
% of people having colonoscopy who are diagnosed with cancer	1.7%
Additional people having colonoscopy per year	816,228

Impacts of policy

Impact - 1st year of policy

Total additional people having FOBt per year	957,950
Total additional people having colonoscopy / flexible sigmoidoscopy per year due to policy	864,126
Total aware population diagnosed the first year of policy	18,776
Total population diagnosed after presenting with symptoms the 1st year of policy	26,811

Impact - Long term equilibrium in number of diagnosed - not including growth trend

Total additional people having FOBt per year	**957,950**
Total additional people having colonoscopy / flexible sigmoidoscopy per year due to policy	864,126
Total number of diagnosed per year	29,569
Long term number of people diagnosed through awareness campaign	18,776
Total number of people still diagnosed after presenting with symptoms	10,793
Total number of people still having colonoscopy / flexible sigmoidoscopy to be diagnosed after presenting with symptoms	215,864
Total additional number of people having colonoscopy / flexible sigmoidoscopy in long term	**543,778**

Evolution of cancer if not treated

	Duration of stages (in months)	Duration of stages (in years)
Stage A	24	2.0
Stage B	12	1.0
Stage C	6	0.5
Stage D	3	0.3
Total	45	3.8

Policy - Change in diagnosed population and proportions by stage

Changes in aware/screened population - depending on screening frequency	0 Year 0	1 Year 1	2 Year 2	3 Year 3	4 Year 4 ->
Stage A	1,324	5,802	5,802	5,802	5,802
Stage B	690	5,989	5,989	5,989	5,989
Stage C	717	5,069	5,069	5,069	5,069
Stage D	28	1,915	1,915	1,915	1,915
Unknown	0	0	0	0	0
Total	2,758	18,776	18,776	18,776	18,776

Changes in number of people diagnosed after presenting with symptoms					
	Year 0	Year 1	Year 2	Year 3	Year 4 ->
Stage A	2,333	2,333	1,636	939	939
Stage B	6,488	6,488	4,550	2,612	2,612
Stage C	6,327	6,327	4,437	2,547	2,547
Stage D	2,467	2,467	1,730	993	993
Unknown	9,196	9,196	6,449	3,702	3,702
Total	26,811	26,811	18,802	10,793	10,793

Changes in total population diagnosed (including growth trend)					
		2012	**2013**	**2014**	**2015**
	Year 0	Year 1	Year 2	Year 3	Year 4 ->
Stage A	3,657	8,134	7,437	6,741	6,741
Stage B	7,178	12,478	10,540	8,601	8,601
Stage C	7,044	11,397	9,507	7,617	7,617
Stage D	2,494	4,382	3,645	2,908	2,908
Unknown	9,196	9,196	6,449	3,702	3,702
Total	**29,569**	**45,586**	**37,578**	**29,569**	**29,569**

Policy - transition in additional number of people having colonoscopy / flexible sigmoidoscopy

	2012 Year 1	**2013** Year 2	**2014** Year 3	**2015** Year 4	**2016** Year 5
Additional number of people going through colonoscopy	864,126	757,343	543,778	543,778	543,778

ANNEX 3B: COLORECTAL CANCER MODEL - RESULTS

1 - Effect of policy on total number of people diagnosed by stage

	year 0	year 1	year 2	year 3	year 4 ->
Stage A	3,657	8,134	7,437	6,741	6,741
Stage B	7,178	12,478	10,540	8,601	8,601
Stage C	7,044	11,397	9,507	7,617	7,617
Stage D	2,494	4,382	3,645	2,908	2,908
Unknown	9,196	9,196	6,449	3,702	3,702
Total	29,569	45,586	37,578	29,569	29,569

2 - impact on average 1-year survival rates at new equilibrium

	Under BAU	Under policy
Stage A	3,474	6,404
Stage B	6,568	7,870
Stage C	5,636	6,093
Stage D	923	1,076
Unknown	4,782	1,925
diagnosed expected to survive one year	**21,382**	**23,368**
Diagnosed	29,569	29,569
% diagnosed expected to survive one year	**72%**	**79%**

	2023 people surviving under BAU	2023 people surviving under policy
Stage A	3,408	6,282
Stage B	5,527	6,623
Stage C	3,311	3,580
Stage D	165	192
Unknown	2,345	944
diagnosed expected to survive five years	**14,755**	**17,621**
Diagnosed	29,569	29,569
% diagnosed expected to survive five years	**50%**	**60%**

	Expected years of life gained from the policy each year
Total	41,409

2 - impact on costs at new equilibrium

First year of policy implementation	2012
Year used to compare steady states	2023

	Equilibrium cost under BAU	Equilibrium cost under policy	% cost increase
Cost of FOBt	£15	£28	5%
Cost of colonoscopy / flexible sigmoidoscopy	£282	£541	100%
Total cost of diagnosing	£297	£569	105%
Total cost of treatment	£452	£438	-5%
Total	£749	£1,007	**100%**
Average cost per diagnosed	£25,318	£34,057	

	2011	2012	2013	2014	2015
Cost of awareness by years of life gained		£4,449	£5,109	£6,241	£6,241

3 - impact on cost NPV

in millions	2011	2012	2013	2014	2015->
Total cost under BAU	£749	£749	£749	£749	£749
Total cost under policy	£749	£1,407	£1,233	£1,007	£1,007

	Over 50 years	Over 40 years	Over 30 years	Over 20 years
NPV of NHS costs under BAU	£17,814m	£15,987m	£13,769m	£10,640m
NPV of NHS costs under policy	£23,948m	£21,833m	£18,849m	£14,640m
Gain from policy	**-£6,134m**	**-£5,846m**	**-£5,081m**	**-£4,000m**
Total number of life years gained	2,189,011	1,774,922	1,360,834	946,746
Cost/savings of policy per year of life gained	-£2,802	-£3,294	-£3,733	-£4,225

ANNEX 4A: BREAST CANCER MODEL - ASSUMPTIONS

The tables in this Annex are extracts from the model spreadsheets, in order to provide greater detail for those readers interested in the detailed assumptions. The actual spreadsheet model is available on request.

General inputs and costs of treatment

Time Discount rate for calculation of present values	3.5%

Cost of treatment	Total cost (2009)
Excellent prognosis	£8,767
Good	£9,945
Moderate	£11,098
Poor	£13,173
Unknown	£0

Cost of diagnosis

Cost of mammography	£45.50
For those positive at screening, cost of further tests	£342.00

Survival rates and mean survival years[40]

	Mean survival years	5-year survival	#s surviving	1 year survival rate	#s surviving
Excellent prognosis	17	97%	16,224	98%	16,469
Good prognosis	13	81%	14,600	96%	17,373
Moderate prognosis	9	55%	2,623	84%	4,018
Poor prognosis	2	24%	397	49%	819
Unknown	0	0%	0	0%	0
Total / Average	13.72	82.05%	33,845	93.8%	38,679

BAU number of diagnosed per year

Total population diagnosed under BAU - 2004	41,250

[40] *Source:* *http://publications.cancerresearchuk.org/WebRoot/crukstoredb/CRUK_PDFs/breast/cs_br_f3.3.xls.*

Averages checked against Source: Eurocare IV England + Wales 1995-1999 - Relative survival rates

SCREENING			
Current population screened			
Total number of 50-69 years old in England + Wales		7,860,800	
Efficiency: Total % of 50-69 years old screened		77%	23%
Screening frequency: every		3	years
Efficiency: Total % of 50-69 years old screened per year		26%	8%
Number of people having mammography per year		2,017,605	
% mammography that are positive (i.e. screened who need to have further tests)		5%	
Number of people having further tests		100,880	
% of mammography who are diagnosed with cancer		0.71%	
Yearly number of diagnosed through screening		14,411	
Distribution of diagnosed when screened			
		BAU number of diagnosed when screened - 1st year	
Excellent prognosis	52%	7,519	
Good prognosis	37%	5,326	
Moderate prognosis	9%	1,253	
Poor prognosis	2%	313	
Unknown	0%	0	
Total	**100%**	**14,411**	

POPULATION PRESENTING WITH SYMPTOMS			
Current population diagnosed outside screening process			
Number of 70+ diagnosed after presenting with symptoms per year		22,534	
Number of below 60 diagnosed after presenting with symptoms per year			
Number of 61-69 diagnosed after presenting with symptoms per year		4,305	
Total diagnosed after presenting with symptoms per year		**26,839**	TRUE
Distribution of diagnosed when presenting with symptoms			
		BAU number of diagnosed when presenting with symptoms	
Excellent prognosis	34%	9,207	34%
Good prognosis	48%	12,748	48%
Moderate prognosis	13%	3,541	13%
Poor prognosis	5%	1,342	5%
Unknown	0%	0	0%
Total	**1**	**26,839**	100%
Total number of people presenting with symptoms			
Total number of 70+ years old in England Wales		4,837,400	
Total number 50-60 years old in England-Wales		0	
Number of people who are going through further tests to be or not diagnosed		187,870	
% of women going through further tests who have cancer		14%	
% of mammogramed women called for further tests		33%	
Number of women having mammography		563,609	
Yearly growth in total number of people presenting with symptoms		0%	

Distribution of diagnosed under BAU - total		
Excellent prognosis	16,726	41%
Good prognosis	18,074	44%
Moderate prognosis	4,794	12%
Poor prognosis	1,655	4%
Unknown	0	0%
Total	41,250	100%

People having mammography	2,581,215
People having further tests	288,750

Policy effects

Cost of policy

Cost of mammography (2 tests)	£45.50
For those positive at screening, cost of further tests	£342.00

Effect 1 - increase in efficiency for currently screened population	
Additional population screened every 3 years	23%
% additional population screened every year	8%
% of mammography whose result are positive and thus have further tests	5.0%
% of screened that are diagnosed with cancer	0.71%
Additional people having mammography per year	602,661
Additional people having further tests per year	30,133
Additional number of 60-69 years old who will be diagnosed through screening the first year of the policy	4,305

Effect 2 - targeting new population to increase awareness	
% of this population who will be sensitivised through awareness campaign	100%
Number of people from this group who will be diagnosed following awareness campaign	22,534
% of mammography tested that are diagnosed with cancer	1.8%
Additional people tested with mammography per year	1,261,893
% of people having further tests who are diagnosed with cancer	14.3%
Additional people having further tests per year	157,737

Impacts of policy

Impact - 1st year of policy

Total additional people having mammography per year	1,864,555
Total additional people having further tests per year due to policy	187,870
Total aware population diagnosed the first year of policy	41,250
Total population diagnosed after presenting with symptoms the 1st year of policy	26,839

Impact - Long term equilibrium in number of diagnosed - not including growth trend

Total additional people having mammography per year	**1,864,555**
Total additional people having further tests per year due to policy	187,870
Total number of diagnosed per year	41,250
Long term number of people diagnosed through awareness campaign	41,250
Total number of people still diagnosed after presenting with symptoms	0
Total number of people still having further tests to be diagnosed after presenting with symptoms	0
Total additional number of people having further tests in long term	**0**

Evolution of cancer if not treated

	Duration of stages (in months)	Duration of stages (in years)
Excellent prognosis	24	2.0
Good	12	1.0
Moderate	6	0.5
Poor	3	0.3
Total	45	3.8

Policy - Change in diagnosed population and proportions by stage

Changes in aware/screened population - depending on screening frequency	0 Year 0	1 Year 1	2 Year 2	3 Year 3	4 Year 4 ->
Excellent prognosis	7,519	12,553	19,433	21,522	21,522
Good	5,326	15,815	15,301	15,245	15,245
Moderate	1,253	11,851	5,999	3,587	3,587
Poor	313	1,032	516	897	897
Unknown	0	0	0	0	0
Total	14,411	41,250	41,250	41,250	41,250

Changes in number of people diagnosed after presenting with symptoms	Year 0	Year 1	Year 2	Year 3	Year 4 ->
Excellent prognosis	9,207	9,207	4,604	0	0
Good	12,748	12,748	6,374	0	0
Moderate	3,541	3,541	1,771	0	0
Poor	1,342	1,342	671	0	0
Unknown	0	0	0	0	0
Total	26,839	26,839	13,419	0	0

Changes in total population diagnosed (including growth trend)		2012	2013	2014	2015
	Year 0	Year 1	Year 2	Year 3	Year 4 ->
Excellent prognosis	16,726	21,760	24,037	21,522	21,522
Good	18,074	28,563	21,676	15,245	15,245
Moderate	4,794	15,392	7,770	3,587	3,587
Poor	1,655	2,374	1,187	897	897
Unknown	0	0	0	0	0
Total	**41,250**	**68,089**	**54,669**	**41,250**	**41,250**

Policy - transition in additional number of people having further tests

	2012	2013	2014	2015 ->
	Year 1	Year 2	Year 3	Year 4
Additional number of people going through further tests	187,870	125,246	0	0

ANNEX 4B: BREAST CANCER MODEL - RESULTS

1 - Effect of policy on total number of people diagnosed by stage

	year 0	year 1	year 2	year 3	year 4 ->
Excellent prognosis	16,726	21,760	24,037	21,522	21,522
Good prognosis	18,074	28,563	21,676	15,245	15,245
Moderate prognosis	4,794	15,392	7,770	3,587	3,587
Poor prognosis	1,655	2,374	1,187	897	897
Unknown	0	0	0	0	0
Total	41,250	68,089	54,669	41,250	41,250

2 - impact on average 1-year survival rates at new equilibrium

	Under BAU	Under policy
Excellent prognosis	16,469	21,190
Good	17,373	14,653
Moderate	4,018	3,006
Poor	819	444
Unknown	0	0
diagnosed expected to survive one year	**38,679**	**39,293**
Diagnosed	41,250	41,250
% diagnosed expected to survive one year	**94%**	**95%**

	2023 people surviving under BAU	2023 people surviving under policy
Excellent prognosis	16,224	20,876
Good	14,600	12,315
Moderate	2,623	1,963
Poor	397	215
Unknown	0	0
diagnosed expected to survive five years	**33,845**	**35,368**
Diagnosed	41,250	41,250
% diagnosed expected to survive five years	**82%**	**86%**

	Expected years of life gained from the policy each year
Total	32,355

2 - impact on costs at new equilibrium

	Equilibrium cost under BAU	Equilibrium cost under policy	% cost increase
Cost of mammography	£117m	£202m	113%
Cost of further tests	£99m	£99m	0%
Total cost of diagnosing	£216m	£301m	113%
Total cost of treatment	£401m	£392m	-13%
Total	£618m	£693m	**100%**
Average cost per diagnosed	£14,972	£16,799	+12%

	2011	2012	2013	2014	2015 ->
Cost of awareness by years of life gained		£1,332	£1,292	£2,329	£2,329

3 - impact on cost NPV

in millions	**2011**	**2012**	**2013**	**2014**	**2015**
Total cost under BAU	£618	£618	£618	£618	£618
Total cost under policy	£618	£1,042	£872	£693	£693

	Over 50 years	Over 40 years	Over 30 years	Over 20 years
NPV of NHS costs under BAU	£14,486	£13,189	£11,359	£8,777
NPV of NHS costs under policy	£16,668	£15,213	£13,159	£10,263
Gain from policy	**-£2,182**	**-£2,024**	**-£1,801**	**-£1,486**
Total number of life years gained	2,036,380	1,712,826	1,389,273	1,065,719
Cost/savings of policy per year of life gained	-£1,072	-£1,182	-£1,296	-£1,394

ANNEX 5A: LUNG CANCER MODEL – ASSUMPTIONS

The tables in this Annex are extracts from the model spreadsheets, in order to provide greater detail for those readers interested in the detailed assumptions. The actual spreadsheet model is available on request.

General inputs and costs of treatment

Time Discount rate, for calculation of present values	3.5%

Cost of treatment	Total cost (2009)
Stage I	£7,135
Stage II	£7,135
Stage III	£6,720
Stage IV	£4,689
Unknown	£6,420

Cost of diagnosis

chest x-rays	£64.70
further tests	£438.96

Survival rates and mean survival years

	Mean survival years	5-year survival	#s surviving	1 year survival rate	#s surviving
Stage I	8	42%	895	47%	1,007
Stage II	4	23%	182	39%	308
Stage III	2	10%	429	31%	1,388
Stage IV	0.5	2%	127	23%	1,466
Unknown		5%	606	27%	3,425
Total / Average	1.22	8.4%	2,240	28.6%	7,594
Check average		7.7%		25.2%	

POPULATION PRESENTING WITH SYMPTOMS			
Current population diagnosed outside screening process			
Number of 70+ diagnosed after presenting with symptoms per year		0	
Number of below 60 diagnosed after presenting with symptoms per year			
Number of 61-69 diagnosed after presenting with symptoms per year		0	
Total diagnosed after presenting with symptoms per year		**26,551**	FALSE
Distribution of diagnosed when presenting with symptoms[41]			
		BAU number of diagnosed when presenting with symptoms	
Stage I	8%	2,124	8%
Stage II	3%	797	3%
Stage III	17%	4,514	17%
Stage IV	24%	6,372	24%
Unknown	48%	12,744	48%
Total	**1**	**26,551**	100%
Total number of people presenting with symptoms			
Number of people who are going through further tests to be or not diagnosed		79,653	
% going through further tests who have cancer		33%	
% of chest x-rays who need further tests		14%	
Number of women having mammography		557,571	
Yearly growth in total number of people presenting with symptoms		0%	

Distribution of diagnosed under BAU - total		
Stage I	**2,124**	8%
Stage II	**797**	3%
Stage III	**4,514**	17%
Stage IV	**6,372**	24%
Unknown	**12,744**	48%
Total	**26,551**	100%

People having mammography	**557,571**
People having biopsy	**79,653**

Policy effects	
Starting year of the policy	**2012**
Cost of policy	
Cost of Chest x-rays (2 tests)	£64.70
Further tests	£438.96

[41] Source: national lung cancer audit

Effect 2 - targeting new population to increase awareness	
% of this population who will be sensitivised through awareness campaign	100%
Number of people from this group who will be diagnosed following awareness campaign	26,551
% of chest x-rays that are diagnosed with cancer	1.8%
Additional people tested with mammography per year	1,460,305
% of people having further tests who are diagnosed with cancer	33.3%
Additional people having biopsy per year	79,653

Impacts of policy

Impact - 1st year of policy

Total additional people having mammography per year	1,460,305
Total additional people having biopsy per year due to policy	79,653
Total aware population diagnosed the first year of policy	26,551
Total population diagnosed after presenting with symptoms the 1st year of policy	26,551

Impact - Long term equilibrium in number of diagnosed - not including growth trend

Total additional people having mammography per year	**1,460,305**
Total additional people having biopsy per year due to policy	79,653
Total number of diagnosed per year	26,551
Long term number of people diagnosed through awareness campaign	26,551
Total number of people still diagnosed after presenting with symptoms	0
Total number of people still having biopsy to be diagnosed after presenting with symptoms	0
Total additional number of people having biopsy in long term	**0**

Evolution of cancer if not treated

	Duration of stages (in months)	Duration of stages (in years)
Stage A	4.8	0.4
Stage B	4.8	0.4
Stage C	9.12	0.8
Stage D	5.28	0.4
Total	24	2.0

Policy - Change in diagnosed population and proportions by stage

Changes in aware population	0	1	2	3	4
	Year 0	Year 1	Year 2	Year 3	Year 4 ->
Stage I	0	3,983	3,983	3,983	3,983
Stage II	0	5,841	5,841	5,841	5,841
Stage III	0	7,965	7,965	7,965	7,965
Stage IV	0	6,638	6,638	6,638	6,638
Unknown	0	2,124	2,124	2,124	2,124
Total	0	26,551	26,551	26,551	26,551

Changes in symptomatic population					
	Year 0	Year 1	Year 2	Year 3	Year 4 ->
Stage I	2,124	2,124	1,062	0	0
Stage II	797	797	398	0	0
Stage III	4,514	4,514	2,257	0	0
Stage IV	6,372	6,372	3,186	0	0
Unknown	12,744	12,744	6,372	0	0
Total	26,551	26,551	13,276	0	0

Changes in total population diagnosed		**2012**	**2013**	**2014**	**2015**
	Year 0	Year 1	Year 2	Year 3	Year 4
Stage I	2,124	6,107	5,045	3,983	3,983
Stage II	797	6,638	6,239	5,841	5,841
Stage III	4,514	12,479	10,222	7,965	7,965
Stage IV	6,372	13,010	9,824	6,638	6,638
Unknown	12,744	14,869	8,496	2,124	2,124
Total	**26,551**	**53,102**	**39,827**	**26,551**	**26,551**

Policy - transition in additional number of people having further tests

	2012	**2013**	**2014**	**2015 etc**
	Year 1	Year 2	Year 3	Year 4
Additional number of people going through further tests	79,653	53,102	0	0

ANNEX 5B: LUNG CANCER MODEL - RESULTS

A - Current scenario

1 - Effect of policy on total number of people diagnosed by stage

	year 0	year 1	year 2	year 3 etc
Stage I	2,124	6,107	5,045	3,983
Stage II	797	6,638	6,239	5,841
Stage III	4,514	12,479	10,222	7,965
Stage IV	6,372	13,010	9,824	6,638
Unknown	12,744	14,869	8,496	2,124
Total	26,551	53,102	39,827	26,551

2 - impact on average 1-year survival rates at new equilibrium

	Under BAU	Under policy
Stage I	1,007	1,887
Stage II	308	2,261
Stage III	1,388	2,450
Stage IV	1,466	1,527
Unknown	3,425	571
diagnosed expected to survive one year	**7,594**	**8,696**
Diagnosed	12,744	26,551
% diagnosed expected to survive one year	**60%**	**33%**

	2023 people surviving under BAU	2023 people surviving under policy
Stage I	895	1,678
Stage II	182	1,335
Stage III	429	757
Stage IV	127	133
Unknown	606	101
diagnosed expected to survive five years	**2,240**	**4,005**
Number of people having further tests	12,744	26,551
% diagnosed expected to survive five years	**18%**	**15%**

	Expected years of life gained from the policy each year
Total	42,083

2 - impact on costs at new equilibrium

First year of policy implementation	2012
Year used to compare steady states	2023

	Equilibrium cost under BAU	Equilibrium cost under policy	% cost increase
Cost of Chest x-rays	£36m	£131m	94%
Cost of further tests	£35m	£35m	0%
Total cost of diagnosing	£71m	£166m	94%
Total cost of treatment	£163m	£168m	6%
Total	£234m	£334m	**100%**
Average cost per diagnosed	£18,353	£12,576	

	2011	2012	2013	2014	2015	2016 etc
Cost of awareness by years of life gained		£3,999	£3,513	£2,376	£2,209	£2,376

3 - impact on cost NPV

First year of policy implementation	2012

in millions	**2011**	**2012**	**2013**	**2014 etc**
Total cost under BAU	£234	£234	£234	£234
Total cost under policy	£234	£532	£439	£334

	Over 50 years	Over 40 years	Over 30 years	Over 20 years
NPV of NHS costs under BAU	£5,486m	£4,995m	£4,302m	£3,324m
NPV of NHS costs under policy	£8,014m	£7,313m	£6,324m	£4,928m
Gain from policy	**-£2,528m**	**-£2,318m**	**-£2,022m**	**-£1,604m**
Total number of life years gained	2,113,858	1,693,025	1,272,191	851,358
Cost/savings of policy per year of life gained	-£1,196	-£1,369	-£1,589	-£1,884

ANNEX 6: PROSTATE CANCER MODEL

It should be noted that the prostate cancer model is different from the other Frontier models. This is because it takes into account the specificity of prostate cancer: a certain percentage of the male population has prostate cancer over a long period to death. The cancer remains at early stages, is never diagnosed and never treated, and is not the cause of death. Raising awareness in the modelling can result in more people getting tested without having symptoms. This would increase incidence, as it would then capture part of this population who would otherwise not be diagnosed. This would potentially result in overtreatment and an increase in total NHS costs.

Frontier created scenarios on the potential awareness policies and their impact on survival rates and on total costs, and analysed two types of policies: the symptomatic and asymptomatic:

- Symptomatic scenarios measure the impacts of more people getting tested for prostate cancer after presenting with symptoms;
- Asymptomatic scenarios measure the impacts of awareness campaigns based on the likelihood to develop the disease after a certain age more than the observation of symptoms.

This Annex presents the model for the symptomatic scenarios only. The tables in this Annex are extracts from the model spreadsheets, in order to provide greater detail for those readers interested in the detailed assumptions. The actual spreadsheet model is available on request.

ANNEX 6A: (SYMPTOMATIC) PROSTATE MODEL ASSUMPTIONS

General inputs and costs of treatment

Time Discount rate, for calculation of present values	3.5%

Cost of treatment of prostate cancer[42]	Total costs of 5 years treatment, 2009
Localised	£8,982
Locally advanced and metastatic	£5,905

Cost of diagnosis[43]

PSA test	£47.24
Further tests (Transrectal ultrasound, biopsy,...)	£333.75

[42] Source: *The economic consequences of prostate and bladder cancer in the UK (2004).* This is including the cost of further tests (staging for example) for people who are diagnosed with prostate cancer

[43] Source: NHS unit cost data This includes average costs for initial diagnosis, i.e.transrectal ultrasound examination, biopsy, etc.

Survival rates and mean survival years

	Mean survival years	5-year survival[44]	#s surviving	1 year survival rate[45]	#s surviving	10 year survival rate est[46]	#s surviving
Localised	20	94%	21,077	97%	21,842	79%	17,789
Locally advanced and metastatic	3.5	28%	2,072	78%	5,855	3%	221
Total / Average	16	77%	23,149	92.25%	27,697	78%	18,010

BAU number of diagnosed per year

Total population diagnosed under BAU - 2004[47]	**30,024**

POPULATION PRESENTING WITH SYMPTOMS			
Current population diagnosed outside screening process			
Total diagnosed after presenting with symptoms per year			**30,024**
Distribution of diagnosed when presenting with symptoms[48]			
Localised	75%	22,518	75%
Locally advanced and metastatic	25%	7,506	25%
Total	**100%**	**30,024**	100%
Total number of people presenting with symptoms			
Total England and Wales males 50+ population			8,543,308[49]
Number of people who are having PSA test			470,758
% people whose PSA test is positive and consequently have further tests			33%[50]
Number of people whose PSA test is positive and consequently have further tests			155,850
% people having further tests who are diagnosed with cancer			19%[51]

[44] *Source: http://www.swpho.nhs.uk/resource/view.aspx?RID=41287l, cancerhelp.org*

[45] *Source: http://www.swpho.nhs.uk/resource/view.aspx?RID=41287*

[46] *Source: Frontier estimate based on http://info.cancerresearchuk.org/cancerstats/incidence/?a=5441*

[47] *Source: http://www.statistics.gov.uk/downloads/theme_health/MB1-37/MB1_37_2006.pdf*

[48] *Source: http://www.pubmedcentral.nih.gov/picrender.fcgi?artid=2704964&blobtype=pdf, cancerhelp.org*

[49] *Source: http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=15095*

[50] *Source: "Symptomatic diagnosis of prostate cancer in primary care: a structured review", William Hamilton and Deborah Sharp*

[51] *Source: "Symptomatic diagnosis of prostate cancer in primary care: a structured review", William Hamilton and Deborah Sharp*

Distribution of diagnosed under BAU - total[52]		
Localised	22,518	75%
Locally advanced and metastatic	7,506	25%
Total	30,024	100%

People having PSA test	470,758
People having Further tests (Transrectal ultrasound, biopsy,...)	155,850

Policy effects

Starting year of the policy: 2012

Cost of policy

Cost of PSA test	£47.24
Further tests (Transrectal ultrasound, biopsy,...)	£333.75

Increasing awareness of the population	
Total England and Wales 50+ male population	8,543,308
TARGET: Total long term number of people diagnosed at a locally advanced stage as a percentage of current number of people diagnosed at a locally advanced stage	50%
Total long term number of people diagnosed at a locally advanced stage	3,753
Frequency of testing (years)	1
Symptomatic population	1,742,835
Share of population tested	64%
Number of people tested per year	1,106,796
% of tested with PSA test whose PSA is high and need to have further tests	33%
Number of tested with PSA test whose PSA is high and need to have further tests	366,418
% of people tested with further tests (Transrectal ultrasound, biopsy,...) who have prostate cancer	19.3%
Number of people tested with further tests (Transrectal ultrasound, biopsy,...) who have prostate cancer	70,589

[52] Here there is currently no screening campaign and no awareness policy so the total number of people diagnosed is equal to the number of people diagnosed after presenting with symptoms.

Distribution of diagnosed population during the first year of awareness policy[53]

	%	Number of diagnosed
Localised	89%	62,595
Locally advanced and metastatic	11%	7,995
Total	100%	70,589

Impacts of policy

Impact - 1st year of policy

Total additional people tested with PSA test the first year	636,038
Total additional people having further tests (Transrectal ultrasound, biopsy,...) per year due to policy	210,568
Total population diagnosed the first year of policy, thanks to awareness campaign	70,589

Impact - Long term equilibrium in number of diagnosed - not including growth trend

Total additional people tested with PSA test the first year	**636,038**
Total additional people having further tests (Transrectal ultrasound, biopsy,...) per year due to policy	210,568
Total number of diagnosed per year	70,589
Total additional number of people having PSA test in long term	636,038
Total additional number of people having Further tests (Transrectal ultrasound, biopsy,...) in long term	210,568

Evolution of cancer if not treated

	Duration of stages (in months)	Duration of stages (in years)
Localised	54.0	4.5
Locally advanced and metastatic	5.0	0.4
Total	12	4.9

Policy - Change in diagnosed population and proportions by stage

Changes in aware population

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7 etc
Localised	0	62,595	62,595	62,595	62,595	62,595	66,592	66,836
Locally advanced and metastatic	0	7,995	7,995	7,995	7,995	7,995	3,997	3,753
Total	0	70,589	70,589	70,589	70,589	70,589	70,589	70,589

[53] Source: Population-based prostate-specific antigen testing in the UK leads to a stage migration of prostate cancer

Changes in total population diagnosed		2012	2013	2014	2015	2016	2017	2018 ->
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7 ->
Localised	22,518	62,595	62,595	62,595	62,595	62,595	66,592	66,836
Locally advanced and metastatic	7,506	7,995	7,995	7,995	7,995	7,995	3,997	3,753
Total	**30,024**	**70,589**	**70,589**	**70,589**	**70,589**	**70,589**	**70,589**	**70,589**

Policy - transition in additional number of people having colonoscopy / flexible sigmoidoscopy

	2012	2013	2014	2015	2016
	Year 1	Year 2	Year 3	Year 4	Year 5 ->
Additional number of people having PSA test	636,038	636,038	636,038	636,038	636,038
Additional number of people having Further tests (Transrectal ultrasound, biopsy,...)	210,568	210,568	210,568	210,568	210,568

ANNEX 6B: PROSTATE CANCER MODEL – RESULTS (SYMPTOMATIC)

1 - Effect of policy on total number of people diagnosed by stage

	year 0	year 1	year 2	year 3	year 4	year 5	year 6	year 7 ->
Localised	22,518	62,595	62,595	62,595	62,595	62,595	66,592	66,836
Locally advanced and metastatic	7,506	7,995	7,995	7,995	7,995	7,995	3,997	3,753
Total	30,024	70,589	70,589	70,589	70,589	70,589	70,589	70,589

2 - impact on average 1-year survival rates at new equilibrium

	Under BAU	Under policy
Localised	21,842	64,831
Locally advanced and metastatic	5,855	2,927
diagnosed expected to survive one year	**27,697**	**67,759**
Diagnosed	30,024	70,589
% diagnosed expected to survive one year	**92.3%**	**96%**

	2023 people surviving under BAU	2023 people surviving under policy
Localised	21,077	62,559
Locally advanced and metastatic	2,072	1,036
diagnosed expected to survive five years	**23,149**	**63,595**
Diagnosed	30,024	70,589
% diagnosed expected to survive five years	**77%**	**90%**

	Expected years of life gained from the policy each year
Total	61,925

2 - impact on costs at new equilibrium

	Equilibrium cost under BAU	Equilibrium cost under policy	% of cost increase
Cost of PSA test	£22m	£52m	6%
Cost of Further tests (Transrectal ultrasound, biopsy,...)	£52m	£122m	15%
Total cost of diagnosing	£74m	£175m	21%
Total cost of treatment	£247m	£623m	79%
Total	£321m	£797m	**100%**
Average cost per diagnosed	£10,686	£11,292	+5.7%

3 - impact on cost NPV

in £millions	2011	2012	2013	2014	2015	2016	2017	2018 ->
Total cost under BAU	£321	£321	£321	£321	£321	£321	£321	£321
Total cost under policy	£321	£784	£784	£784	£784	£784	£796	£797

	Over 50 years	Over 40 years	Over 30 years	Over 20 years
NPV of NHS costs under BAU	£7,526m	£6,852m	£5,901m	£4,560m
NPV of NHS costs under policy	£18,179m	£16,504m	£14,143m	£10,811m
Gain from policy	**-£10,653m**	**-£9,653m**	**-£8,242m**	**-£6,251m**
Total number of life years gained	2,680,344	2,061,099	1,441,854	822,609
Cost/savings of policy per year of life gained	-£3,975	-£4,683	-£5,716	-£7,599

ANNEX 7A: MELANOMA MODEL ASSUMPTIONS

The tables in this Annex are extracts from the model spreadsheets, in order to provide greater detail for those readers interested in the detailed assumptions. The actual spreadsheet model is available on request.

General inputs and costs of treatment

Time Discount rate, for calculation of present values	3.5%

Cost of treatment[54]	Unit cost
Stage 1	£1,373
Stage 2	£3,340
Stage 3	£4,822
Stage 4	£5,302
Unknown	£4,872

Cost of diagnosis

percentage of patients who will go through 3 outpatient appointments for diagnosis	26.5%[55]
Biopsy (exc. cost of outpatient visit)	£180
Unit cost of 1 to 2 additional outpatient appointments	£107

Survival rates and mean survival years

	Mean survival years[56]	5-year survival[57]	#s surviving	1 year survival rate[58]	#s surviving
Stage 1	35	97%	6,190	99%	6,317
Stage 2	30	76%	1,378	96%	1,740
Stage 3	10	58%	505	91%	792
Stage 4	2	15%	22	36%	52
Unknown	10	56%	81	80%	116
Total / Average	30.65	87.4%	8,175	96.4%	9,017

BAU number of diagnosed per year

Total population diagnosed under BAU	9,354

[54] Source: *Frontier based on NHS data and publicly available data.* This includes the cost of the announcement visit where patients learn that they have melanoma, as well as the cost of staging when necessary.

[55] This is Frontier's assumption on the percentage of patients who will go through 2 outpatient appointments for diagnosis instead of one. Note that the cost of the announcement visit where patients learn that they have melanoma is included in the costs of treatment, as well as the cost of staging.

[56] Source: Frontier estimate

[57] Sources: http://www.cancerhelp.org.uk/type/melanoma/treatment/melanoma-statistics-and-outlook. Total from Rachet & al. Confirmed by midsummer night's dream article.

[58] Sources: Total from NCIN. Melanoma epidemic: a midsummer night's dream? 1-year survival rate for >4mm: Frontier estimate based on Eurocare average.

POPULATION PRESENTING WITH SYMPTOMS

Current population diagnosed outside screening process	
Size of the potentially risky population[59]	44,235,000
Current incidence per 100,000	21
Total diagnosed after presenting with symptoms per year	**9,354**

Distribution of diagnosed when presenting with symptoms[60]			
		BAU number of diagnosed when presenting with symptoms	
Stage 1	68%	6,381	68%
Stage 2	19%	1,813	19%
Stage 3	9%	870	9%
Stage 4	2%	145	1.55%
Unknown	2%	145	1.6%
Total	**100%**	**9,354**	100%

Total number of people presenting with symptoms[61]	
% of diagnosed per people going through biopsy	50.0%
Number of people going through biopsy	18,708
% referrals who have melanoma[62]	10.0%
number of people referred	93,540

Distribution of diagnosed under BAU - total

Stage 1	**6,381**	68%
Stage 2	**1,813**	19%
Stage 3	**870**	9%
Stage 4	**145**	2%
Unknown	**145**	2%
Total	**9,354**	100%

People having biopsy	**18,708**

Policy effects

Starting year of the policy	2012

Increasing awareness

Total risky population	44,235,000

[59] Source: National statistics online - all men and women from 15 to 99

[60] Source: Midsummer night dream

[61] Source: Frontier assumption

[62] Sources: 2006 study from Sheffield (Westbrook et al 2006) quoted in " Skin conditions in the UK: a health care needs assessment" from Julia Shoffield, Cox 2004

The likely impact of earlier diagnosis of cancer on costs and benefits to the NHS

Potential incidence if everyone tested[63]	**26.54**
Total incidence if everyone tested	11,741
TARGET: Total long term number of people diagnosed at stage 4 as a percentage of current number of people diagnosed at stage 4[64]	**35%**
TARGET Total long term number of diagnosed at stage 4	51
Long term number of diagnosed at stage 4 if everyone tested	0
Actual total number of diagnosed at stage 4 after presenting with symptoms[65]	51
Derived total number of diagnosed	10,905
Number of diagnosed after presenting with symptoms	3,274
Number of diagnosed because they are aware	7,631
Number of people tested with biopsy per year	21,810
% of biopsies that are diagnosed with melanoma for people viting because they are aware[66]	50.0%
Number of people referred per year	109,052
% referrals who have melanoma	10.0%

Incidence for aware people during the first year of the policy[67]

	Incidence (%)
Stage 1	73.73%
Stage 2	17.63%
Stage 3	8.27%
Stage 4	0.37%
Unknown	0.00%
Total / Average	1.00

Impacts of policy

[63] Frontier assumption based on trends

[64] ="Figure has to be lower than 100%"

[65] This is assuming that the number of people diagnosed at stage 4 after presenting with symptoms is a linear function of the total number of people diagnosed.

[66] Figure has to be lower than or equal to 50%.

[67] Source: Frontier based on http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2121231/figure/fig1/ and midsummer night dream.

The likely impact of earlier diagnosis of cancer on costs and benefits to the NHS

Impact - 1st year of policy

Total additional people having biopsy per year due to policy	15,263
Total number of people having biopsy	33,971
Total additional people referred to secondary care per year due to policy	76,313
Total number of people referred	169,853
Total aware population diagnosed the first year of policy	7,631
Total population diagnosed after presenting with symptoms the 1st year of policy	9,354

Impact - Long term equilibrium in number of diagnosed - not including growth trend

Total additional people having biopsy per year due to policy	15,263
Total number of people having biopsy	21,810
Total additional people referred to secondary care per year due to policy	76,313
Total number of people referred	109,052
Total number of diagnosed per year	10,905
Long term number of people diagnosed through awareness campaign	7,631
Total number of people still diagnosed after presenting with symptoms	3,274

Evolution of cancer if not treated

	Duration of stages (in months)	Duration of stages (in years)
Stage 1[68]	50	4.2
Stage 2[69]	50	4.2
Stage 3[70]	14	1.2
Stage 4[71]	10	0.8
Total	124	10.3

Policy - Change in diagnosed population and proportions by stage

Changes in aware population	0 Year 0	1 Year 1	2 Year 2	3 Year 3	4 Year 4
Stage 1	0	5,626	5,626	5,626	5,626
Stage 2	0	1,346	1,346	1,346	1,346
Stage 3	0	631	637	643	651
Stage 4	0	28	22	16	8
Unknown	0	0	0	0	0
Total	0	7,631	7,631	7,631	7,631

Changes in number of people diagnosed after presenting with symptoms	Year 0	Year 1	Year 2	Year 3	Year 4
Stage 1	6,381	6,381	5,966	5,551	5,137
Stage 2	1,813	1,813	1,695	1,577	1,459
Stage 3	870	870	814	757	700

[68] Source: Melanoma - part 1 - epidemiology, risk factors and prevention

[69] Source: Melanoma - part 1 - epidemiology, risk factors and prevention

[70] Source: Frontier assumption

[71] Source: Frontier assumption.

Stage 4	145	145	136	126	117
Unknown	145	145	136	126	117
Total	9,354	9,354	8,746	8,138	7,530

Changes in total population diagnosed (including growth trend)					
		2012	**2013**	**2014**	**2015**
	Year 0	Year 1	Year 2	Year 3	Year 4
Stage 1	**6,381**	**12,007**	**11,593**	**11,178**	**10,763**
Stage 2	**1,813**	**3,158**	**3,041**	**2,923**	**2,805**
Stage 3	**870**	**1,502**	**1,451**	**1,400**	**1,352**
Stage 4	**145**	**173**	**158**	**142**	**125**
Unknown	**145**	**145**	**136**	**126**	**117**
Total	**9,354**	**16,985**	**16,377**	**15,769**	**15,161**

Total number of people having biopsy	18,708	33,971	32,755	31,539	30,323
Total number of people referred to secondary care	93,540	169,853	163,773	157,693	151,613

ANNEX 7B: MELANOMA MODEL – RESULTS

1 - Effect of policy on total number of people diagnosed by stage

	year 0	year 1	year 2	year 3	year 4	year 5
Stage 1	6,381	12,007	11,593	11,178	10,763	10,348
Stage 2	1,813	3,158	3,041	2,923	2,805	2,687
Stage 3	870	1,502	1,451	1,400	1,352	1,303
Stage 4	145	173	158	142	125	107
Unknown	145	145	136	126	117	107
Total	9,354	16,985	16,377	15,769	15,161	14,553

2 - impact on average 1-year survival rates at new equilibrium

	Under BAU	Under policy
Stage 1	6,317	9,113
Stage 2	1,740	1,242
Stage 3	792	277
Stage 4	52	18
Unknown	116	41
diagnosed expected to survive one year	**9,017**	**10,691**
Diagnosed	9,354	10,905
% diagnosed expected to survive one year	**96%**	**98%**

	2023 people surviving under BAU	2023 people surviving under policy
Stage 1	6,190	8,929
Stage 2	1,378	983
Stage 3	505	177
Stage 4	22	8
Unknown	81	28
diagnosed expected to survive five years	**8,175**	**10,125**
Number of people having further tests	9,354	10,905
% diagnosed expected to survive five years	**87%**	**93%**

	Expected years of life gained from the policy each year
Total	22,202

2 - impact on costs at new equilibrium

First year of policy implementation	2012
Year used to compare steady states	2023

The likely impact of earlier diagnosis of cancer on costs and benefits to the NHS

	Equilibrium cost under BAU	Equilibrium cost under policy	% cost increase
cost of GP	£10m	£12m	17%
Cost of biopsy	£3m	£4m	17%
Total cost of diagnosing	£13m	£16m	17%
Total cost of treatment	£20m	£19m	-8%
Total	£34m	£35m	2%
Average cost per diagnosed	£3,625	£3,172	

first year of policy implementation	2012

	2011	2012	2013	2014	2015
Total cost under BAU	£34m	£34m	£34m	£34m	£34m
Total cost under policy	£34m	£60m	£58m	£56m	£54m

	Over 50 years	Over 40 years	Over 30 years	Over 20 years
NPV of NHS costs under BAU	£795	£724	£624	£482
NPV of NHS costs under policy	£929	£856	£754	£609
Gain from policy	**-£134**	**-£132**	**-£130**	**-£127**
Total number of life years gained	2,531,927	2,309,911	2,087,896	1,865,881
Cost/savings of policy per year of life gained	-£53	-£57	-£62	-£68

SOURCES

	Colorectal	Breast	Lung	Melanoma	Prostate
Current incidence by stage	Steele et al., National Cancer Intelligence network, Eurocare IV	"a UK analysis of all symptomatic and screen detected breast cancers diagnosed in 2006", Cancer Research UK (CRUK)	National lung cancer audit (NHS)	Source: "Melanoma epidemic: a midsummer night's dream?" (Levell et al., 2009)	pubmedcentral .nih.gov
Current 1-year relative survival rates by stage	NCIN	CRUK	Frontier estimate based on Eurostat, and Goldstraw et al (2007)	Source: cancerhelp.org, rachet et al, "Melanoma epidemic: a midsummer night's dream?" (Levell et al., 2009)	swpho.nhs.uk
Current 5-years relative survival rates by stage	NCIN	*Frontier estimate based on CRUK observed survival rates*	Frontier estimate based on Eurostat, and Goldstraw et al (2007)	Source: cancerhelp.org, rachet et al, Levell et al., 2009 op cit.	swpho.nhs.uk
Mean survival years by stage	ScHARR[72]	*Frontier estimate based on survival rates*	*Frontier estimate based on survival rates*	*Frontier estimate based on survival rates*	*Frontier estimate based on survival rates*
Unit cost of diagnosis	ScHARR	NHS breast screening programme (2009), NHS unit cost data	ScHARR on colorectal cancer	ScHARR on colorectal cancer	ScHARR on colorectal cancer
Unit cost of treatment	ScHARR	ScHARR	Fleming et al (2008)	*Frontier estimate based on detailed skin cancer model*	*"The economic consequences of prostate and bladder cancer in the UK" (2004)*
Target average relative survival rates	Eurocare IV SEER	Eurocare IV SEER	Eurocare IV SEER	Frontier based on Eurocare IV, SEER and other sources	Eurocare IV SEER
Long term incidence with	Screening data (provided by	NHS breast screening data	*SEER*	Levell et al. (2009), *Frontier*	*Driven by assumption on*

[72] The ScHARR research is written up in the following reports:

Bowel Cancer Services: Costs and Benefits - Summary Report to the Department of Health, from YHEC and SCHARR, Paul Trueman et al, April 2007
Estimating the costs of bowel cancer services provided by the National Health Service in England, by Bending et al, YHEC, undated.
The costs and benefits of bowel cancer service developments using discrete event simulation, by Pilgrim et al, in Journal of Operational Research Society, 2008.

	Colorectal	Breast	Lung	Melanoma	Prostate
awareness campaign	Faye Taylor)				*number of men still diagnosed at late stage*
% people positive at first test	"Bowel cancer screening" The Facts NHS Cancer Screening Programme	"The accuracy of "one-stop" diagnosis for 1110 patients presenting to a symptomatic breast clinic"	*Frontier assumption*	*Frontier assumption*	"Symptomatic diagnosis of prostate cancer in primary care: a structured review", William Hamilton and Deborah Sharp
% people positive at further test	"Bowel cancer screening" The Facts NHS Cancer Screening Programme	*Frontier assumption*	*Frontier assumption*	2006 study from Sheffield (Westbrook et al 2006) quoted in " Skin conditions in the UK: a health care needs assessment" from Julia Shoffield, Cox 2004	William Hamilton and Deborah Sharp op cit.

Cancer	*Experts*
Colorectal	David Forman Sue Moss Julietta Patnik
Breast	Julietta Patnik
Lung	Mick Peake Rupert Suckling
Prostate	Jane Wolstenholme
Skin	Julia Schofield