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DISCUSSION PAPER

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Keywords: Public Health, Measures of Output, Diabetes Prevention, National Accounts, Quality Adjustment

JEL classification: I19, E01, C43

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Revised 4th December 2024

Abstract

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1 Introduction

This paper explores how the national accounts should reflect the provision of new medical services including preventative public health measures. The treatment of non-marketed services in the national accounts remains a source of considerable controversy and the treatment of health services might be thought to be a major issue, at least in those countries where the health service is largely in the public sector. A number of authors (e.g. Brynjolfsson et al. (2019)) feel that the conventional valuation of services free at their point of use, at their cost of production, leads to a sharp underestimate of the "value" of services such as social media. But this point may be even more relevant for health services.

This article sets out an approach to the introduction of four different health interventions to an overall volume measure of health services gross output or consumption[1]. The key to all of them is to assume that, in the period before introduction of new treatments or after withdrawal of old treatments, they are available but only at their demand reservation price, i.e. the minimum price at which there would be no demand for the new or withdrawn good or service. This makes it possible to infer the implications for a price index, and the volume index can be deduced from the price index and value data.

For health interventions it is assumed the gross benefit can be measured in discounted quality-adjusted life years (QALYs). If a value is put on a QALY, a reservation price can be computed as the cost at which the intervention delivers only just enough health benefits to be worthwhile. With preventative treatment the savings in future treatment costs are also material for the reservation price.

The first case we examine is a treatment for an existing but hitherto untreatable disease. The treatment is assumed to lead to a higher level of QALYs than that experienced by untreated patients but not necessarily the same level of QALYs as is enjoyed by those who do not contract the disease. In this example it is assumed that the treatment and the benefits it delivers are contemporaneous. This provides a simple example with which to illustrate the approach.

In our second example we consider an improved treatment which displaces an existing treatment, either as a treatment which delivers more QALYs for the same price or as

[1]There is a degree of international trade in medical services, but our focus is on government consumption of health services which are provided free or nearly free at the point of use, and we treat this as synonymous with the gross health service output of the public sector

one which delivers the same benefit as before but at a lower price. We again assume that the treatment and the benefits are contemporaneous. We show that the reservation price approach is, when quality increases, directly equivalent to the quality-adjustment approach proposed by System of National Accounts (2008) and Schreyer (2012). When costs fall, the replacement treatment approach is shown to be directly equivalent to a fall in price.

Our third example considers a situation where continuing treatment may be needed and where the benefits do not co-incide with the treatment. Such a situation may arise, for example, with an organ transplant. The main cost is at the start, although continuing treatment may be needed, and the benefits are likely to be spread over time.

The fourth example looks at a public health measure which reduces the probability of developing a chronic disease. The assumed fall in the price of the public health measure from its reservation price to its actual cost of production allows us to calculate the reduction in the overall price of medical treatment and thus the associated increase in volume.

In all four cases we assume that aggregate price changes are computed using a Törnqvist index. The Fisher index would also deliver coherent, if slightly different, results. But the approach would not work if Laspeyres or Paasche indices were used, even if those indices were chain-linked. Laspeyres indices would markedly overstate the contribution of withdrawn goods or services. Paasche indices would overstate the contribution of new goods or services. And, since they would give a zero weight to withdrawn goods or services, they would be likely to understate the impact of product withdrawal.

We also consider all four cases through the lens provided by Cutler et al. (2022). Thsi focuses on the health gain measured relative to the total health gain generated by health services. We show that the treatment proposed by Cutler et al. (2022) yields different answers from those linked directly to the main-stream national accounts.

In all these cases it is important to bear in mind that we are discussing measurement of output rather than well-being. A reduction in the incidence of disease, as a result of public health measures, is likely to have the impact of reducing the the output of the health sector. Factors of production will be diverted to other economic activities and there may be an increase in well-being, even if GDP is broadly unchanged.

We illustrate the final case by looking at the effects of the Diabetes Prevention Programme (NHS England, 2016), a public health measure. The evidence available to date

(Ravindrararajah et al., 2023) suggests participation in the programme reduces the risk of developing type-2 diabetes or at least delays its onset. The approach we set out here shows how the effects of preventative public health measures can be incorporated into measures of the gross output of medical services. We find in fact that the contribution of the particular programme considered to health service gross output and consumption is small.

We begin with a literature review. We then set out in section 3 theoretical examples to illustrate our four cases. This is followed in section 4 by a brief description of type 2 diabetes and an account of the Diabetes Prevention Programme. In section 5 we assess the implications for volume measures of health service gross output in the national accounts. Section 6 concludes.

2 Literature Review

While national accountants have been aware of the problems of measuring the output of public services since modern national accounts have existed, Atkinson (2005) produced a substantial report on the matter. A key concern of his was that the widely-used treatment of measuring volume changes in outputs by volume changes in inputs left no room for productivity growth or changes in quality. The report made the distinction between outputs, the direct products of public services such as, in the case of medical services, consultations and procedures, and the outcomes such as improved life quality and extended life-span. At much the same time Cutler, Rosen, and Vijan (2006) looked at the output of the United States' health sector in terms of life-years gained without any adjustment for the quality of life. Shortly afterwards Castelli et al. (2007) raised the possibility of measuring outcomes in QALYs and using this as a quality-adjusted metric of the output of the health sector.

Support for the principle of quality-adjustment is not universal. The System of National Accounts (2008) advises statistical offices that quality adjustments to public sector output volume measures should be made.The European System of Accounts (2010), however, prohibits such adjustments to public sector output while endorsing them for private sector output.

There are in fact two distinct approaches to producing quality-adjusted measures of health sector output and they lead to different answers. The first can be used to incorporate new and preventative treatments into the existing national accounts while the

second uses a satellite account, measuring directly the QALY impact of these treatments.

The first approach draws on the work by Brynjolfsson et al. (2019). They focus on developing an extended measure of GDP which pays proper attention to the introduction of new goods and services. They were concerned with social media, but their approach can equally be applied to medical services. Following Fisher and Shell (1972), and implicitly Hicks (1942), they suggest valuing new goods at their reservation prices in the period before their introduction and at their actual price (if traded in the market sector) or cost of production afterwards. This makes it possible to incorporate new goods or services into a price index. This price index can then be used to deflate the relevant value figure to show the volume effect of the introduction of that new good or service. We use that approach in looking at the treatment of new medical services or public health measures in the mainstream national accounts; we adopt a symmetric approach to the removal of old superseded treatments, calculating a reservation price for them once they have been withdrawn. Use of QALYs as a measure of outcomes means that, provided the medical effects of the treatment are known, reservation prices can be computed directly. For other goods and services experiments may need to be used to establish prices (Diewert, Fox, and Schreyer, 2022), but that is not a concern here.

Cutler et al. (2022) go down an alternative route. They focus on QALYs as outcomes. They measure the increase in productivity in the medical sector as the value of the increase in expected quality-adjusted life years (QALYs) that it delivers, less the increase in costs (measured in constant prices). Obviously reliance on QALYs as an outcome measure fits directly into this approach.

To deliver a growth rate for gross output since 1999 they divide by their estimate of QALYs attributable to medical care in the base year. They focus on undiscounted QALYs but also look at the effects of discounting future years by 3% p.a. The fact that they are producing a satellite account for medical services means they do not need to worry about the effects of their results on the rest of the national accounts or the price index for medical services. But the value used for QALYs (US$100,000 per healthy life year in their work) will yield an estimate of the output of medical services which is likely to be quite different from that shown in the US National Accounts. Atkinson (2005) was well aware of this issue[2]. This awkwardness also seems to be one of the elements lying

[2]I am grateful to Joe Grice for helpful conversations on this issue. The problem may be even more acute in the UK where the value of the output of the National Health Service, measured by the cost of production. Joe Grice has pointed out that the current income/expenditure account could be reconciled

behind the critique in Triplett (2009) although he was also concerned about accuracy of health sector outputs measured in QALYs. Cutler et al. (2022) resolve the matter by constructing a satellite account, outside the main-stream of the national accounts. Cutler's approach does not have any difficulty with the introduction of new goods and services since the increase in gross output is simply measured as the resulting increase in QALYs.

A third strand of the literature should be mentioned. Schreyer (2012), building on the work of Atkinson (2005) and Castelli et al. (2007), advocates using indicators of quality to make quality adjustments to output. Applied to medical services this would naturally mean treating QALYs generated as the dominant indicator of quality, although a case can be made (Castelli et al., 2007) for using factors such as patient satisfaction[3] as secondary indicators of quality.

While this offers a clear approach to measuring quality changes, it does not deal with the question of new treatments, whether direct or preventative. It does, in contrast to Cutler *et al*, however, produce data which fit into the main-stream national accounts. Even when QALYs are used as the only indicator of quality, a difference between this and Cutler's approach arises from the way in which different components of the affected industry (e.g. medical services) are aggregated. Cutler et al. (2022) imply that shares in total medically-generated QALYs should be used while Schreyer (2012) uses shares of production costs in current or lagged health service consumption as cost weights for combining the different activities. The use of cost weights rather than QALY weights has the consequence that the magnitude of the overall quality adjustment will depend on way in which the individual components are aggregated. If adjustment takes place at the aggregate level and QALYs are the only indicator of quality, then the reported absolute increase in output will be the same as that proposed by Cutler et al. (2022).

3 Theory

We begin this section by looking at the introduction of a treatment for a hitherto untreatable disease. We then look at the introduction of a new and better, or cheaper,

only by the use of a new form of factor income whose value is derived as a balancing variable.

[3]The time spent waiting for treatment might seem to be an additional quality factor, but if QALYs are counted properly, then the costs to quality of life resulting from delays to treatment will be reflected in the QALY measure. With suitable discounting the QALYs lost from delay will be deducted from the QALY gain resulting from treatment without delay.

treatment which supersedes an existing treatment. In our third case we look at the implications of treatment spread over time, Finally we examine the effect of the introduction of a public health measure which reduces the prevalence of an existing, partially treatable, disease.

In all cases the issue that arises is the management of the introduction of a new good or service. As is common in this area, we focus on the implications for the price deflator, with volume changes derived from that so as to be consistent with the value data. In the second case we also need to consider how to account for the withdrawal of the superseded treatment.

If a Laspeyres output deflator is used, and a new good or service has appeared between the base year and the current period, then it will have zero weight in the price index because expenditure on it in the base period is zero. This carries the implication that a Laspeyres output deflator is always going to be behind the game. The problem is not resolved by the use of a chain-linked Laspeyres index notwithstanding that that corresponds to current recommended practice. If we think of new goods or services as goods or services which appear because their price has fallen below a reservation price, then the usual upward bias in the Laspeyres deflator will be augmented. The benefits of the new good or service do not appear.

If a Paasche or Fisher output deflator is constructed, a price has to be inferred for the base period, notwithstanding that expenditure was zero in that period. The same problem over a base-period price arises if, as in this study, a Törnqvist price index is adopted. Fisher and Shell (1972) suggest the problem can be resolved by the use of a reservation price.

Fisher and Shell (1972), however, make the distinction between a supply reservation price and a demand reservation price, suggesting that, when an output price index like the GDP deflator is under consideration, the supply reservation price is the relevant one. In practice, we cannot observe a supply reservation price; on the other hand a demand reservation price can be calculated as the maximum a consumer (the health service in this case) is prepared to pay for the treatment in question based on a standard valuation of the health benefits it delivers. If the demand reservation price were to exceed the supply reservation price, then there would be production at above the supply reservation price. So we can infer that the demand reservation is always below the supply reservation price in the situation of interest to us. By measuring the actual price relative to the demand

reservation price we are probably understating the impact of the introduction of the new treatment relative to the supply reservation price and thus understating its impact on the output price index. On the other hand this makes our treatment consistent with the reservation price recommended for use in the production of cost of living indices. We show here how the relevant demand reservation prices can be derived in our particular circumstances.

We now set out the general Törnqvist price index that we use.[4] For simplicity, we assume that the only change which happens between period 0 and period 1 is that a new treatment is introduced in period 1, with reservation price $p_{Res,0}$ in period 0 and actual price p in period 1. Expenditure on the new treatment is 0 in period 0 and s_1 in period 1, with all other expenditure on medical services, M, unchanged. Then the change in the log Törnqvist the price of medical services between period 0 and period 1 is $\Delta logP_{0,1}$, with

$$\Delta logP_{0,1} = log\frac{P_1}{P_0} = \frac{1}{2}\frac{s_1}{s_1 + M}log\frac{p_1}{p_{Res,0}} \tag{1}$$

The corresponding change in volume, $\Delta logY_{0,1}$ is then given simply as

$$\Delta logY_{0,1} = log\frac{Y_1}{Y_0} = log\frac{M + s_1}{M} - \Delta logP_{0,1} \tag{2}$$

Since p_1 is, by assumption, less than $p_{Res,0}$, we can see that both terms on the right-hand side add to output. The value of output rises and at the same time the price of output falls.

3.1 A New Treatment: Contemporaneous Treatment and Benefit

In this example we assume that the quality of life is represented by health status indicated by the variable h. We consider a population split between healthy people, each of whom has a health status h^h and people with the disease in question with a health state h^u. The disease does not last beyond the period in which it becomes apparent. A new treatment is developed which delivers a health status of $h^{treated}$ to the diseased patient after treatment. V is the value put on a unit quality-adjusted life year and C is the cost of the treatment. Then the value of the QALY gain from treatment. and thus the

[4]It is important to remember, however, that, despite the general appeal of the Törnqvist index, medical treatment does not fit happily into conventional consumer demand theory. The choice is typically between receiving and not receiving a given treatment rather than deciding how much treatment to buy.

reservation price of gross output, is $V(h^{treated} - h^u)$ and the treatment is likely to take place if

$$V(h^{treated} - h^u) \geq C \tag{3}$$

In the conventional national accounting, with a population, N, and annual incidence of the disease, ρ, the total nominal consumption of medical services increases by ρNC. System of National Accounts (2008) suggests assuming that the price of the new treatment has moved in line with the price of existing treatment. So if other prices are unchanged, this increase in value would also be used to indicate the increase in the volume of health services, and the price level of medical services would be assumed to be unchanged. But that is not what emerges either with measurement using the reservation price or direct measurement based on the number of QALYs generated.

3.1.1 Measurement using the Reservation Price

As noted above, the reservation price is given by $p_{Res,0} = V(h^{treated} - h^u)$. If C, the price of the treatment, exceeds this, the treatment is not provided.

If the whole of the relevant population is treated when the new treatment is introduced, then, with total medical expenditure of M, excluding expenditure on the treatment of the disease, and assuming this to be unchanged when the new treatment is introduced, the share of the new treatment in total spending is 0 in the period before introduction and $\frac{N\rho C}{M+N\rho C}$ in the period of introduction. We can now evaluate the Törnqvist index for the change in the log price level of all medical services, $\Delta logP_{0,1}$, making the additional assumption that the prices of other medical services are unchanged from the previous period. We have

$$\Delta logP_{0,1} = \frac{N\rho C}{2(M + N\rho C)} log \frac{C}{V(h^{treated} - h^u)} \tag{4}$$

and the associated change in the quantity index, $\Delta logY$ is given straightforwardly as

$$\Delta logY_{0,1} = log \frac{M + N\rho C}{M} - \Delta logP_{0,1} \tag{5}$$

With $\Delta logP_{0,1} < 0$ if the reservation price exceeds the actual cost. it follows immediately that the increase in output is larger than would be inferred using the approach suggested in System of National Accounts (2008) which ignores the fall in price.

Even in this simple case there is one issue that will require attention. The treatment may not be made available to all patients in the year of its introduction. If it is made

available to N_1 patients in the year of its introduction and to N_2 patients in the subsequent year, then the reservation price approach needs to be applied to the second-year patients as well as to the first-year patients.

3.1.2 Direct Measurement using QALYs

An alternative means of computing the increase in gross output, recommended implicitly by Castelli et al. (2007), Schreyer (2012) and Cutler et al. (2022) is with reference to the outcome of the treatment, in terms of the increase in QALYs to which it gives rise. Castelli et al. (2007) and Schreyer (2012) focus implicitly only on a situation where the treatment leads to an immediate increase in QALYs while Cutler et al. (2022) discusses the issue of discounting. But in our particular case the issue of discounting does not arise because the treatment and the benefit are contemporaneous.

The increase in QALYs is given straightforwardly as

$$\rho N(h^{treated} - h^{u}) \tag{6}$$

but to measure the percentage increase in output resulting from the new treatment, it is necessary also to know the number of QALYs generated by existing medical services. Cutler et al. (2022) assume that half of those expected by the population aged 65 and over in 1999 could be attributed to medical services. Some similar assumption is needed in order to put the increase in QALYs generated by new treatment in its context.

3.2 An Improvement in Treatment and a Reduction in Costs

Here we consider the situation where the treatment is improved while the cost/price remains the same or where the treatment is unchanged but is provided more cheaply. The first case can be seen in two ways. First, it can be seen as the withdrawal of an existing good and its replacement by a new good. Secondly, it can be seen as an increase in quality. We show that, as might be hoped, the two treatments yield the same results, confirming that the treatment of quality proposed by Schreyer (2012) is consistent with the treatment of new goods and services suggested here. The second case, similarly, can be seen as a straight reduction in price, or as the replacement of an expensive good by a cheaper one. We show, also in this case, that both approaches give the same answer

3.2.1 An Improvement in Treatment

The connection between price changes and new and disappearing goods can be seen by the following simple example. We assume that the treatment described in section 3.1 which delivered Q_0 discounted QALYs is replaced by one which delivers $Q_1 > Q_0$ QALYs at the same cost.

With discounted QALYs as the outcome variable, the price per discounted QALY drops from C to CQ_0/Q_1. Before introduction, the new treatment has a reservation price of

$$p^*_{Res,0} = CQ_1/Q_0.$$

This is used to compute the fall in price from the introduction of the new treatment. Similarly, after the introduction of the new treatment, the reservation price of the old treatment is $p_{Res,0} = CQ_0/Q_1$. Thus, making the assumption that the number of patients benefitting from the improved treatment is the same as that benefitting from the old treatment, the contribution to the Törnqvist index of the fall in the price of the withdrawn treatment from its actual price to its reservation price is

$$\Delta logP^W_{0,1} = \frac{1}{2}\frac{N\rho C}{M + N\rho C} logQ_0/Q_1 \tag{7}$$

and the contribution of the new treatment is also

$$\Delta logP^N_{0,1} = \frac{1}{2}\frac{N\rho C}{M + N\rho C} logQ_0/Q_1. \tag{8}$$

Adding these together, the overall contribution of the replacement treatment is

$$\Delta logP_{0,1} = \frac{N\rho C}{M + N\rho C} logQ_0/Q_1 \tag{9}$$

and with total spending unchanged the resulting increase in the volume measure is

$$\Delta logY_{0,1} = \frac{N\rho C}{M + N\rho C} logQ_1/Q_0. \tag{10}$$

This is entirely consistent with the quality adjustment proposed by Schreyer (2012) which is that an index of quality be established (here given by the discounted QALYs generated) and that this index, relative to its base year, be used to scale the output measure, in this case the number of patients treated. The treatment differs from that advocated by Cutler et al. (2022) because the change in the number of QALYs is weighted by the expenditure share rather than by the QALY count measured as a share of the total number of QALYs generated.

3.2.2 A Reduction in Price

That the two treatments, replacement of an expensive good by a cheaper one and a simple reduction in price, give the same answer can be seen directly from the previous case. There the implied reduction in price reflected an increase in quality. In this case the price is simply lower. The log of total expenditure will fall by the decline in log of price weighted by the two expenditure shares and, provided there is no change in the number of procedures the Törnqvist volume index will remain unchanged. Similarly there is no change in the number of QALYs generated, so a QALY-based index of gross output will remain unchanged. This does not, of course, mean that welfare is unchanged. If medical treatment becomes cheaper more can be spent on other things.

While these results come as no surprise, it is worth pointing out that statistical offices may need to revise their processes to ensure that this path is followed. Shapiro, Shapiro, and Wilcox (2001) draw attention to the fact that an old treatment of cataracts was replaced by a new one in specialist centres. The new treatment was much cheaper than the old one. But the Bureau of Economic Analysis treated it as a separate activity and therefore did not identify the reduction in cost in the US national accounts.

3.3 Treatment and Benefits spread over Time

We now develop the approach of section 3.1 to consider a situation where the patient needs sustained treatment to manage the condition, but, while the treatment may continue throughout life, very different costs are incurred at different stages, and the costs of the treatment in any particular year are not aligned to the benefits in that year. An example of this would be an organ transplant. Large costs are incurred at the start of the treatment but the patients have to take drugs throughout life in order to avoid fatal rejection of the transplant. The discounted sum of the expected benefits may exceed the discounted sum of the expected costs, but in the year in which the treatment starts, costs may well exceed the benefit in that year. This approach encompasses forms of "one-off" treatment such as cataract surgery with no continuing maintenance costs. Expected benefit exceeds expected costs over the life-time but not necessarily in the year of treatment. But it is in fact the need for continuing treatment rather than the receipt of continuing benefits that distinguishes this case from that of section 3.1.

To measure the price and quantity changes we assume that treatment must commence in the year in which the disease is contracted, notwithstanding that continuing treatment

is needed. This allows us to compare the cohort exposed to the disease in year t=0, for whom no treatment is available, with the cohort exposed to the disease in year t=1, for whom treatment is available. t indicates the calendar year and τ indicates the number of years the individual has been affected by the disease. The individuals in the cohort exposed in $t = 1$ are not at further risk if they do not contract the disease in $t = 1$. There are however subsequent cohorts exposed to the disease; all cohorts are assumed to be of the same size and to face the same risk of contracting the disease. It should be noted that these assumptions are needed so as to identify clearly what is going on; the price change associated with the introduction of the treatment does not rely on them, while the implications of this for the overall price index, the value change and the quantity index do. As we show in the empirical section, they are not needed for application of the theory, but some assumptions are necessary.

We again consider three possible situations. In the first case, the individual is healthy. In the second case s/he contracts the disease and is not treated. In the third case s/he contracts the disease and is treated. π_τ^h is the probability of living from the year in which the cohort is exposed to year τ for the healthy individual. $\pi_\tau^{treated}$ is the probability for a treated individual and π_τ^u is the probability for an untreated individual. The healthy individual enjoys a health status of h_τ^h in year τ, following exposure with comparable terms for the treated and untreated individuals, $h_\tau^{treated}$ and h_τ^u respectively. The h terms are measured as fractions of a fully healthy life year. Even for the average individual without the disease, h is likely to be below 1 as ageing progresses. δ is the discount factor.

We can then write the discounted value of remaining life-time QALYs for the three types of individual, with the year of exposure equal to 1, as

$$Q^h = \sum_{\tau=1}^{\infty} \pi_\tau^h \delta^{\tau-1} h_\tau^h \tag{11}$$

$$Q^{treated} = \sum_{\tau=1}^{\infty} \pi_\tau^{treated} \delta^{\tau-1} h_\tau^{treated} \tag{12}$$

and

$$Q^u = \sum_{\tau}^{\infty} \pi_\tau^u \delta^{\tau-1} h_\tau^u \tag{13}$$

$p_{t+\tau-1}^\tau$ is the cost of treatment in year $t + \tau$, giving a total discounted cost of treatment

of

$$C = \sum_{\tau=1}^{\infty} \pi_\tau \delta^\tau p^\tau_{t+\tau-1} \tag{14}$$

Here $p^\tau_{t+\tau-1}$ is the price of the treatment appropriate to the τth period of treatment in calendar year $t+\tau$ for the cohort exposed in year t.

With V the money value put on a QALY, treatment should be provided if

$$V(Q^{treated} - Q^u) > C \tag{15}$$

This condition is more likely to be met by those who have a high survival rate than those who have low survival prospects, which means that the treatment may be provided only to the younger part of the population. In order to assess its impact on the national accounts, however, we drop the subscript t. We look at the cohorts for which t=0 and t=1. With N the cohort size and ρ the risk of contracting the disease in the relevant year, we can write ρN as the number of people beginning the new treatment. Then the discounted sum of consumption of health services increases by ρNC in the year in which the treatment is introduced.

For national accounting purposes, however, we need to consider what happens in each year of treatment, since the national accounts measures of output relate to activity in each year, rather than to outcomes which may arise long after the activity in question. We make the simplifying assumption that that there are in fact only two activities- the treatment when τ =1 and the treatment for subsequent years $\tau > 1$. In year t, the price of the first is denoted p^1_t and the price of the second activity p^2_t. $p^1_{Res,0}$ is the reservation price of the first activity in year 0 with $p^2_{Res,1}$ similarly defined. $\pi_2^{treated}$ is the average probability of surviving to the second year of the treatment.

3.3.1 Measurement using the Reservation Price

Using the reservation price was straightforward when all the treatment and thus all the costs were incurred in the first year. Here, the reservation cost has to be derived from a comparison of discounted costs and discounted benefits, and not from a comparison of costs and benefits in any particular year. The treatment, while consisting of two different activities, has to be seen as a package. This contrasts with the example discussed in section 3.1 where, even if the disease was chronic, each year could be treated separately.

With two activities, the first year treatment and the second and subsequent-year treatment, we assume that in the second year the number of new patients is the same

as in the first year, so there is no further increase in treatment volumes as a result of treatment of new patients. But the patients treated in the first year receive the new second-year treatment, and this contributes a further increase in output

We still face the problem that, while in the national accounts each year is treated separately, here the introduction of the new service in one year makes sense only if the continuing treatment is available in the next year. The most obvious way to derive the reservation prices is to assume that these are proportional to the actual cost of treatment in the year of introduction of the new treatment and in the subsequent year when a separate treatment is introduced. Thus the reservation prices in the year of introduction ($\tau = 1$) and the next year, ($\tau = 2$) are

$$p^{\tau}_{Res,\tau-1} = \frac{V(Q^{treated} - Q^{u})}{C} p^{\tau}_{\tau-1} \tag{16}$$

.

If M is expenditure on other medical services is assumed constant in years 0, 1, and 2, a Törnqvist price index for year 1 can be calculated with the change in the log price of the treatment of

$$log \frac{p^1_1}{p^1_{Res,0}} \tag{17}$$

and an average expenditure share of the treatment of

$$\frac{1}{2} \frac{\rho N p^1_1}{M + \rho N p^1_1}. \tag{18}$$

If no other changes take place elsewhere in the health industry, then the change in the price of output is

$$\Delta log P_{0,1} = \frac{1}{2} \frac{\rho N p^1_1}{M + \rho N p^1_1} log \frac{p^1_1}{p^1_{Res,0}} \tag{19}$$

and the change in the volume of output, Y, is, consistent with maintaining coherence in the current price accounts,

$$\Delta log Y_{0,1} = log \frac{M + \rho N p^1_1}{M} - \Delta log P_{0,1} \tag{20}$$

In the second year of treatment, the change in the log price of treatment is

$$log \frac{p^2_2}{p^2_{Res,1}} \tag{21}$$

and the average share of expenditure is, with the assumption that a new group of patients receives the year 1 treatment

$$\frac{1}{2} \frac{\pi^{treated}_2 \rho N p^2_2}{M + \rho N p^1_1 + \pi^{treated}_2 \rho N p^2_2}. \tag{22}$$

The change in the price of output is

$$\Delta logP_{1,2} = \frac{1}{2}\frac{\pi_2^{treated}\rho N p_2^2}{M + \rho N(p_1^1 + \pi_2^{treated}p_2^2)} log\frac{p_2^2}{p_{Res,1}^2} \tag{23}$$

and the change in the volume of output, Y, is, consistent with maintaining coherence in the current price accounts,

$$\Delta logY_{1,2} = log\frac{M + \rho N(p_1^1 + \pi_2^{treated}p_2^2)}{M + \rho N p_1^1} - \Delta logP_{1,2} \tag{24}$$

The share of the new treatment in period 2 reflects the assumption that the period 1 treatment is offered to a new cohort of patients.

3.3.2 Direct Measurement using QALYs

The increase in QALYs is, with $\tau = 1$ or 2, given as

$$\rho\pi_\tau^{treated} N h_\tau^{treated} - \rho\pi_\tau^u N h_\tau^u \tag{25}$$

and this, measured as a proportion of all other discounted QALYs generated by medical treatment shows the increase in the volume of gross output. Once again the issue of relating this to the number of QALYs generated by existing medical services arises.

3.4 Public Health Measures

These observations lead us on to a discussion of public health measures. In contrast to the previous examples, a public health measure is an intervention designed to reduce risk. It follows immediately that the resulting increase in QALYs should be treated as an increase in gross output, when measured in the manner Cutler et al. (2022) suggest. But the more substantial question, which we consider first, is how it should be treated in the existing framework of mainstream national accounts.

We consider the introduction of a public health measure with cost H, which has the consequence of reducing the risk of contracting the disease from ρ to ρ^h. ρ^h therefore reflects the fact that only a part of the population may follow the public health advice. C is the discounted sum of the costs of treatment. Q^n is the discounted number of QALYs enjoyed by someone not affected by the disease. $Q^{treated}$ is the measure for someone affected and treated. The cost of the public health measure is allocated on a *per capita* basis.

	No Public Health Measure		Public Health Measure	
	Welfare	Cost	Welfare	Cost
Not affected	$(1-\rho)Q^n$	0	$(1-\rho^h)Q^n$	$(1-\rho^h)H$
Treated	$\rho Q^{treated}$	ρNC	$\rho^h Q^{treated}$	$\rho^h(H+NC)$

Table 1: Costs and Benefits with and without the Public Health Intervention

Table 1 shows the relevant costs and the benefits with and without the public health measure in place. Once again, there are two ways of looking at the problem. The first focuses on the price changes while the second focuses on the QALY gain.

3.4.1 Measurement using Reservation Prices and Costs

First we look at the reservation price approach. The cost saving from the measure is, making the assumption that treatment is provided to everyone who would benefit from it,

$$W_{Costs} = (\rho - \rho^h)NC \tag{26}$$

Additionally, with V the value put on a QALY, the sum of total of welfare without the public health measure in place is

$$W = V\{(1-\rho)Q^n + \rho Q^{treated}\} \tag{27}$$

while with the public health measure in place it is

$$W_{PH} = V\{(1-\rho^h)Q^n + \rho^h Q^{treated}\}. \tag{28}$$

Comparing the two welfare values, the money value of the gain in wellbeing is

$$W_{Welb} = NV(Q^n(1-\rho^h)+\rho^h Q^{treated} - Q^n(1-\rho) - \rho Q^{treated}) = NV(Q^n - Q^{treated})(\rho - \rho^h) \tag{29}$$

The total reservation price, W_{Tot} of the public health measure, needs to reflect both the welfare gain and the benefit of the saving in treatment costs. This means it is given as

$$W_{Tot} = W_{Cost} + W_{Welb} = N(C + V(Q^n - Q^{treated}))(\rho - \rho^h). \tag{30}$$

The actual price is of course H. It should be noted that the reduced level of treatment does not count as a withdrawn service. The treatment is still needed; there is simply less of it.

We need now to work out the change in the Törnqvist index of the price of medical services. The annual price of treatment in the absence of the public health programme,

p is assumed unchanged, so it does not contribute to the overall change in the price measure.

The cost of first-year treatment is shown as the first term in the discounted sum in equation (14). With a probability of contracting the disease of ρ and a population of N, the total first year expenditure in the absence of the programme is [5] $Np\rho$.

With the programme in place there are two changes. First, a smaller proportion of the population, $\rho^h < \rho$, requires treatment. Secondly, the costs of the public health measure have to be met. So, with p the cost of treatment assumed constant, first year expenditure changes to $Np\rho^h + H$, and the share of expenditure on the programme becomes, in the period of its introduction,

$$\frac{H}{M + Np\rho^h + H} \tag{31}$$

while in the period before introduction it had been zero. Here M once again reflects other medical expenditures, including treatment of patients who contracted the disease before the public health programme was in place, and whose treatment cost does not change.

The overall change in the Törnqvist price index for medical services as a result of the programme is then given as:

$$\Delta logP_{0,1} = \frac{1}{2}\frac{H}{M + Np\rho^h + H} log\left(\frac{H}{N(C + V(Q^n - Q^{treated}))(\rho - \rho^h)}\right) \tag{32}$$

and, with $Y_{0,1}$ representing the output measure,

$$\Delta LogY_{0,1} = log\frac{Np\rho^h + H + M}{Np\rho + M} - \Delta logP_{0,1} \tag{33}$$

It should be noted that the denominator in the first term of equation (33) is the total money value of expenditure in period 0, before the new programme had been introduced. The decline in the number of people who need treating shows up as a fall in year 1 expenditure relative to year 0 expenditure.

We also face the issue of what should be done in subsequent years, as the first treated cohort lives out its life-span. Less treatment is needed and consumption of medical services falls, but this is entirely a volume effect. Prices do not change. Some care is needed to compare like with like. We assume that the treatment is already in place for the whole of the population. Then the change in the volume of output in year

[5] The simplifying assumption is made that death occurs at the end of each period.

t is given by the ratio of spending in year t on the population exposed to the public health measure, relative to the expenditure on the previous cohort without the public health measure in place. With π_τ the chance of surviving from year 1 to year τ, $(\tau > 1)$, when suffering from the disease, the value change from year $t-1$ to year t is

$$log\left(\frac{M+H+\rho^h Np\pi_\tau}{M+H+\rho Np\pi_\tau}\right) \tag{34}$$

Here it is assumed that the price of treatment remains fixed at p and M is all medical expenditure except that of the first treated cohort. With no changes in the other prices, this is also the change in log volumes, $\Delta logY_{t-1,t}$. It should be stressed that this need not translate into a fall in aggregate output or consumption. Consumption of medical services will be replaced by other forms of consumption and there will in fact be an increase in welfare over and above that occasioned by the reduced prevalence of the disease. But the decline in medical output also highlights the point that we are discussing output indices and not measures of living standards or of the cost of living. A cost of living index would ideally reflect the benefits of spending less on medical services when there is less need for the spending.

One point to be noticed from this is that the initial change in output takes place when the programme is introduced. We are assuming that it is sustained on the same scale in all subsequent years, with the implication that it does not contribute to a further movement in output. But the decline in the demand for treatment continues until the death of the last member of the first cohort to be exposed to the programme.

The form of the calculations would not change very much if there were additional costs, beyond those of treatment, for people who contract the disease. If, for example, it were unpleasant or required a period of quarantine, the estimated costs to the patient could be reflected by an increment to C. In other word C should measure the total social costs of contracting the disease, and not merely the medical costs.

That does, however, raise a further issue. For some diseases there may be patients who are not aware that they would benefit from treatment and who suffer as a result; the public health measure may serve to reduce the number of patients in this category[6].

[6]For example Reidy et al. (1998) found that three quarters of cases of glaucoma in a North London population aged sixty-five years and older, were not known to the relevant medical services. Glaucoma is a disease which untreated can lead to eventual blindness and whose early stages are largely asymptomatic. This discovery led to a policy of encouraging all old people in the United Kingdom to have their eyes examined free by high street opticians every two years.

3.4.2 Heterogeneous Programme Costs

There is one further point to note[7]. So far public health interventions have been presented as non-exclusive services. Like television transmissions the cost of producing them is taken to be broadly independent of the number of people for whom they are relevant. This is largely true of media campaigns but much less true of other forms of preventative treatment. The costs of reaching different groups of the population may vary. In that case expression (32) can be applied separately to each group in the population (for example of size N_a, N_b etc. The overall average change in price would be given, with k indexing the different groups, as

$$\begin{aligned} \Delta logP &= \sum_k \frac{1}{2} \frac{H_k}{M + (\sum_k N_k p \rho^h) + \sum_k H_k} \\ & \quad log\left(\frac{H_k}{N_k(C + V(Q^n - Q^t))(\rho - \rho^h)} \right). \end{aligned} \tag{35}$$

As elsewhere, the change in the volume index is derived from this and the change in the money value of output of medical services.

3.4.3 Direct Measurement using QALYs

An alternative means of reckoning is to consider QALYs as an outcome indicator, and to assess the proportionate change in output in terms of the proportionate change in QALYs. With the treatment in place but before the introduction of the public health measure, the increase in QALYs in year $t + \tau$ as a result of treatment is

$$\rho(\pi^t_{t+\tau} h^t_\tau - \pi^u_{t+\tau} h^u_\tau) \tag{36}$$

With the public health measure replacing treatment, the associated increase in QALYs is

$$(1 - \rho^h)\pi^h_{t+\tau} h^h_{t+\tau} + \rho^h \pi^t_{t+\tau} h^t_{t+\tau} \tag{37}$$

while before the measure was introduced, utility in the period in question was

$$(1 - \rho)\pi^h_{t+\tau} h^h_{t+\tau} + \rho \pi^t_{t+\tau} h^t_{t+\tau} \tag{38}$$

so the increase in QALYs is

$$(\rho - \rho^h)(\pi^h_{t+\tau} h^h_{t+\tau} - \pi^t_{t+\tau} h^t_{t+\tau}) \tag{39}$$

[7] I am grateful to Richard Heys for drawing this to my attention.

It is, however, more usual to attribute output to the time when the activity which gives rise to that output takes place. That points to the first-year increase in output being measured by the increase in the discounted sum of QALYs (see equations (11) and (12)), i.e. as

$$(\rho - \rho^h)(Q^h - Q^{treated}) \tag{40}$$

and with this metric the proportionate change in gross output would be given by calculating this as a fraction of the total discounted sum of QALYs attributable to medical services. The net measures can be calculated by adding back any cost savings to the money value of the QALY gain, and deducting the cost of the programme itself. This is then measured as a proportion of the money value of the QALYs generated by medical services net of the costs involved.

4 An Example: Diabetes and the Diabetes Prevention Programme

Type-2 diabetes (T2D) is a disease whereby the sufferer is unable to control blood sugar levels adequately. T2D increases the risk of cardio-vascular disease, and is also associated with foot problems sometimes leading to amputation of toes or feet, visual impairment and kidney disease. These complications become more likely the longer the patient is diabetic, pointing to health gain even if an intervention delays rather than prevents the onset.

The prevalence of doctor-diagnosed T2D has increased from 2% of the adult population in 1990 to 6% in 2021. Among people 75 and over prevalence has increase from 6% to 16% over the same period [8]. Excess weight is a major risk factor. Thus in 2018 the prevalence of diabetes [9] among people with a body mass index of at least 30 was 12% while for those with a body mass index of 18.5 to 25, described as the normal range, it was only 5%[10]. The increasing prevalence over time is widely associated with the increasing average body mass index, from 25.8 in 1993 to 27.6 in 2019[11] but may also have happened because mortality rates of those with T2D have declined (Holden et al.,

[8] https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/2021-part-2

[9] All forms but T2D was much the most common

[10] http://digital.nhs.uk/pubs/hse2018

[11] http://healthsurvey.hscic.gov.uk/data-visualisation/data-visualisation/explore-the-trends/weight/adult/bmi.aspx

2017).

The Diabetes Prevention Programme (DPP) was set up on a test basis in 2017 (NHS England, 2016). It offers classes for people who are regarded as being at risk of developing diabetes. Patients are referred to it if they have blood sugar levels regarded as higher than normal but not yet so high as to be regarded as diabetic[12]. In a series of 15 classes advice is offered on factors such as what constitutes a healthy diet, weight management and exercise. A recent study (Ravindrararajah et al., 2023) suggested that, three years after completion of the course, 127/1000 referrals had developed diabetes while, among those who did not undertake the course, the prevalence of diabetes was 154/1000. These figures, although suggesting that the course was successful were derived from a matched cohort study rather than a random control trial. Evidence from other countries where random control trials have been carried out pointed to larger effects, suggesting the possibility that the impact of the programme was understated in the UK study. But the question faced here is how should the effects of programmes such as DPP be shown in measures of national income rather than the precise magnitude of the effect of the DPP.

4.1 The Costs of Diabetes

For the UK, there are estimates of the total cost of T2D to the National Health Service. Hex et al. (2024) suggest that in 2021/22 the costs of diagnosis and management amounted to £3.2bn while the treatment of complications cost £5.6bn. With 4mn people diagnosed with T2D in 2022/3 [13] that implies an average cost of £800 p.a. for diagnosis and management and £1,400 p.a. for treatment of complications. Doyle et al. (2022), in a study of the Irish Republic look at the annual costs of care for five categories of patient, those with optimal blood sugar control, those with suboptimal blood sugar control but no complications, those with kidney disease, those with active foot disease, those at moderate risk of active food disease and those who have suffered myocardial infarction. Seventy to eighty per cent of patients fall into the first or second category. In the first case the treatment cost about €800 per patient year, and in the second case about €1,200 or approximately £1,000 per patient year. We use a figure of £1000 as an annual cost of treating diabetes, noting that the late stage costs are discounted. If we

[12]In the UK a level of glycated haemoglobin (HbA1c) in the range 42-47 mmol/mol is regarded as pre-diabetic and was the main criterion for referring patients to the DPP. A value of 48 mmol/mol is regarded as diabetic while a level of 41 mmol/mol or lower is regarded as normal

[13]https://www.diabetes.org.uk/about-us/about-the-charity/our-strategy/statistics#: : text=Our%20data%20shows%20that%204.4,by%20167%2C822%20from%202021%2D22.

assume that this is incurred for twenty years and discounted at $3\frac{1}{2}$ p.a., then the average discounted cost per case is £14,600.

4.2 The Effects of the Programme

In assessing the effects of the programme it is necessary to distinguish referral from enrolment and again enrolment from following most or all of the course. NHS England (2016) provides estimates of the costs and benefits of the National Diabetes Prevention Programme in terms of cases of diabetes prevented or delayed by at least four years based on enrolment and participation in at least the first session, while Ravindrararajah et al. (2023) studied the effects of referral to the programme on the prevalence of diabetes three years later. They were unable to identify what proportion of referrals were actually enrolled although an earlier study (Valabhji et al., 2020) does provide some estimates of this. It is not possible to say precisely how the estimates of cases delayed by at least three years compared with those delayed by at least four years. But figure 2 (Ravindrararajah et al., 2023) suggests that, while prevalence rises among both the participants in the programme and the non-participants, the gap between the two values does not change much in the fourth year.

The total cost of the programme "excluding implementation, support and local costs", was estimated at £105m for the anticipated 390,000 participants. Implementation and support costs added £10.34m to this, making a cost of £29.6m per 100,000 participants rounded to £30m per 100,000. It is possible, of course, that some of these costs would fall if the scheme were permanent.

The base assumption made was that 37% of those eligible would enrol (NHS England, 2016, page 10) - meaning actually participating in the first session and that 63% of those who enrolled would fail to complete the course. Valabhji et al. (2020) looking at early data, found that 53% of those referred to the programme actually participated in an initial assessment and of those who joined the initial assessment 64% went on to at least one intervention session. Given the timing of this study only a fairly small number of referrals were in a position to have completed. But again 53% of those who had attended at least one intervention session completed the course. These last two figures suggest 34% of those who enrolled completed the course- a figure very similar to the initial assumption. Initial enrolment was, however, nearly 50 % higher than assumed in the prospective study. Taken in the round, these figures give us a penetration ratio of

$0.53 \times 0.64 \times 0.53 = 18\%$ of the population at risk. In contrast to the example of section 3.4.1, the programme is exclusive. We assume that no costs are faced from those who do not undertake the initial assessment. But we assume that once someone attends the initial assessment, the full costs are incurred. In practise, presumably an allowance can be made for the savings which result from those who do not proceed to the course. We therefore probably overstate the costs.

NHS England (2016) assumed that for every 100,000 participants enrolled in the programme 4,500 cases of diabetes would be delayed by at least four years or prevented[14]. It is noted that this is a conservative estimate; in a comparable programme in Finland it was estimated that 7,400 cases per 100,000 referrals were delayed or prevented (Lindström et al., 2006). NHS England (2016) also suggested, rather conveniently, that one QALY is generated[15] per case of diabetes prevented or delayed by at least four years. We work with this figure when discussing how the programme might be treated in the national accounts.

As noted earlier, the main medical problems associated with diabetes arise often many years after onset of the disease itself. If we assumed that the one year QALY gain came on average twenty years after onset, then discounting at $3\frac{1}{2}$ % p.a. would yield a current value QALY gain of $\frac{1}{2}$ QALY and, without better guidance as to timing, we work with this figure.

It is unclear what the long-term prognosis is for those for whom onset is delayed by four years. NHS England (2016) suggest that the benefits may be over-stated if there is a 'catch-up' effect. Equally, however, one might think that, at least for those who eventually die of some cause not related to diabetes, the costs saved are the higher costs associated with the late stages of the disease. NHS England (2016) simply assume that the average costs are saved and we follow that approach.

Ravindrararajah et al. (2023) studied the effects of referral, not initial participation, three years after referral. They found that the probability of *not* converting to diabetes

[14]Chris Whitty has kindly pointed out that the course has benefits beyond those of delaying or preventing diabetes. It focuses on obesity and this can cause other medical problems in addition to those related to diabetes

[15]This is a very cautious assumption. Taking the figures on diabetes incidence by age provided by Holden et al. (2017) and the impact on survival from Emerging Risk Factors Collaboration (2023) leads to the approximate calculation that the average diabetes patient loses nearly five years of life. The number of life years lost declines sharply with age at diagnosis. It is estimated at 15 for someone diagnosed at age 40 but at 1.4 years for someone diagnosed at age 80. These figures obviously reflect the fact that the 80-year old is much more subject to mortality risk from other causes than is the 40-year old.

Table 2: Key Programme Statistics per Thousand Patients Referred

Referred	1000
Attended initial assessment	530
Attended at least one session	340
Completed Course	180
Diabetic at three years	127
Cases of diabetes delayed	27
Value of QALYs generated	£810,000
Discounted saving in cost of treatment	£394,200
Total discounted benefit	£1,204,200
Cost per thousand participants	£300,000
Cost per thousand referrals	£159,000

from pre-diabetes was 87.3% for those who were referred to the course and 84.6% for those who were not referred to the course- a reduction in the prevalence of diabetes at three years from 15.4% to 12.7 %, a drop of 18.5% or 2.7 percentage points, as noted earlier. Those referred had higher body mass index and were more likely to have smoked at some time in their lives. Analysing the data using Cox proportionate hazard model suggests that referral to the programme reduces the risk of progression to diabetes by 20%- a number not very different from the result inferred directly by comparing crude conversion rates at three years. We also note that the drop of 2.7 percentage points contrasts with the drop of 4.5 percentage points assumed by NHS England (2016). However that figure of 2.7 percentage points was based on referrals, not enrolment. If we use the enrolment ratio of 53% from Valabhji et al. (2020), it implies a drop of 2.7/0.53= 5.1 percentage points or 5,100 per 100,000 among the enrolled population - slightly higher than that assumed by the prospective study, suggesting a result slightly better than had been assumed. The key programme statistics[16] are summarised in table 2.

5 Implications for the National Accounts

It might be tempting to take the discounted benefit of £1.204mn per 1000 participants and simply add this to the output of the health service and the estimates of consumption of health services. But this is inappropriate for a number of reasons.

First, the national accounts show financial costs and benefits separated in the years

[16]Valabhji et al. (2020) and Ravindrararajah et al. (2023)

in which they are incurred or realised. So in the current price accounts in the first year it is necessary to show an increase in spending of £300,000 per 1000 participants, or, with a participation ratio of 0.53, £159,000 per thousand referrals and not an unrealised benefit. The subsequent reductions in spending on treatment also need to be shown when they occur.

In volume terms, the gross output figures need to reflect the increase in QALYs in the year in which the DPP takes place. The reason for this is as follows. Changes in QALYs are seen as changes in the quality of medical services. But the services themselves are provided when the programme runs and not when the benefits are realised and quality adjustments should therefore be made when the services are produced.

In order to derive the proportional effect of the programme on the QALY output of the public sector, we largely follow the assumption of Cutler et al. (2022) that its output is measured by half the number of QALYs enjoyed by the population aged 65 and over. We estimate the total number of QALYs enjoyed by the population aged 65 and over using the self-reported health assessment data compiled by the Office for National Statistics[17]. This shows, for the whole of the United Kingdom as well as for much smaller geographic units, period life expectancy and also period life expectancy in good health. Someone is categorised as being in good health if they report their health as being good, very good or excellent. Those who report their health as fair or poor are counted as being in poor health. The ONS focus on healthy life expectancy, effectively, and with no justification, putting a zero weight on time spent in poor health. Palmer et al. (2021), however, explore the impact of health state on a measure of life satisfaction, and suggest that time in poor health is valued at about 75% of time in good health. The ONS provides the relevant data [18] at five-year intervals and we use these to estimate the total number of expected QALYs by sex and age. The maximum age shown is 90 and we assume that for people older than 90 the mortality rate is independent of age. This gives a total of 138m undiscounted QALYS accruing to the population aged 65 and over; with discounting the figure is 88.8m. With each QALY valued at £60,000, the total value of QALYs for those aged 65 and over is £5,326bn.

We are now in a position to calculate the impact, looking first at the mainstream

[17]https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthandlifeexpectancies/datasets/healthstatelifeexpectancyallagesuk

[18]https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/populationestimatesforukenglandandwalesscotlandandnorthernireland

accounts and secondly at the satellite account calculation proposed by Cutler et al. (2022).

5.1 Data on Health Spending

The value of QALYs for those aged sixty-five and over provides a basis for gross output calculations, while to look at the impact on net output, we need to deduct the relevant discounted costs of medical treatment. Here the data are not clear. Government expenditure on health in fiscal year 2018/19 amounted in total to £151,573m [19] according to ONS data consistent with the national accounts. The data set *Effects of Taxes and Benefits* allocates this collective consumption to households on the basis of what is known about use of health services by different individuals. This shows, for 2018/9, much smaller expenditure, of £42,953 m in total and £15,552m attributed to retired households. If we take the ratio of these, the implication is that 36% of total spending is undertaken on behalf of retired households, and applying this ratio to the national accounts figure for spending, we have £54,880m of spending on retired people. Applying a multiplier of ten *faut de mieux* to derive discounted future costs gives discounted expenditure of £549bn.

We came to a figure of 88.8m discounted QALYs as the expected discounted number of QALYs accruing to those aged 65 and over. If each QALY is valued at £60,000 and half of the discounted QALYs accruing to the population aged 65 and over are attributed to health treatment, then the discounted QALY value of the medical system is £2,663bn, or 4.9 times the estimated costs giving a net figure of £2,114bn. It is clear that relatively small revisions to estimates of costs will not have a large impact on the net benefit, calculated as the value of discounted QALYs less discounted costs.

5.2 The Diabetes Prevention Programme in the Mainstream National Accounts

We set out in section 3.4.1 the way in which the programme can be introduced into the national accounts as a new good whose price falls from its reservation price to its actual cost of production. The total benefit of the programme stands at £120.4mn per 100,000 referrals, giving the reservation price, $p_{0,Res}$ while the actual price, p_1 is £15.9mn, so the

[19] https://www.ons.gov.uk/economy/grossdomesticproductgdp/datasets/ breakdownofgeneralgovernmentfinalconsumptionexpenditure

log of the ratio of the reservation price to the actual cost/price, is

$$\Delta log \frac{p_1}{p_{0,Res}} = log \frac{15.9}{120.4} = -2.02 \tag{41}$$

The share in total expenditure is 1×10^{-4} as we noted earlier. This gives us a total weighted in the price index for health services in the Törnqvist index of

$$\Delta log P_{0,1} = \frac{-2.02 \times 10^{-4}}{2} = -10^{-4} \tag{42}$$

In the first year, then, we have an increase in the value of spending of 10^{-4} and a reduction in the price level of 10^{-4}.

The increase in the volume of output is therefore given by

$$\Delta log Y_{0,1} = log \frac{151589}{151573} - \Delta log P_{0,1} = 2 \times 10^{-4} \tag{43}$$

so in percentage terms there is an increase in output of $2 \times 10^{-2}\%$

In subsequent years output is reduced in exactly the same way as in the previous example. There is no further change in price. It is simply that the demand for services provided to diabetics has declined because there are fewer diabetics. With 2,700 cases avoided per 100,000 referrals and an assumed treatment cost of £1000 p.a., the saving is £2.7mn per annum. This is a reduction in health service output of $1.8 \times 10^{-3}\%$

5.3 The Diabetes Prevention Programme in a Satellite Account

We follow Cutler et al. (2022) in assuming that the QALY output of the health serivces is equal to half the number of discounted QALYs enjoyed by the population aged sixty-five and over. We start with the observation that the gain in discounted QALYs per 100,000 referrals is worth £81mn (see table 2). The proportionate increase in gross output is given by the ratio of this to the stock of medically-generated QALYs which was valued at £2663 bn.The increase in gross output per 100,000 referrals which would be recorded in a satellite account is therefore

$$\frac{81}{2663000} = 3 \times 10^{-3}\% \tag{44}$$

In terms net of costs, the increase in output is calculated by adding back the saving in treatment costs but deducting the cost of the programme.

$$\frac{81 + 39.4 - 15.9}{2114000} = 5 \times 10^{-3}\% \tag{45}$$

6 Conclusions

This paper has shown how it possible to consider new and improved medical treatments including public health and other forms of preventative medicine when producing estimates of the consumption of health services in the national accounts. It should be noted that the approach adopted here, in contrast to Jones and Klenow (2016), does not involve putting any value on life years generated by public health measures. Rather, following the proposal of Castelli et al. (2007) and the approach adopted by Cutler et al. (2022) it assumes that the increase in the number of QALYs associated with medical and public health services represents a change in the outcomes of these services.

These outcomes can be used to derive reservation prices so as to incorporate the effects of new treatments including preventative public health measures directly into the national accounts. When looking at a quality improvement the approach is consistent with System of National Accounts (2008) and Schreyer (2012) in adjusting measures of output to reflect the quality of the good or service provided. Alternatively the increase in QALYs can be used directly in a health satellite account as suggested by Cutler et al. (2022). The impact of the Diabetes Prevention Programme on the output of medical services is small although larger when incorporated into the mainstream national accounts than when put into a satellite account.

In concluding it is important to note that the Diabetes Prevention Programme is a public health measure whose effects are particularly well defined. It is possible to identify who participates and to examine the impact on the participants. Many public health measures are more diffuse than this, with the implication that it is harder to assess their impact. But that does not provide a good reason for assuming implicitly that impact is very low. Imprecise estimates provide a better guide to outcomes than does ignoring the issue.

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A The Calculation of Total Expected Health-adjusted Life Years

The core of the calculation is provided by the ONS template for the calculation of healthy life expectancy, available from the ONS web site[20]. This tabulates the population in five year age bands, with age 90+ treated as a single group. From given mortality rates for

[20]https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthandlifeexpectancies/datasets/healthstatelifeexpectancytemplate

these age bands, it computes life expectancy at the start of each age band, and also healthy life expectancy. The former is calculated by adding up expected future life years while the latter is calculated by cumulating expected future healthy life years. We focus on health-adjusted life expectancy which gives a weight of 0.75 to time expected to be spent in poor health.

The template does not indicate to which year it applies or whether it is for men or women. We are, however, able to obtain mortality rates for England and Wales only, from NOMIS[21], the ONS portal for tailored data requests. The mortality rates for men for 2018 are very similar to those shown in the template. We use these mortality rates in place of those in the template to obtain health-adjusted life expectancy for each of men and women at the start of each age band. We apply a discount factor, assuming a discount rate of $3\frac{1}{2}\%$ p.a. to the centre of each age band. Thus the health-adjusted life years expected between age 60 and 64 are discounted for $2\frac{1}{2}$ years, while those expected between age 65 and 69 for a current 60 year old are discounted over $7\frac{1}{2}$ years, etc A $2\frac{1}{2}$ year discount factor to expected life years is assumed to apply for a 90 year old.

The population data, also available from NOMIS, show the number of people in each age band.

[21] https://www.nomisweb.co.uk/default.asp