Estimating the costs of health inequalities

A report prepared for the Marmot Review

February 2010

Introduction

Sir Michael Marmot was commissioned to lead a review of health inequalities in England post 2010. The aim of the review is to propose an evidence based strategy for reducing health inequalities in England from 2010. Frontier was commissioned by the Marmot Review to carry out a short piece of work to estimate the cost of prevailing health inequalities in England. Given the short time scale for the work (4 weeks), our analysis did not seek to capture the full range of complex changes that would result from decreased health inequalities.

Rather our approach has been to focus on a small number of well-understood indicators with the aim of identifying the order of magnitude of costs associated with health inequalities. The indicators used in our analysis include:

- life expectancy;
- disability free life expectancy;
- producitivity losses[1];
- impact on government receipts and expenditures [1]; and
- direct costs to the NHS.[2]

It is important to note that these calculations do *not* seek to estimate the benefits of implementing the policy recommendations of the Review. Instead, they give some scale of the potential benefits which could be obtained through reduced health inequalities.

The remainder of this pack is structured as follows:

- approach and data sources;
- key findings;
- summary; and
- annexes.

[1] Our estimates of these costs have been obtained by modifying previous estimates of total costs of illness to find the proportion attributable to health inequalities. While we have carried out additional cross-checks where feasible, the methodology behind the original estimates has not been assessed.

[2] We interpret the results of an existing study

The costs of health inequality

To estimate the economic costs associated with health inequalities we need to identify:

- The costs associated with health inequality – what types of costs are imposed on society as a result of health inequalities, and
- The appropriate counterfactual – to identify the costs of inequality we need to compare outcomes today against the outcomes we would observe if health inequalities were eliminated or substantially reduced

In line with the standard literature on health inequalities, we have identified three major categories of cost imposed by health inequality:

- **Premature death and disability:** the greatest impact of health inequalities is premature death and disability. When we examine life expectancy by neighbourhood income or social class, we see that average life expectancy and years of disability free life are considerably higher for people living in higher income neighbourhoods or in higher social classes. Using standard measures for the value of life we can value the cost of premature death associated with health inequality. However, care must be exercised in interpreting this value, as it is not a direct cost imposed on government or society, but rather a way of quantifying by far the most disturbing effects of health inequalities.
- **Days of work lost:** working-age illness resulting from health inequalities leads to two types of cost:
  - Productivity losses if individuals are less capable of work. This represents an overall cost to the economy
  - Lost taxes and increased welfare payments due to worklessness. This is a cost borne by the government, but will not affect the economy as a whole (since taxes and welfare payments are transfers from one group of people to another)
- **Direct costs to the healthcare system:** The additional costs incurred by the health services in treating illnesses and disease arising as a result of health inequalities

Defining the counterfactual

There is no absolute measure of health inequality. Rather, one's assessment of the costs imposed by health inequalities depends on the counterfactual against which one compares today's health outcomes. Our focus has been to examine health inequalities related to income, although similar analysis could be conducted on the basis of social class.

The life expectancy and disability-free life expectancy data are available at a neighbourhood level, where each neighbourhood contains around 7,000 individuals. Both average income and health outcomes, for example life expectancy and disability-free life expectancy, vary across neighbourhoods. In general, areas with lower average incomes experience lower life expectancies, as illustrated in figure 1 below.

For our analysis of the costs of inequality we have used two different counterfactuals:

- **Counterfactual 1:** Assume that all neighbourhoods have the same distribution of health outcomes (life expectancy and years of disability free life) as the top decile of neighbourhoods as measured by neighbourhood income. It is important to note here that areas are ranked by income and not by life expectancy – our focus is on the costs associated with health inequalities associated with income. See figure 2 for an illustration.
- **Counterfactual 2:** Assume that all neighbourhoods have the same distribution of health outcomes as the top half of neighbourhoods as measured by neighbourhood income (figure 3)

It can be seen that these counterfactuals lead to a discontinuity in the relationship between income and health. While this is unrealistic, the effect upon aggregate health indicators would be the same as applying the distribution of health outcomes of the top 10% or 50% of the population to the entire population (figure 4 illustrates this for counterfactual 1). Finally, note that health inequalities *within* areas are not taken into account.

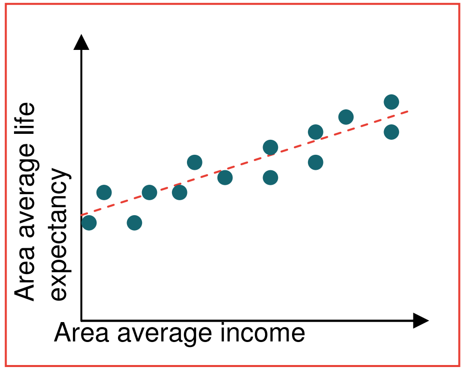


Figure 1: Existing income/health distribution across areas

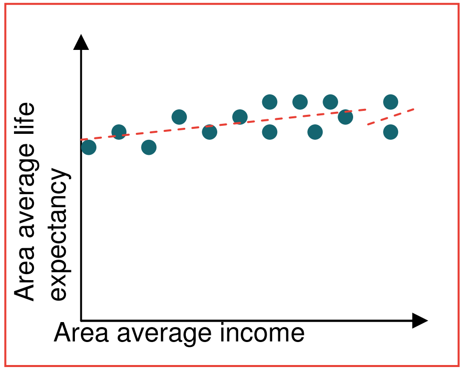


Figure 2: Illustration of counterfactual 1

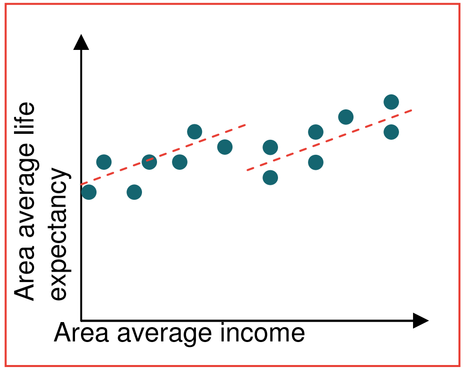


Figure 3: Illustration of counterfactual 2

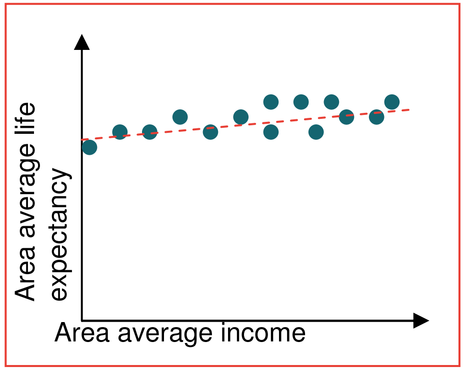


Figure 4: Equivalent to counterfactual 1

Data sources

The table below summarises the sources of data which have been used for this analysis.

Dataset	Link	Used for
MSOA LE DFLE Index of deprivation years lost	Supplied by Marmot Review, based on Office for National Statistics data http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=12964	Income, life expectancy and DFLE for each MSOE area
Middle Layer Super Output Area population estimates for England and Wales, mid-2008 (experimental)	http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=14357	Size and composition of each MSOE area
English life tables (period and cohort)	http://www.statistics.gov.uk/downloads/theme_population/NPP2008/wEngcohort08.xls ; http://www.statistics.gov.uk/downloads/theme_population/NPP2008/wEngperiod08.xls	Estimating cohort life expectancies at different ages from period life expectancy at birth
Death rates by age (2004)	http://www.statistics.gov.uk/STATBASE/Expodata/Spreadsheets/D8983.xls	Estimating the composition of the death cohort
2008-based national population projections	http://www.statistics.gov.uk/downloads/theme_population/NPP2008/wengsumcc.xls	Size of the birth and death cohorts for 2010

Years lost due to premature death – results

There are a number of ways of thinking about the costs associated with health inequalities. Here, we focus on the cohort of children born in 2010, and consider the increased life expectancy this group would enjoy were policies implemented that reduced or eliminated health inequalities. Annexe A includes alternate calculations (looking at the entire population or the cohort who would otherwise die in 2010) and attempts to place a monetary value on the number of years lost to inequality. The technical annexe sets out in detail how we have calculated the numbers presented in the following slides.

The table below shows the benefits from greater life expectancy that will accrue **to those individuals born in 2010**. This is the first cohort that would be expected to feel the full impact of any policies which reduced health inequalities.

	Counterfactual 1: All neighbourhoods have the same distribution of health outcomes as the top decile of neighbourhoods by income	Counterfactual 2: All neighbourhoods have the same distribution of health outcomes as the upper half of neighbourhoods by income
Total number of years of life lost due to health inequalities	1.3 million	0.8 million
Average years of life lost to health inequalities per person	2	1.3

It can be seen that:

- If health inequalities were reduced as described in counterfactual 1, those born in 2010 could expect to live, between them, an extra 1.3 million person-years (0.8 million under the more conservative second counterfactual). This can be considered the total number of years which are currently lost due to health inequalities.
- Around 664,000 children are expected to be born in 2010. If the above increases in life expectancy were allocated evenly among the cohort, each child could expect to live for around two extra years (1.3 years under the second counterfactual).

Years lost due to premature disability – results

The table below considers the benefits from greater disability-free life expectancy that will accrue **to those individuals born in 2010**. Further details are presented in the two annexes.

	Counterfactual 1: All neighbourhoods have the same distribution of health outcomes as the top decile of neighbourhoods by income	Counterfactual 2: All neighbourhoods have the same distribution of health outcomes as the upper half of neighbourhoods by income
Total number of years of DF life lost due to health inequalities	2.8 million - 4.1 million	1.7 million - 2.5 million
Average years of DF life lost to health inequalities per person	4.1 - 6.1	2.5 - 3.8

The figures above are given as ranges. This is due to the data potentially double-counting increases in lifespan:

- Total disability-free years of life have been calculated for each area under the existing situation and the two counterfactuals. As with life expectancy, the difference between the two indicates the aggregate number of years of life lost to disability by the birth cohort (e.g. 4.1 million years under counterfactual 1).
- Some of this increase may just be due to increases in life expectancy already taken into account on the previous slide. At the extreme, it could be the case that no-one within an area is expected to become disabled (their disability-free life expectancy is equal to their life expectancy). Any increase in life expectancy would increase disability-free life expectancy by the same amount. To remove any such double-counting, we have taken away the years of life gained (previous page) from the years of disability-free life gained (e.g. 4.1m – 1.3m = 2.8m for counterfactual 1).

In reality, the average additional years of disability-free life (those not already taken account of) is likely to be somewhere between 2.8m and 4.1m. Data deficiencies (the lack of cohort disability-free life expectancies) will also affect these calculations; this is explained in the technical annexe.

Economic losses resulting from health inequalities

Every year, health inequalities result in substantial levels of working age ill-health and disability. This in turn has a direct impact on the economy in terms of:

- **Lost output:** Individuals experiencing ill-health or disability may not be able to work as much as healthy individuals, or may have to leave the labour force altogether. Health inequalities will therefore decrease the total output of the economy.
- **Reduced taxes:** Individuals who are unable to work (or work for fewer hours or pay) due to health inequalities will pay less income tax and national insurance contributions to the government.
- **Higher welfare payments:** In addition to lower tax-receipts, ill-health causes by health inequalities will result in the government having to spend more on benefits.

To estimate the costs associated with this aspect of health inequality, we have used the findings from the Black Review of working age ill-health (*Working for a Healthier Tomorrow*). This 2008 study provided estimates of the costs, as defined above, caused by all working-age ill-health. Only some of this ill-health will be a result of health inequalities (even in a perfectly equal world there will be illness and disability). Using neighbourhood-level data on disability free life expectancies, we have attempted to estimate the proportion of these costs attributable to health inequalities.

These results are clearly dependent on the validity of the original Black Review figures. While we have not been able to check the method used to calculate them, we have carried out some simple cross-check to verify the order of magnitude of the costs. These utilise data on Incapacity Benefits payments.

The following slides set out the findings from these approaches. We note that these costs relate only to the productivity losses associated with ill health. Obviously premature death before the age of 65 will also have productivity impacts, however, we do not attempt to measure these here

Costs due to working age ill-health (Black Review)

Working for a Healthier Tomorrow provides estimates the costs of all working age health in the UK, which are reproduced on the right.

- The cost of lost production is £63bn. We have not included sickness absences since, unlike long-term disability, we have no data which would indicate the proportion of this cost that is due to health inequalities.
- The cost to the government from both increased benefits and lost taxes is between £57bn and £65bn. The costs to the NHS of health inequality are not included in our calculations.

These figures alone substantially over-state the costs of health inequality in England since:

- they relate to the whole of the UK and not just England; and
- even if health inequalities were eliminated entirely we would still expect some working age ill-health to occur.

The following slide shows how we account for these factors.

Costs to government of working-age ill health

Type of cost	2007 cost (£bn)
Worklessness – benefits	29
Healthcare	5 - 11
Forgone taxes	28 - 36

Source: Black Review

Costs to total economy of working-age ill health

Type of cost	2007 cost (£bn)
Worklessness – lost production	63
Sickness absence	10
Informal care	25-45
Healthcare	5-11

Source: Black Review

Health inequalities are estimated to give rise to economic losses of £31-33 billion

The Black Review figures on the previous page need scaling to account for those costs of working age ill-health attributable to health inequalities. To determine the amount by which they should be reduced we have used the same disability-free life expectancy data used for the prior calculations of years of life lost:

- The disability-free life expectancy data indicate that all individuals currently living are expected to loose 207 million years to disability before the age of 65[1]
- To determine an equivalent number without health inequalities, we use the counterfactual 1 health outcomes. Under this scenario, just 84 million years of life are lost to disability before the age of 65.
- We therefore estimate that 123 million years of working age disability are avoidable by reducing health inequalities to the level implied in counterfactual 1 (207 million minus 84 million). This is 59% of the total years lost at present.
- Assuming that the Black Review figures refer to total working-age disability, we hypothesise that 59% of the costs are associated with income-based health inequalities.

It is also necessary to scale the figures for the English population, which constitutes around 84% of the entire UK (this ignores any systematic differences that may exist in working-age health across the nations). Multiplying the numbers on the previous slide by both 59% and 84%, we estimate that:

- Health inequalities result in lost production of **£31 billion**
- The cost to the government of higher benefit payments and lost taxes resulting from health inequalities is between **£28 and £32 billion**

[1] Our data only provides average area disability-free life expectancy. Estimating each individual's disability-free lifespan until the age of 65 is a non-trivial calculation which depends on the distribution of disability-free lifespans within each area. The technical annexe explains how we have attempted to resolve this issue, but it should be borne in mind that these figures are subject to a large degree of uncertainty.

Simple cross-checks agree with the scale of the Black Review numbers

As a cross check, we also considered payments to Incapacity Benefit recipients. 2.7 million people were on incapacity benefit in February 2009. Assuming average productivity of £25,000 (the median pay for fulltime employees in the UK) implies lost productivity of £67.5bn. As before, we must adjust this figure for England and to account only for health inequalities. The resulting cost is **£33billion** per year, which is close to the above estimate of £31 billion derived from the Black Review numbers.

We have also used this methodology to cross-check the tax and welfare losses associated with health inequality:

- For tax losses, we take the lost production figure of £33 billion, and apply an average tax rate of 30% - this suggests a tax loss of **£10 billion**
- For welfare losses, we know that total spending on benefits for disabled people in the UK is around £20 billion (CEP 2004). Applying our discount rates to adjust the figures for England and to account only for health inequalities, suggests a benefit saving of **£10 billion.**

This suggests a cost to government of **£20 billion,** which is somewhat lower than the estimates we derive from figures from the Black review (£28 - £32 billion),

Health inequalities may cost the NHS £5.5 billion per year

This slide summarises the findings of work provided to Frontier by the Marmot Review[1]

This study considers the direct cost to the NHS of treating illness and ill-health arising from health inequalities. To estimate the direct health costs the paper compares the current NHS treatment budget to an estimate of what the treatment budget might be if all areas had the same level of health as a set of reference areas with good health (and, as a result, the same level of use of healthcare services).

The paper presents estimates separately for acute activity, prescribing activity and mental health activity. It finds that:

- For acute activity, expenditure would be 10-17% lower in the absence of health inequalities
- For prescribing activity, expenditure would be 4-6% lower in the absence of health inequalities
- For mental health activity, expenditure would be 20-50% lower in the absence of health inequalities

Overall, the paper suggests that total treatment costs would be **15% lower in the absence of health inequalities.** Given a total treatment budget of £37 billion, this implies a direct cost to the NHS of £5.5 billion as a result of health inequalities.

We note that this figure is most likely a lower bound, as it does not include a range of health costs (i.e. primary care) that might be expected to also be affected by inequality. The figure of £37 billion covers only approximately one third of the total health budget.

[1] Morris S (2009) Private communication

Summary of findings

Almost all countries in the world suffer from pervasive health inequalities – in almost every country poor people die younger and suffer more years of diminished health. When proposing policies to reduce health inequalities the most common argument put forward is equity. However, health inequalities also impose significant economic costs. Our work has examined the costs imposed by health inequalities by comparing the present to a world in which everyone had the same health outcomes as the richest 10% of the population. We find that health inequalities lead to:

- Productivity losses of £31-33 billion per year
- Lost taxes and higher welfare payments in the range of £20-32 billion per year
- Direct NHS healthcare costs of £5.5 billion (note, this figure relates only to costs associated with acute activity, prescribing and mental health activity, which represent approximately one third of the NHS budget. In consequence, it is likely that this figure under estimates the full impact of health inequalities on direct healthcare costs).

Most stark, however, are the impact of health inequalities on premature death. Looking at the nearly 700,000 children who will be born in 2010, we find that if policies could be implemented to eradicate health inequalities, then each child could expect to live two years longer. This represents approximately 1.3 million total years of life currently lost to health inequalities. An additional 2.8 million years of disability-free life could be added by removing health inequalities.

It should be noted that the aim of these figures is to illustrate the benefits that would be achieved were inequalities to be eradicated immediately. Obviously, there is no world in which this could happen, but the figures are helpful for providing an indication of the likely scale of the costs of health inequalities.

- Approach and data
- Key findings
- Summary
- Annexe A: Other cohort and population estimates
- Annexe B: Technical details

Years lost due to premature death and disability – alternative approaches

In the main document we presented estimates of the years lost to premature death and disability for the cohort of children born in 2010. While this is an intuitive measure, there are at least two further methods which could be used:

Total number of years of life lost for the cohort of people who are expected to die in 2010

Around 450,000 people will die in England in 2010. In the absence of health inequalities, many would have lived for longer. Unlike the "birth cohort", this "death cohort" will comprise people of many different ages. In addition, the age structure of the cohort will vary across areas: in an area with good health, those who die in a given year will tend to be older than those dying in a worse-off area. As a simplification, we have applied the distribution of ages of death for the English population as a whole to each area. For example, around 6.7% of 80 – 85 year olds died in 2004. We therefore include 6.7% of life years from this age band in the "death cohort", regardless of the area-specific death rates. It is then possible to calculate total years of life under the counterfactuals and thus estimate the number of years that are lost compared to this.

Since these individuals would have died in 2010, no discounting is required. It must however be stressed that the resulting financial costs are *not* immediately attainable by any policy. In reality, the individuals who would otherwise have died in 2010 would receive very little benefit from a policy implemented that year.

Total number of years of life lost for the entire population due to health inequalities

This approach applies the two counterfactuals to the entire population of the country, not just one cohort. We ask how many extra years each person in the country would expect to live under conditions of health equality and sum these together. This figure will be much greater than any ongoing annual cost of inequalities, as it considers all cohorts currently alive.

The following slides provide estimates of the cost of inequality using all three methods. We have also attempted to place a monetary value on the costs of premature death, as explained in the following slide.

Valuing the cost of a year of life

Once we have established measures of the years of life lost, it is possible to place a value on that life. This is a complex (and controversial) matter. Nevertheless, it is possible to imply people's willingness-to-pay for an extra year of life by observing decisions they make that affect the chances of mortality. The technical annexe describes a number of different values for life, but here we are using the Department for transport's figure of £58,000.

We assume that the additional years of life occur at the end of an individual's life, in the future. It is therefore necessary to discount these values (we use the Green Book discount rate of 3.5% per year). It should be stressed that the resulting figure is subject to many uncertainties, not least the assumed value of life. It should not be considered as the annualised cost of health inequalities.

We do not attempt to directly value the cost of years lost to disability in such a way. It is extremely hard to place a subjective value on the cost of a year of disability, and our data do not provide any indication of the typical severity of disability suffered.

Years lost due to premature death – results

Counterfactual 1: All neighbourhoods have the same distribution of health outcomes as the top decile of neighbourhoods by income

	Costs based on total population	Costs based on birth cohort	Costs based on death cohort
Total number of years of life lost due to health inequalities	98 million	1.3 million	0.6 million
Average years of life lost to health inequalities per person	2	2	1.3
Discounted cost of life lost due to health inequalities	£1,500bn	£3.5bn	£36 bn

Counterfactual 2: All neighbourhoods have the same distribution of health outcomes as the upper half of neighbourhoods by income

	Costs based on total population	Costs based on birth cohort	Costs based on death cohort
Total number of years of life lost due to health inequalities	58 million	0.8 million	0.4 million
Average years of life lost to health inequalities per person	1.2	1.3	0.8
Discounted cost of life lost due to health inequalities	£900bn	£2.2bn	£20 bn

The tables above present the key findings from our analysis for each of the counterfactuals we used. It is important to consider carefully the interpretation of these findings, none of which represent an annualised cost of health inequality: We discuss below with reference to counterfactual 1, however, the same interpretation applies to the figures under counterfactual 2.

- The total population figures set out the benefits that would be achieved if health inequalities were immediately removed for the existing population of England. They show that if health inequalities were removed people would live, on average for 2 years longer. The benefits of £1,500 bn have been discounted to take into account the fact that these benefits would accrue in the future
- The birth cohort figures demonstrate the benefits that would accrue to the cohort of children born in 2010 if health inequality were to be eradicated. We see that children born in 2010 could each expect to live 2 years longer on average in the absence of health inequalities. The value placed against this increased life expectancy is relatively low, at £3.5 billion. This reflects the fact that although there is a substantial benefit to the cohort born in 2010, they do not enjoy that benefit for 70-80 years, and so the value today is much lower.
- The death cohort figures show how much longer the individuals who will die in 2010 would have lived had health inequalities been eradicated in their lifetimes. The value is considerably higher at £20 billion, because the benefits would have accrued over the short term and so do not need to be discounted.

Years lost due to premature disability – results

Counterfactual 1: All neighbourhoods have the same distribution of health outcomes as the top decile of neighbourhoods by income

	Costs based on total population	Costs based on birth cohort
Total number of years of DF life lost due to health inequalities	187 million - 285 million	2.8 million - 4.1 million
Average years of DF life lost to health inequalities per person	3.7 - 5.7	4.1 - 6.1

Counterfactual 2: All neighbourhoods have the same distribution of health outcomes as the upper half of neighbourhoods by income

	Costs based on total population	Costs based on birth cohort
Total number of years of DF life lost due to health inequalities	113 million - 171 million	1.7 million - 2.5 million
Average years of DF life lost to health inequalities per person	2.2 - 3.4	2.5 - 3.8

As in the main document, these costs are presented as ranges due to the possibility of double-counting.

Since we do not have data on the number of individuals becoming disabled each year, it has not been possible to calculate a "disability cohort" figure (the equivalent of the "death cohort" on the previous slide).

- Approach and data
- Key findings
- Summary
- Annexe A: Other cohort and population estimates
- **Annexe B: Technical details**

Overview of technical annexe

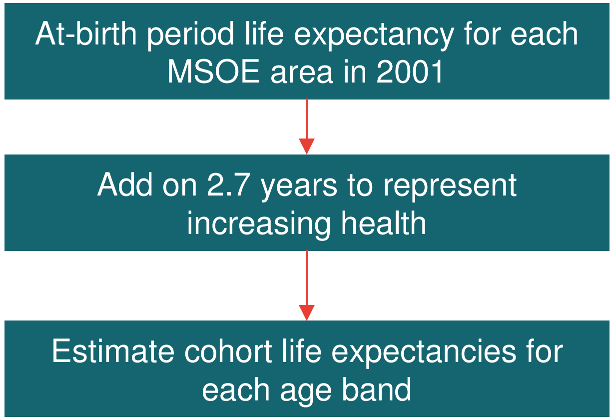
The following pages describe in more detail the methods that have been used to estimate the various costs of health inequalities.

Estimation of years lost to premature death has been carried out by applying the two counterfactuals to current UK data, aggregating total years of life and determining the difference.

Estimation of years lost to premature disability uses a very similar method, focussing on disability-free life expectancy instead of total life expectancy. These calculations are less certain owing to the lack of cohort disability-free life expectancies.

Estimation of *working years* lost to premature disability is required for scaling the Black Review figures. Years of disability before the age of 65 can be estimated from the overall disability-free life expectancies for each area. This requires an extra step in the calculations and an assumption regarding the distribution of disability-free lifespans within each area.

Calculating total years of life lost (1)



The primary data source is ONS data on period life expectancy at birth by MSOE area. This is an average over both males and females; in what follows, we assume each area has the nationwide gender ratio.

Uniformly increasing life expectancy

The ONS life expectancy data is for 2001. By 2010, life expectancies will have increased across the board. 2.7 years are added to each area's life expectancy to take account of this[1] (2.7 year figure provided by the Review).

Estimating cohort life expectancies

There are two key problems with the raw life expectancy data:

- Period life expectancies do not take into account future decreases in mortality. We require cohort life expectancies.
- It is desirable to disaggregate the life expectancy by age: conditional on reaching advanced age, an individual's total life expectancy will be greater than at birth.

We have estimated cohort life expectancies based on historical life tables between 1981 and 2008. This is explained in greater detail on the following slide.

[1] The addition of a constant number of years on to all life expectancies will not actually affect the final results of this calculation. It is included for consistency with the disability-free working years calculations, which are sensitive to this value.

Calculating total years of life lost (2)

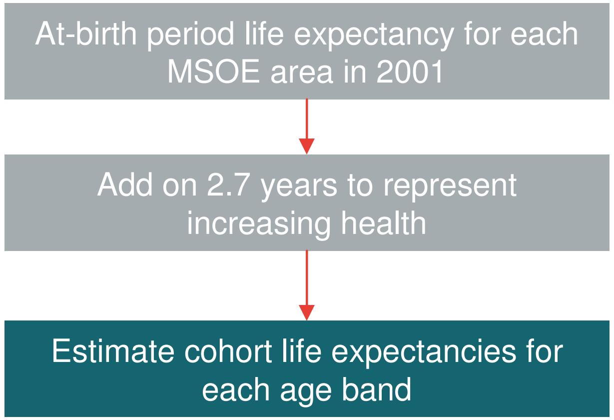
Estimating cohort life expectancies

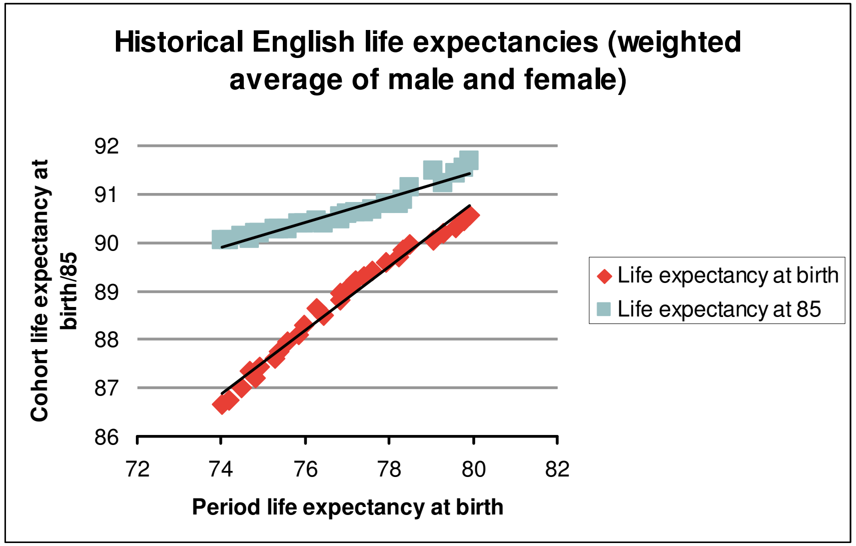
Our area-level data include period life expectancy at birth only. English life expectancies have consistently increased over the years. Using life tables from 1981 to 2008, we carried out a regression for each cohort life expectancies at different ages on period life expectancy at birth. This provides a linear relationship that can be used to derive cohort life expectancies for each area from the period life expectancy at birth.

In using this technique, we are assuming (for example) that an area with a period life expectancy at birth of 74 (the same value the English average in 1981) will have similar cohort life expectancies to the English average in 1981.

As seen from the graph on the right, a year's increase in period life expectancy at birth has historically been linked to a relatively small increase in cohort life expectancy at 85. Our methodology therefore "compresses" the distribution of cohort life expectancies at old age: while our estimated current cohort life expectancies at 0-4 include values from 84.1 to 98.6 (a range of 14.5 years), estimated cohort life expectancies at 85+ vary from 90.2 to 95.0 (a range of only 4.8). As an alternative, we could have simply added constants on to life expectancy at birth for each area in order to obtain cohort life expectancies for the other ages. This would eliminate the "compression" of the oldest cohort life expectancies. If life expectancies at 85+ had the same variation as those at birth, they would exceed 100 in some areas, which seems unrealistic.

This "compression" of life expectancies explains why the average number of years lost to inequality is so much lower for the "death cohort" (1.3) than the whole population (2). Much of the "death cohort" will be relatively old, and our methodology lessens the adverse effects of health inequalities for this group.





Calculating total years of life lost (3)

Creating the counterfactuals

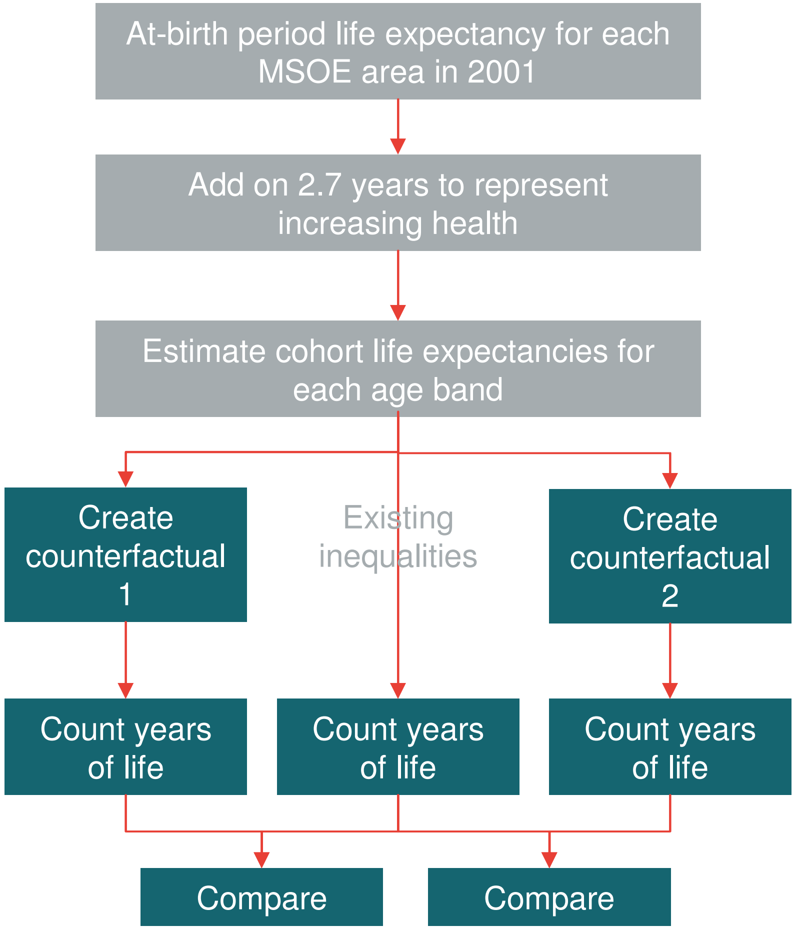
The process described on the previous page generates estimated cohort life expectancies for each 5-year age band for each of the MSOEs under the existing health inequalities. We now generate similar lists under the two counterfactuals.

Counting years of life

For each counterfactual (and the existing situation), the life expectancies are multiplied by the population of that age and summed, to produce the total years of life that the current population can expect to live. One difficulty is that population is only available in 5-year bands. For all but the topmost band, it is assumed that everyone's age falls into the middle of the band. For example, life expectancy at 47 is applied to those aged 45 – 50. The top band is "85+" and so it is not possible to define an average age without further data (we utilise the life expectancy at age 87).

Comparing the counterfactual with current inequalities

By taking the difference between years of life under each counterfactual and the current situation, it is possible to determine the number of years of life that are being lost due to inequality. Dividing this number by the population will generate the average number of years this represents for each individual.



Calculating total years of life lost (4)

Valuing the additional years

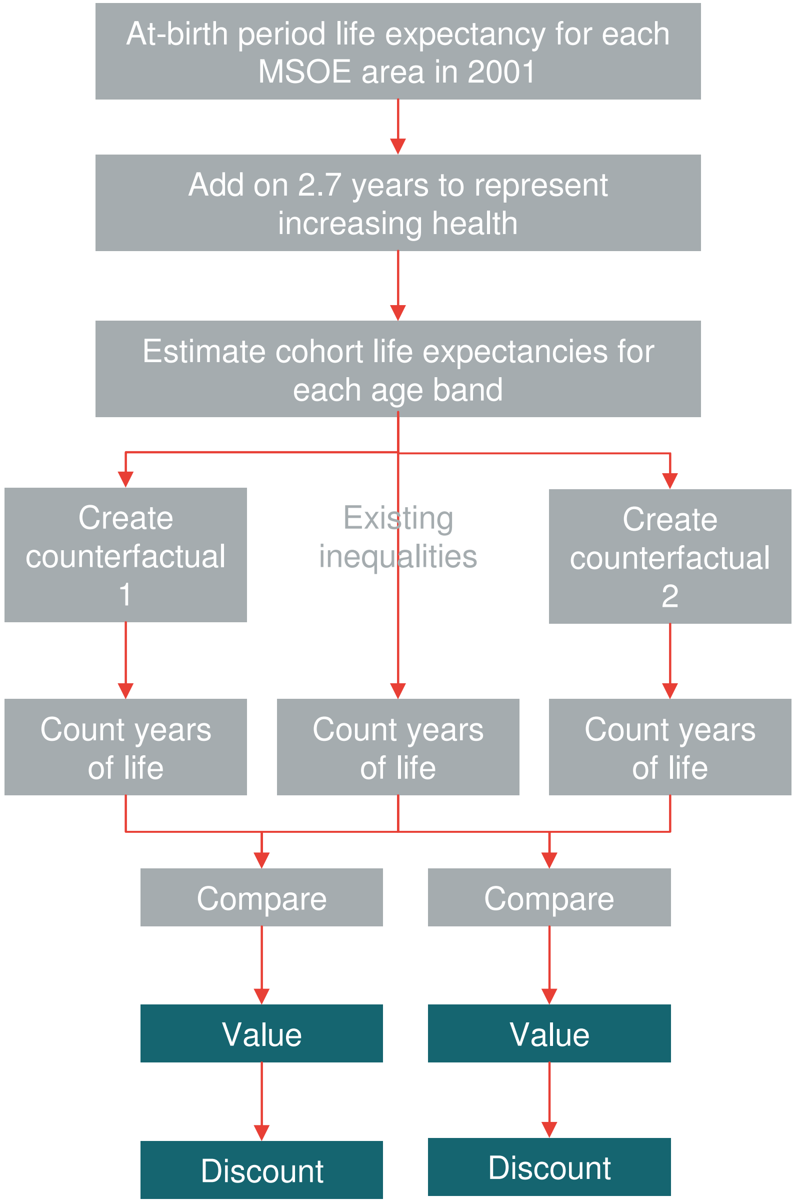
Placing a value upon a year of life is a complex (and controversial) matter. Nevertheless, it is impossible to imply people's willingness-to-pay for an extra year of life by observing decisions they make that affect the chances of mortality.

- The National Institute for Clinical Excellence (NICE) do not generally fund drugs that cost more than £30,000 for a quality-adjusted life year (one QALY is equal to a year of life in perfect health so this is equivalent to a value of a year's life)
- This is, however, fairly arbitrary. NICE have occasionally permitted drugs with a higher cost and their own research indicates that people may be willing to pay more for a year of life
- A higher figure (£58,000) can be derived from Department for Transport valuations
- Many academic studies have produced higher values

We use the £58,000 value.

Discounting

We assume that the additional years of life occur at the end of an individual's life, in the future. It is therefore necessary to discount these values using the Green Book discount rate of 3.5% per year. A different discount rate is used for each age band within each area, according the average number of years remaining until they would expect to die under *existing* health inequalities. For example, assume the life expectancy of 47 year olds in an area is currently 80 and will become 85. The increase in years of life (5 multiplied by the area population) is discounted over 33 years (the difference between 80 and 47).



Calculating total years of life lost (5)

As explained in the main document, we have produced additional estimates of years of life lost for two cohorts: The "birth cohort" who are born in 2010, and the "death cohort" who would otherwise have died in 2010. The general process remains the same, with an additional step to isolate the members of the population falling into the particular cohort:

The "birth cohort"

2008-based population projections are used to estimate the total number of 2010 births in England. These will be distributed unevenly among areas due to differing birth rates. The number of 0 – 4 year olds in each area has been used as a proxy for this. For example, it is assumed that an area which contained 0.01% of all 0-4 year olds in the country will contain 0.01% of the total 2010 birth cohort.

Using cohort life expectancies at birth, it is possible to determine the gains from increased health equality as before.

The monetary value of gains from life expectancy has been discounted. The gain is assumed to occur in the year that the individual would have died under current health inequalities (i.e around 80 years in the future).

The "death cohort"

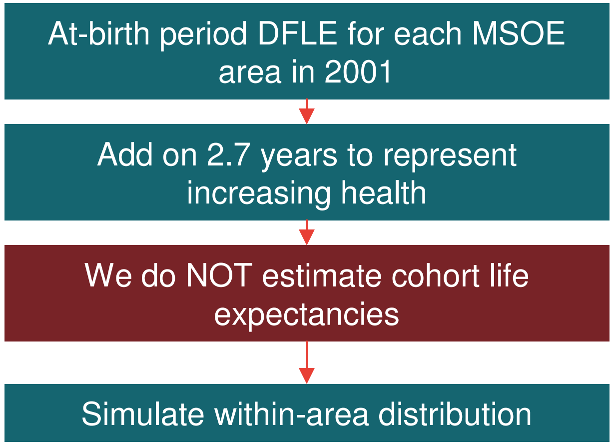
The total death cohort has also been retrieved from population projections. Unlike the birth cohort, the death cohort will comprise people of many different ages (while everyone is born at age zero, people can die at any age). In addition, the age distribution of the cohort will vary across areas: In an area with good health, those who die in a given year will tend to be older than those dying in a worse-off area. In theory, it may be possible to estimate mortality rates for each age and area, however this is a highly complex calculation.

Instead, we have applied the distribution of ages of death for the English population as a whole to each area. For example, around 6.7% of 80 – 85 year olds died in 2004. We therefore include 6.7% of life years from this age band in the "death cohort" for each area.

Gains from increased equality can be calculated as before. Since this cohort would have died in 2010 anyway, there is no need to discount the resulting monetary values.

Calculating years lost to disability (1)

The primary data source is ONS data on period disability-free life expectancy at birth (DFLE) by MSOE area.



Uniformly increasing life expectancy

As with life expectancies, 2.7 years are added to each area's DFLE to take account of additional years gained due to improving health.

Period DFLE at birth only

Unlike with life expectancy, we do not currently have information on cohort DFLE or DFLE by age. We assume all members of the population (regardless of their age) become disabled at the at-birth period DFLE for the area. Cohort DFLE at other ages may increase less than one-for-one with period DFLE at birth, as happens with life expectancy. If this is the case, we will over-estimate costs.

Simulate within-area distribution of DFLE (*this step only required to calculate working years lost to disability*)

For each area, we only have average DFLE. The actual age at which an individual becomes disabled will be widely distributed around this average, however (the within-area distribution may well be wider than the between-area distribution of average DFLE).

Consider an area with an average DFLE of 65. We could assume that everyone experienced the mean DFLE and so no individuals lost working years to disability. In reality, some individuals become disabled before or after this average. For those above the average this does not matter; they will still experience no working years lost to disability. Those becoming disabled below 65 will lose working years to disability however, and so within the area as a whole there will be years lost. In this case, just using the area average would lead us to underestimate the number of years lost.

This result arises since "working years lost to disability" is formed by censoring the DFLE series at 65. It is not immediately obvious which way the bias will affect our estimates of the cost of inequality, as there will be errors under both the current situation and the counterfactual. The following slide outlines the way in which we have attempted to overcome this issue.

Calculating years lost to disability (2)

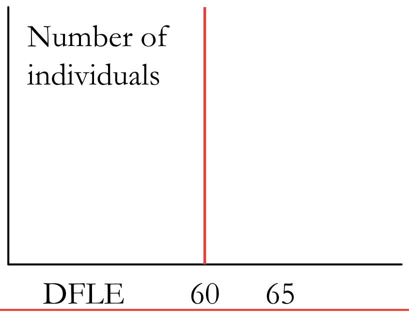
Our data provides the average of DFLE per area. We wish to find the average of "years lost to disability under the age of 65", that is the average of this censored distribution:

65 - Min(65,DFLE)

This is done in the following way for each area:

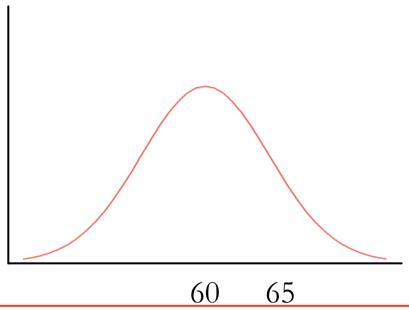
1

Each area has an average DFLE: in this example it is 60



2

Assuming DFLE is normally distributed around this average, we have drawn 5,000 individuals from the distribution



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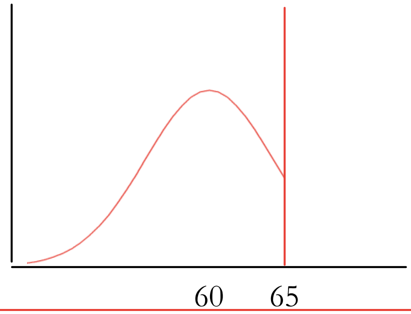
The simulated DFLE values have been censored at 65 (observations above 65 are set to 65)



4

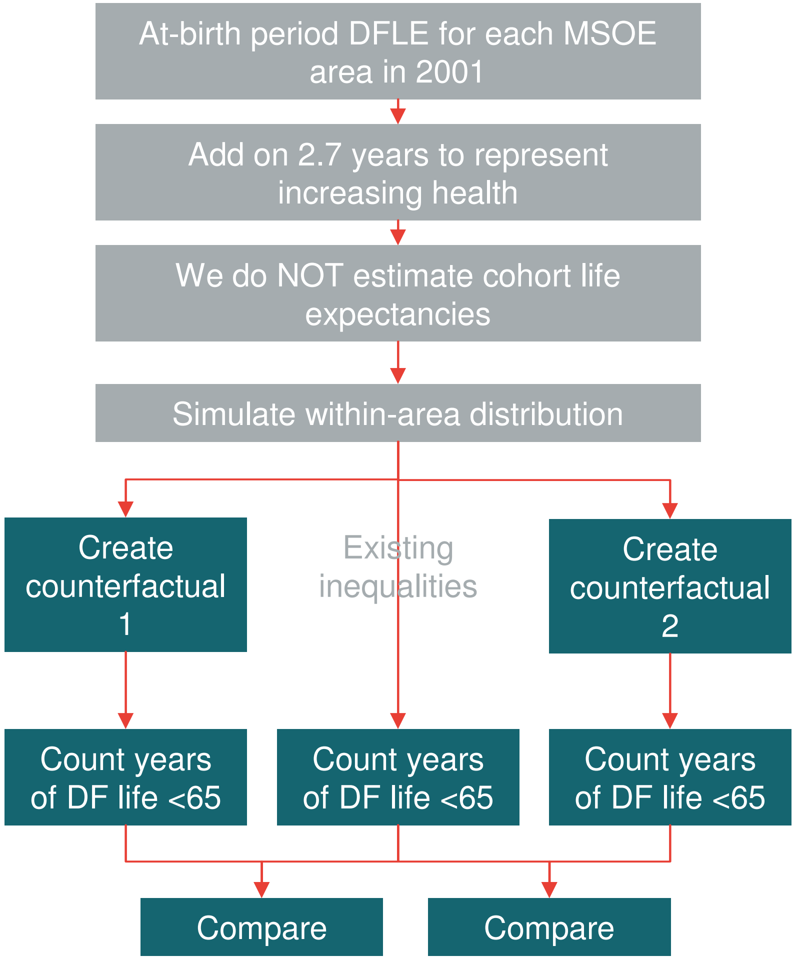
The 5,000 values have been averaged. The average will be somewhat below 60. The difference between this and 65 is the average number of years lost to disability under the age of 65.

The problem with this approach is that we do not know the within-area distribution of DFLE among individuals to use in step 2. As this is likely to be greater than the difference across areas (some individuals will become disabled at birth or never at all) our data do not help – we would require individual-level data on the age at which people became disabled. At present, we are assuming a seemingly "reasonable" standard deviation of 10 years. To put this in context, the SD of area DFLE average is 4.5 years, while the SD of adult *lifespan* in the US is around 15 years[1].

[1] Edwards, R. D. (2008), *The Cost of Uncertain Life Span*, NBER Working Paper 14093

Calculating working years lost to disability (3)

Using the simulated data, it is again possible to replicate the DFLE of higher-income areas over the lower-income areas in order to generate the two counterfactuals. For each situation, it is possible to count the number of years of working age life lost to disability.



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