6 Health cost decompositions

6.1 Decomposition methods

Ageing will have big effects on government funded social expenditures and particularly health care costs. Other factors will also affect such costs, such as growth in Australia's population, changes in real health prices and varying patterns of demand for services per capita. This paper shows that different methods produce wildly different relative contributions of these various factors to the change in health spending. All of the answers are correct for the questions being posed — what distinguishes them is whether the questions, given the policy problems of interest, are sensible. This paper outlines the many ways of representing the effects of ageing versus other factors on health expenditure and discusses their drawbacks and advantages.

The simple approach: partial allocation methods

At the most simple level, total real health expenditure per capita at any one time is the sum of spending across age groups:

$$E_t = \sum_{j=0}^{85} S_{jt} \times C_{jt} \qquad \{1\}$$

where j represents each year of age up to 84 years and a residual group combining people of ages 85 and over; S_{jt} is the share of the total population of age j at time t; and C_{jt} is the average (government) cost of health care in year t for the jth age group.

The change in expenditure between time t and t-1 is:

$$\Delta E = \sum_{j=0}^{85} \{(S_{j,t} \times C_{j,t}) - (S_{j,t-1} \times C_{j,t-1})\} \qquad \{2\}$$

There are many different ways of casting questions about the effects of ageing and other influences on total costs, with each providing usually different perspectives. A common approach is the *discrete derivative* approach. This assesses the extent to which per capita health costs would change from present levels if the age structure changed to that prevailing 40 years later, but all age-specific costs stayed at their current values. The total change in costs would be:

$$V_1 = E_t\big|_{C_{j,t}=C_{j,t-1}} - E_{t-1} = E_{t-1}\big|_{S_{j,t-1}=S_{j,t}} - E_{t-1} = \sum_{j=0}^{85} \Delta S_{j,t} \times C_{j,t-1} \qquad \{3\}$$

where t-1 is the period 40 years before period t. This is akin to comparing today's costs with those of a fictional world in which population ageing occurs overnight.

An alternative version of this approach is to ask by how much would future health care costs change if all age specific costs remained at their *future* values, but the age structure had shifted to its present values? This is akin to comparing future projected costs with those of a fictional future world in which the last 40 years of population ageing is reversed, but with age-specific expenditures staying fixed at their future levels. It is calculated as:

$$V_2 = E_t - E_{t-1}\big|_{C_{j,t-1}=C_{j,t}} = E_t - E_t\big|_{S_{j,t}=S_{j,t-1}} = \sum_{j=0}^{85} \Delta S_{j,t} \times C_{j,t} \qquad \{4\}$$

Both {3} and {4} are answers to the question: what happens to per capita health expenditure if age structure changes, but age-specific costs stay the same. The difference between them is the choice of the benchmark period — now or the future.

There are corresponding expressions to {3} and {4} that measure the effect of rising real age-specific costs per person (which collectively picks up the effects of excess of medical inflation above background inflation in the economy and increases in real health care demand per capita). These are, respectively:

$$V_3 = \Delta E_{|\Delta S=0,\, base\ year\ is\ t-1} = \sum_{j=0}^{85} \Delta C_{j,t} \times S_{j,t-1} \qquad \{5\}$$

and

$$V_4 = \Delta E_{|\Delta S=0,\, base\ year\ is\ t} = \sum_{j=0}^{85} \Delta C_{j,t} \times S_{j,t} \qquad \{6\}$$

It is possible to extend this approach to total real expenditure or even total nominal expenditure rather than per capita expenditure, by redefining E as:

$$\hat{E}_t = \sum_{j=0}^{85} S_{jt} \times C_{jt} \times POP_t \quad \text{or} \quad \tilde{E}_t = \sum_{j=0}^{85} S_{jt} \times C_{jt} \times POP_t \times PRICE_t \qquad \{7\}$$

where POP_t and $PRICE_t$ is the total population and the general price index at time t, respectively. In the case of $\hat{E}$, the change in total real spending can be decomposed into a spending effect, and two demographic effects: changes in the age structure and changes in population numbers. This was the approach used in the Intergenerational Report.

Expressed as a share of the relevant definition of ΔE, ageing appears to play a small relative role (table 6.1), especially when the initial year is used as the base year and the decomposition is applied to the change in *nominal* health expenditure. But the results, while easily derived and technically correct, are apt to be misunderstood and have several drawbacks as measures of the effects of various factors on health costs.

Table 6.1 **Different decompositions of the change in health spending using partial effect models[a]**

2003-04 to 2044-45

Definition of health expenditure	*Ageing*	*Real age-specific per capita costs*	*Population numbers*	*General price effects*	*Sum of partial effects*
	Share of total change				
	%	%	%	%	%
Current base					
(1) Real spending per capita	12.7	67.8	..	..	80.5
(2) Real health spending	8.0	42.7	11.3	..	62.0
(3) Nominal health spending	2.5	13.2	3.5	15.0	34.2
Future base					
(4) Real spending per capita	32.2	87.3	..	..	119.5
(5) Real health spending	28.6	77.5	37.0	..	143.1
(6) Nominal health spending	24.3	65.8	31.4	69.1	190.6

a Average cost profiles for each age up to age 85 were estimated for all health costs. Rather than use the projected GDP series from chapter 5, the growth rate in age-specific health costs per person was assumed to be equal to a constant GDP per capita growth rate of 1.7 per cent per year plus a 0.6 per cent premium (or 2.3 per cent per annum). This allowed easier experimentation with different growth trajectories, while being close to the observed series (noting that the main purpose of this paper is to illustrate the impacts of different computational methods). Inflation was assumed to be 2.5 per cent per annum.

Source: Commission estimates.

Drawbacks of the simple approach

Results vary with choice of base year

Different answers will be obtained depending on whether the current year or future year is used as the benchmark year. For example, ageing accounts for under

13 per cent of the total change in real health expenditure using a current base year approach, but over 32 per cent of the total change using a future base year approach. This drawback may be alleviated by expressing the change in expenditure as a ratio to an appropriate counterfactual. For example {3} can be normalised by initial year expenditure:

$$\frac{E_{t-1}|_{S_{j,t-1}=S_{j,t}} - E_{t-1}}{E_{t-1}} = \frac{\sum_{j=0}^{85} \Delta S_{j,t} \times C_{j,t-1}}{\sum_{j=0}^{85} (S_{j,t-1} \times C_{j,t-1})} \qquad \{8\}$$

while {4} can be normalised by the expenditure that would occur in the future were age-specific costs to be at their future values, but with the present age structure:[1]

$$\frac{E_t - E_t|_{S_{j,t}=S_{j,t-1}}}{E_t|_{S_{j,t}=S_{j,t-1}}} = \frac{\sum_{j=0}^{85} \Delta S_{j,t} \times C_{j,t}}{\sum_{j=0}^{85} (S_{j,t-1} \times C_{j,t})} \qquad \{9\}$$

If all age groups face a common rate of change in per capita age-specific costs over time[2] (as assumed, for example in the Intergenerational Report), then {8} and {9} give the same answer. If the rates are not common, then {8} and {9} will be different, but will still be similar for credible profiles of age-specific costs over time.

One of the advantages of formulations of this kind is that the percentage effect of ageing on health expenditure is the same — at 29 per cent — regardless of whether a broad or narrow definition of spending is adopted. Accordingly, the percentage effect on nominal spending of holding all other factors fixed at the initial values, but letting the age structure shift to its 2041-42 level is the same as the percentage effect on real per capita health spending of holding all other factors fixed at the initial values, but letting the age structure shift to its 2041-42 level. This is in marked contrast to expressing partial effects relative to ΔE as in table 6.1, where the impact of ageing can be made to virtually disappear by expressing it over the change in nominal spending.

[1] Where the effects of spending is being estimated, the counterfactual is appropriately re-defined.

[2] To be precise, {5} = {6} when, for any given set of years from t, t+1, t+2, … v, $C_{j,v} = C_{j,t} \times \prod_{k=t}^{v-1} (1+\zeta_k)$ for all j, where ζ_k is the growth rate in age-specific costs per capita in year k.

Table 6.2 **How much percentage difference does ageing and other influences have on health expenditure, all other things being equal?**

2003-04 to 2044-45[a]

Ageing	*Real age-specific per capita costs*[b]	*Population numbers*	*General price inflation*[c]
% points	% points	% points	% points
28.8	154.0	40.7	175.2

[a] Each effect is measured as the percentage difference to spending in 2003-04 made by changing the relevant component of costs to its 2044-45 value. Thus, the effect of ageing is measured as: $\{E_{t-1}|_{S_{j,t-1}=S_{j,t}} - E_{t-1}\}/E_{t-1}$

while the effect of population on expenditure, holding all other influences fixed is $\{E_{t-1}|_{POP_{j,t-1}=POP_{j,t}} - E_{t-1}\}/E_{t-1}$ with a similar form for other effects. As noted in the body of the paper, so long as all age groups face a common rate of change in per capita age-specific costs over time, the measured effects are the same as the percentage difference between spending in 2044-45 and the spending that would have occurred in the future had the relevant expenditure component been set to its 2003-04 value, with all other future expenditure components left unchanged. [b] A growth rate of 2.3 per cent real per capita age-specific health spending was assumed. [c] An inflation rate of 2.5 per cent per year was assumed.

Source: Commission estimates.

Partial methods fail an adding up condition

A second drawback in {3} – {9} is that the sum of the partial impacts (for example, V_1+V_3 or V_2+V_4) does not equal the total change in expenditures. The sum of the partials with a present base year (V_1+V_3) underestimates the total change in expenditure by ΔC ΔS, while the sum of the partials with a future base year (V_2+V_4) overestimates the total expenditure by ΔC ΔS:

$$V_1 + V_3 = \sum_{j=0}^{85}\{\Delta S_{j,t} \times C_{j,t-1} + \Delta C_{j,t} \times S_{j,t-1}\} = \Delta E - \Delta S_{j,t} \times \Delta C_{j,t} \qquad \{10\}$$

$$V_2 + V_4 = \sum_{j=0}^{85}\{\Delta S_{j,t} \times C_{j,t} + \Delta C_{j,t} \times S_{j,t}\} = \Delta E + \Delta S_{j,t} \times \Delta C_{j,t} \qquad \{11\}$$

These biases occur because as age structure changes, so do age-specific costs — this gives rise to the ‘mix’ effect, ΔC ΔS. Only where changes in each factor are very small are the sums of the partials equal to the actual change. Over a lengthy period, the changes are not small.

In a technical sense, the fact that the partials do not add to the total change in expenditure is not a problem, but it can lead to misinterpretation of partial impacts and confusion about the sources of expenditure increases. In particular, if it is found that ageing accounts for a given percentage of ΔE, **it cannot be inferred that cost factors account for the residual percentage.**

In this context, it would be useful to have a method for fully apportioning the change in expenditure to its various constituents. One method that does this is the *linear interpolation* method. Say that we observe just two points: A (C_{t-1},S_{t-1}) and B (C_t,S_t), but that we imagine a straight line joining these two points across the time interval from t-1 to t.[3] This line can be broken into n arbitrarily small segments (figure 6.1). Applying the discrete derivative method to the first segment (the move from A to a_1), the change in the value of total expenditure, given fixed age-specific costs, is $\Delta E_1 |_{\text{fixed C}} = C_{t-1} \times \Delta S_t / n$.[4] The same method is applied in the second segment to estimate the effect from a_1 to a_2, but taking note of the fact that age-specific costs have changed by a small amount from A to a1:

$$(E_1 - E_2)|_{\text{fixed C}} = \Delta E_2 \,|_{\text{fixed C}} = \Delta S_t \,/\, n \times C_{t-1+1/n} = \Delta S_t \,/\, n \times (C_{t-1} + \Delta C_t \,/\, n) \qquad \{12\}$$

In the next segments the comparable measures are:

$$\Delta E_3 \,|_{\text{fixed C}} = \frac{\Delta S_t}{n} \times (C_{t-1} + \frac{2}{n} \Delta C_t), \quad \textit{and so on until...} \quad \Delta E_n \,|_{\text{fixed C}} = \frac{\Delta S_t}{n} \times (C_{t-1} + \frac{(n-1)}{n} \Delta C_t)$$

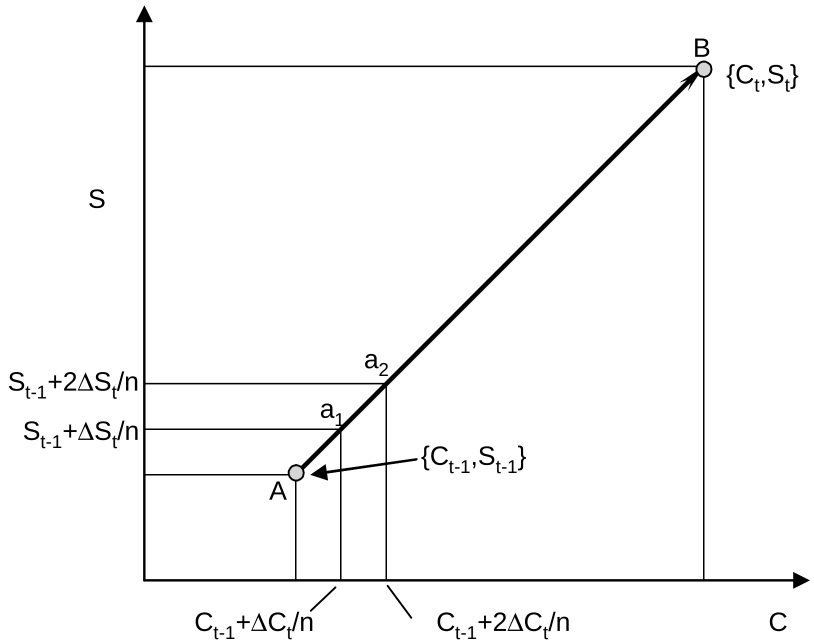
Thus, this method takes account of the fact that as ageing occurs, age-specific costs are also changing. Similar partials may be calculated for changes in E arising from changes in age-specific costs, given a fixed age structure over any given segment.

If the small changes in E are summed across all n intervals then the estimated components of ΔE are:

[3] For ease of computation, the age subscripts have been dropped. These calculations are undertaken for each of the relevant age groups.

[4] Note that if the total change over the first segment is calculated it includes a term $(\Delta S_t \times \Delta C_t) / n^2$, but this can be ignored relative to the remaining components as n gets large.

Figure 6.1 **The linear interpolation method**



$$\underset{n\to\infty}{LIM}\sum_{i=1}^{n}\Delta E_i\,|_{\text{fixed C}} = (\Delta S_t \times C_{t-1} + \frac{\Delta S_t \Delta C_t}{2}) = \Delta S_t(\frac{C_{t-1}+C_t}{2}) = \Delta S_t \overline{C} \text{ and} \qquad \{13\}$$

$$\underset{n\to\infty}{LIM}\sum_{i=1}^{n}\Delta E_i\,|_{\text{fixed S}} = (\Delta C_t \times S_{t-1} + \frac{\Delta S_t \Delta C_t}{2}) = \Delta C_t(\frac{S_{t-1}+S_t}{2}) = \Delta C_t \overline{S} \qquad \{14\}$$

These sum to the total change in E as in equation {2}, so that the exact percentage contribution of ageing versus age-specific costs can be calculated. To produce an estimate of the impacts of ageing or costs across more than one year, the results from the linear interpolation method are simply added — representing a piecewise linear interpolation through all successive points.

The same decomposition achieved by taking limits from the linear interpolation method can be derived in a more straightforward way by noting that there are two (symmetric) representations of ΔE:

$$\Delta E_t = S_t C_t - S_{t-1}C_{t-1} = S_t C_t - S_{t-1}C_{t-1} + (S_t C_{t-1} - S_t C_{t-1}) = S_t \Delta C_t + C_{t-1}\Delta S_t \qquad \{15\}$$

and that also

$$\Delta E_t = S_t C_t - S_{t-1}C_{t-1} = S_t C_t - S_{t-1}C_{t-1} + (S_{t-1}C_t - S_{t-1}C_t) = S_{t-1}\Delta C_t + C_t \Delta S_t\,, \qquad \{16\}$$

which on averaging gives:

$$\Delta E_t = \Delta C_t \times (\frac{S_t + S_{t-1}}{2}) + \Delta S_t \times (\frac{C_t + C_{t-1}}{2}) = \Delta C_t \times \overline{S} + \Delta S_t \times \overline{C} \qquad \{17\}$$

It is possible to extend this simple approach to more complex cases, averaging over the multiple representations of ΔE. For example, suppose the variable of interest is total health expenditure (not per capita spending) and that the separate contributions of age structure, population change and age-specific costs are wanted. In that case, it can be shown that (for each age group):

$$\Delta E_t = \frac{\Delta C_t .(2\overline{S}\ \overline{P} + \overline{SP}) + \Delta S_t .(2\overline{C}\ \overline{P} + \overline{CP}) + \Delta P_t .(2\overline{C}\ \overline{S} + \overline{CS})}{3} \qquad \{18\}$$

where P is the total population. This gives rise to three partial effects that add to the total change in health expenditure and can also be shown to be the same solution as that found when the limits are taken of the results from the linear interpolation method applied to the three variable case. So, the linear interpolation approach provides the analytical motivation for deriving the partial effects as the average of the multiple representations of ΔE. The method can be seen as calculating the effects of each of the various factors on expenditure along a time path in which the values of the 'fixed' variables are updated along the adjustment path (in contrast to the discrete derivative method, which holds the value of the fixed variable at the same starting value at every point along the adjustment path).

While analytical decompositions of the form {17} can be found for any number of multiplicative terms, the expressions become increasingly elaborate. For example, for a four variables case (x1 to x4 where E = x1*x2*x3*x4) then the decomposition of the change in E from t-1 to t is made up of 4 components (these were calculated by taking the limit as iterations approached infinity in the interpolation approach). Thus for each of the transitions from t-1 to t, the change in E can be decomposed as follows:

$$\Delta E \text{ due to } x_1 = \Delta x_1 \times \left\{ \begin{array}{l} x_{4,t-1} \times x_{2,t-1} \times x_{3,t-1} + \frac{1}{2}\Delta x_4 \times x_{2,t-1} \times x_{3,t-1} + \frac{1}{2}\Delta x_3 \times x_{4,t-1} \times x_{2,t-1} + \\ \frac{1}{2}\Delta x_2 \times x_{3,t-1} \times x_{4,t-1} + \frac{1}{3}\Delta x_4 \times \Delta x_2 \times x_{3,t-1} + \frac{1}{3}\Delta x_2 \times \Delta x_3 \times x_{4,t-1} + \\ \frac{1}{3}\Delta x_4 \times \Delta x_3 \times x_{2,t-1} + \frac{1}{4}\Delta x_4 \times \Delta x_2 \times \Delta x_3 \end{array} \right\}$$

$$\Delta E \text{ due to } x_2 = \Delta x_2 \times \left\{ \begin{array}{l} x_{1,t-1} \times x_{3,t-1} \times x_{4,t-1} + \frac{1}{2}\Delta x_1 \times x_{3,t-1} \times x_{4,t-1} + \frac{1}{2}\Delta x_4 \times x_{1,t-1} \times x_{3,t-1} + \\ \frac{1}{2}\Delta x_3 \times x_{4,t-1} \times x_{1,t-1} + \frac{1}{3}\Delta x_1 \times \Delta x_3 \times x_{4,t-1} + \frac{1}{3}\Delta x_3 \times \Delta x_4 \times x_{1,t-1} + \\ \frac{1}{3}\Delta x_1 \times \Delta x_4 \times x_{3,t-1} + \frac{1}{4}\Delta x_1 \times \Delta x_3 \times \Delta x_4 \end{array} \right\}$$

$$\Delta E \ due\ to\ x_3 = \Delta x_3 \times \begin{Bmatrix} x_{1,t-1} \times x_{2,t-1} \times x_{4,t-1} + \frac{1}{2}\Delta x_1 \times x_{2,t-1} \times x_{4,t-1} + \frac{1}{2}\Delta x_4 \times x_{1,t-1} \times x_{2,t-1} + \\ \frac{1}{2}\Delta x_2 \times x_{4,t-1} \times x_{1,t-1} + \frac{1}{3}\Delta x_1 \times \Delta x_2 \times x_{4,t-1} + \frac{1}{3}\Delta x_2 \times \Delta x_4 \times x_{1,t-1} + \\ \frac{1}{3}\Delta x_1 \times \Delta x_4 \times x_{2,t-1} + \frac{1}{4}\Delta x_1 \times \Delta x_2 \times \Delta x_4 \end{Bmatrix}$$

$$\Delta E \ due\ to\ x_4 = \Delta x_4 \times \begin{Bmatrix} x_{1,t-1} \times x_{2,t-1} \times x_{3,t-1} + \frac{1}{2}\Delta x_1 \times x_{2,t-1} \times x_{3,t-1} + \frac{1}{2}\Delta x_3 \times x_{1,t-1} \times x_{2,t-1} + \\ \frac{1}{2}\Delta x_2 \times x_{3,t-1} \times x_{1,t-1} + \frac{1}{3}\Delta x_1 \times \Delta x_2 \times x_{3,t-1} + \frac{1}{3}\Delta x_2 \times \Delta x_3 \times x_{1,t-1} + \\ \frac{1}{3}\Delta x_1 \times \Delta x_3 \times x_{2,t-1} + \frac{1}{4}\Delta x_1 \times \Delta x_2 \times \Delta x_3 \end{Bmatrix}$$

It is likely that further manipulation can simplify the expressions in terms of averages as in the 3 and 2 variable cases above, but this is not straightforward or necessary. The final decomposition is achieved by summing across all of the time periods. The clear symmetry of the decompositions is apparent — and allows higher order decompositions to be derived readily.

It is also possible to use a computer intensive technique (box 6.1) to provide the appropriate decomposition for any number of multiplicative terms without elaborate algebraic manipulation and this method can readily be extended to the use of cubic splines instead of piecewise linear interpolation.[5]

There are still major variations between results based on different definitions of expenditure, but all partial effects add to the total (table 6.3).

[5] However, results using cubic splines were found to be nearly identical to those of piecewise linear interpolation.

Table 6.3 **Different decompositions of the change in health spending using the 'full allocation' approach**[a]

2001-02 to 2041-42

		Ageing	*Real age-specific per capita costs*	*Population numbers*	*General price inflation*	*Total*
		Share of total change				
		%	%	%	%	
(1)	Nominal health spending[b]	8.6	38.3	11.5	41.6	100.0
(2)	Real health[c] spending	15.6	63.8	20.7	..	100.0
(3)	Real health spending per capita[c]	20.0	80.0	..	..	100.0

[a] Where a 'full allocation' result is shown it is based on piecewise linear interpolation using data for all years between the two endpoints. [b] Inflation is assumed to be 2.5 per cent per annum. [c] The growth rate in age-specific health costs per person is assumed to be 2.3 per cent per annum.

Source: Commission estimates and 'Health Decomposition' spreadsheet accompanying the technical appendix.

Using an inappropriate benchmark for significance

As is apparent in tables 6.1 and 6.3 Interpreting the relative extent to which ΔE can be ascribed to one effect on another can be crucially dependent on how expenditure is characterised.

For example, suppose that instead of apportioning the increase in real health care expenditure between ageing, population growth and real age-specific expenditures, an analyst decided to apportion the increase in *nominal* health care expenditure between ageing, population growth, real age-specific expenditures and inflation. In the case where inflation is running at 2.5 per cent per annum, the contribution of ageing to the total change in expenditure is only 2.5 per cent when a partial approach with an initial base year is used (table 6.1), and still only around 9 per cent with a full allocation method (table 6.3). If inflation were higher, then the share of the increase explained by the remaining factors would be even smaller, and over the long run, nearly zero, though clearly nothing real would have changed in the economy.

Box 6.1 Computer intensive methods for linear interpolation

Suppose that there are m variables denoted {x_1,x_2, ...x_q,… x_m) such that for any given age and time period:

$$E = \prod_{i=1}^{m} x_i$$

In this case, the impact of the qth variable on the change in aggregate spending (i.e. across all ages) from the starting period (period 1 eg 2004) to a completion year (period T eg 2045) is:

$$\Delta E \mid due\ to\ x_q = \sum_{t=1}^{T-1}\left[\sum_{j=0}^{85}\left(\sum_{k=1}^{n}\frac{\Delta x_{q,j,t+1}}{n}\prod_{i=1,i\neq q}^{m}\left\{x_{i,j,t}+k\times\frac{\Delta x_{i,j,t+1}}{n}\right\}\right)\right]$$

For example, in a three variable case, where E = C.S.P (as in the main text) a computer algorithm would be:

Step 1: sum1=0, sum2=0, sum3=0 *; initialise the partial effects to zero*

Step 2: For t = 1 to T-1 *; set up a loop across periods, ages and iteration counts (n)*
For j = 0 to 85
For k= 1 to n *; n needs to be around 100 for good accuracy*

Step 3:

$$sum_1 = sum_1 + \frac{\Delta C_{j,t+1}}{n}(S_t + k\times\frac{\Delta S_{j,t+1}}{n})(P_t + k\times\frac{\Delta P_{j,t+1}}{n})$$ *; the effect due to C*

$$sum_2 = sum_2 + \frac{\Delta S_{j,t+1}}{n}(S_t + k\times\frac{\Delta C_{j,t+1}}{n})(P_t + k\times\frac{\Delta P_{j,t+1}}{n})$$ *; the effect due to S*

$$sum_3 = sum_3 + \frac{\Delta P_{j,t+1}}{n}(S_t + k\times\frac{\Delta S_{j,t+1}}{n})(P_t + k\times\frac{\Delta C_{j,t+1}}{n})$$ *; the effect due to P*

Step 4: Next k *; iterate loops*
Next j
Next t

Step 5: $Partial_1 = sum_1$, $Partial_2 = sum_2$, $Partial_3 = sum_3$ *; solutions are the cumulative sums*

In that case, a statement to the effect that ageing does not matter much to rises in health care expenditure would be misleading, merely reflecting the extraneous influences of inflation. The nominal rise in expenditure is not interesting for policymakers since the purely inflationary component does not represent a burden to government. As shown in table 6.4, inflation would push up the tax revenue needed to finance nominal health care spending by around the same amount as the inflationary component of health care.

Table 6.4 **Putting the different contributors to health expenditure change into context[a]**

Effect	*Contribution to change in health spending*	*Contribution to change in government revenue to finance health spending*	*Net budget position*
Population	α	α	0
General inflation	π	π	0
Population age structure	β	$-\phi$	$-\phi-\beta$
Increases in real age-specific spending per capita	Δ(GDP/POP)+γ	Δ(GDP/POP)	$-\gamma$
Total	$\alpha+\pi+\beta+\lambda+$ Δ(GDP/POP)	$\alpha+\pi-\phi+$ Δ(GDP/POP)	$-\phi-\beta-\gamma$

[a] The results here are illustrative rather than precise, and would apply only for small changes and short intervals of time. An accurate decomposition is derived below.

Two other approaches to measuring impacts on expenditure have similar deficiencies:

- Analysing total real expenditure (as was undertaken in the Intergenerational Report) instead of real expenditure per capita is also problematic. Governments would not generally be concerned about a rise in total health spending that arose only from population growth so long as per capita income levels were maintained. As with the inflation example, government revenue would also grow with population, so that the net position for government (for a given age structure) would not deteriorate (row 1 of table 6.1).
- More subtly, analysing the full impact of rises in age-specific expenditure rates can be misleading since much of the increase in such rates stems from economic growth, which also enhances governments' capacity to finance such increases. It is only the premium on the growth rate of age-specific health expenditures above GDP per capita growth rates (λ in table 6.4) that presents a potential funding problem for government.

In contrast, ageing has a double effect. It both increases expenditure in a way that is not automatically compensated by revenue benefits and reduces GDP growth by depressing labour participation rates.

This suggests that the significance of various factors on expenditure should abstract from changes that have no effective policy significance. A way to do this is to ask what level of revenue governments would collect in the future were they to maintain the implicit tax rate needed to fund current value health spending in current dollars. Clearly, this represents the status quo in that no change in tax or funding policy is required by that stance. With nominal total health expenditure of ($\tilde{E}$), the implicit tax rate (τ) is:

$$\tau = \frac{\tilde{E}_{t-1}}{POP_{t-1} \times P_{t-1} \times GDPt - 1} \quad or \quad \frac{\sum_{j=0}^{85} (S_{jt-1} \times C_{jt-1})}{GDP_{t-1}} \qquad \{19\}$$

the revenue it would collect with such a tax rate in subsequent years would be:

$$REVENUE_t = \sum_{j=0}^{85} (S_{jt-1} \times C_{jt-1}) \times POP_t \times P_t \times \frac{GDP_t}{GDP_{t-1}} = \sum_{j=0}^{85} (S_{jt-1} \times C_{jt-1}) \times POP_t \times P_t \times IGDP_t \qquad \{20\}$$

where IGDP is an index of real GDP per capita (with a value of one at time t-1). The actual cost of health expenditure at time t is:

$$COSTS_t = \sum_{j=0}^{85} (S_{jt} \times C_{jt}) \times POP_t \times P_t = \sum_{j=0}^{85} (S_{jt} \times C_{jt-1} \times IGP_t \times IGDP_t) \times POP_t \times P_t \qquad \{21\}$$

where IPG is an index of the *premium* real per capita age-specific health spending, set such that $IPG \times IGDP = IH$ where IH is an index of age-specific per capita real health spending (with IPG equalling one at t-1).[6] The revenue shortfall between costs and revenue — which is the policy-relevant issue — is:

$$(COSTS_t - REVENUE_t) = \sum_{j=0}^{85} \left\{ C_{jt-1} \times IGDP_t \times POP_t \times P_t \right\} \times (S_{jt} \times IGP_t - S_{jt-1}) \qquad \{22\}$$

In per capita real GDP growth-adjusted terms, this shortfall is:

$$BURDEN_t = \sum_{j=0}^{85} \left\{ C_{jt-1} S_{jt} \times IGP_t - C_{jt-1} S_{jt-1} \right\} = \sum_{j=0}^{85} \left\{ \hat{C}_{jt} S_{jt} - C_{jt-1} S_{jt-1} \right\} \qquad \{23\}$$

where $\hat{C}_{jt}$ is real per capita age-specific expenditure adjusted for the effects of GDP growth. This can be decomposed into ageing and cost factors using the approaches described above (box 6.2 provides another insight into this decomposition).

6 That is, if GDP growth is g per cent per annum and total per capita real health spending is h per cent per annum, then the premium growth rate is $\lambda = (h-g)/(1+g)$.

Box 6.2 **Conceptualising GDP-adjusted spending**

Another way of conceptualising the GDP-adjusted measure is to note that adjusting for effects such as prices or population is equivalent to normalising their values to unity for all periods:

Thus: $$\underbrace{\sum_{j=0}^{85}(S_{jt} \times C_{jt} \times POP_t \times P_t)}_{\text{total nominal spending}} \Rightarrow \underbrace{\sum_{j=0}^{85}(S_{jt} \times C_{jt})}_{\text{real per capita spending}} \quad if \;\; POP_t = P_t = 1$$

Accordingly, GDP-adjusted spending merely extends this principle:

$$\underbrace{\sum_{j=0}^{85}(S_{jt} \times C_{jt-1} \times IPG_t \times IGDP_t \times POP_t \times P_t)}_{\text{total nominal spending}} \Rightarrow \underbrace{\sum_{j=0}^{85}(S_{jt} \times C_{jt-1}) \times IPG_t}_{\text{real per capita spending adjusted for GDP growth}} \quad if \;\; POP_t = P_t = IGDP_t = 1$$

This implies, as in the main text, that:

$$V_5 = (E_t - E_{t-1})\Big|_{\substack{IGDP_t = IGDP_{t-1} = 1 \\ POP_t = POP_{t-1} = 1 \\ P_t = P_{t-1} = 1}} = \sum_{j=0}^{85}(S_{jt} \times IPG_t \times C_{jt-1} - S_{jt-1} \times C_{jt-1})$$

$$= \sum_{j=0}^{85}(S_{jt}\hat{C}_{jt} - S_{jt-1}C_{jt-1})$$

It is possible, with assumptions about γ (the premium rate of health expenditure growth), to determine how much of the change in this adjusted measure of health expenditure can be attributed to ‘unbalanced’ health expenditure growth and how much to changes in the age structure.

With the assumption that yearly growth in (age-adjusted) per capita real health spending exceeds GDP growth by 0.6 percentage points, ageing accounts for about half of the increase in real health expenditure that could be expected to concern policymakers. This is much more than is sometimes suggested by more simple, policy-naïve, decomposition methods.

Table 6.5 **Policy relevant decomposition of the change in health spending**
2001-02 to 2041-42[a]

	Ageing	*Real age-specific per capita costs*	*Total*
	Share of total change		
	%	%	%
Real health spending per capita[c] GDP adjusted	50.4	49.6	100.0

[a] Based on piecewise linear interpolation using data for all years between the two endpoints, it is assumed that the difference between annual real GDP growth and total age-specific real health expenditure growth is 0.6 percentage points. This implies that the premium growth rate is (1.017+0.006)/1.017-1.

Source: Commission estimates.

In conclusion, there are a plethora of methods for decomposing expenditure, but only several answer interesting questions or are of real value in understanding the dynamics of spending over time. In our view, these are:

- using a 'percentage effect' approach (table G2). This assesses the percentage impact of ageing on spending were all other factors to remain fixed; and
- the 'revenue shortfall' approach (table G5), where policymakers want an estimate of the contribution of aging to the *change* in spending over some period.