



**Returns on Investment in Public Health:
Comments on the Report by Applied Economics**

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July, 2004

ISSN 1448 - 6822

ISBN 1 876662 70 0

SYNOPSIS

The purpose of the report by Applied Economics was to determine whether or not the community's expenditures on public health have been justified by the benefits obtained from them. Additionally, however the study extends the time frame and, on the basis of the historical evidence, seeks to determine the 'return' on current investment in public health to the year 2010. The report does not consider further investment in public health. Only benefits obtained from current expenditures are projected into the future. For example, the community will continue to receive benefits for some years from vaccinations administered in 2000, and these benefits are included in the study. However the estimated benefits and costs of vaccinations administered after 2000 are not considered.

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1 Introduction

The question: The purpose of the report by Applied Economics was to determine whether or not the community's expenditures on public health have been justified by the benefits obtained from them. Additionally, however the study extends the time frame and, on the basis of the historical evidence, seeks to determine the 'return' on current investment in public health to the year 2010. The report does not consider further investment in public health. Only benefits obtained from current expenditures are projected into the future. For example, the community will continue to receive benefits for some years from vaccinations administered in 2000, and these benefits are included in the study. However the estimated benefits and costs of vaccinations administered after 2000 are not considered.

The criterion for answering this question is whether or not the benefits from past investments in public health exceed the costs. With an unconstrained budget this would be equivalent to the criterion that the ratio of benefits to costs should exceed unity. However the funds available for public health programs are limited and the technically correct criterion for successful investment is, therefore, that the ratio of benefits to costs should exceed the shadow price of capital. Restated, the incremental benefit of a dollar spent on a program financed from a limited budget should exceed the benefit which could be obtained from the next best investment in the health sector. While the shadow price is not known¹, the likelihood that the criterion will be met increases as the ratio of the net present value (the present value of benefits less costs) per unit of budgetary expenditure increases.

Difficulty of the Task: The evaluation of public health programs—PHP's—is problematical and a number of conceptual and practical problems arise in the implementation of such a study. First, PHP's are generally concerned with 'public goods': the class of goods and services where the use by one person does not reduce availability for others. Traditional examples include defence, law, street lighting and, closer to the health sector, sanitation and regulations to preserve a minimum level of hygiene. In all of these cases it is not possible to use the criterion of 'revealed preference'—the amount a person is willing to pay in a marketplace—to determine the value of the benefits. In the absence of markets and prices the alternative methodology is to determine the effect of PHP's upon health outcomes and to determine whether or not the value of these outcomes exceed the cost of the program².

¹ The marginal opportunity cost of capital in the context of a constrained budget is commonly assumed to be about 7 percent. However as the return to public health is more uncertain than the return on most public investments a higher figure could easily be justified.

² The willingness to pay criterion is not, even in principle, equivalent to the value of health outcomes per unit of cost. Willingness to pay does not map perfectly into health outcomes both because of the different tastes and incomes of the beneficiaries. For this reason orthodox economists have regarded the use of health outcomes as a benefit measure as a second best solution. Others have argued that, in the context of a public health scheme, the true objective is health outcome and not individual utility as proxied by the willingness to pay. While the present study converts benefits into dollar equivalent values it is more consistent with the second class of analyses as the dollar values used are not derived from willingness to pay studies.

Secondly, the impact of public health programs upon health outcome is not directly observed. Program benefits take the form of episodes of mortality and morbidity that do not occur: heart attacks averted and the non-transmission of HIV. Measurement therefore requires an assumption about the unobserved counterfactual. The obvious difficulty of this task is accentuated by the fact that health outcomes will be affected, not simply by public health programs but also by other events: changing incomes, changing prices, new taxes, technological innovations, fashion and the diffusion of information. Because of this it is difficult to establish and quantify the causal relationship between health programs and health outcomes.

Thirdly, public health programs seek to reduce both morbidity and mortality. There is, therefore, a methodological problem. How can dollar costs be compared with lives and life years gained and how may the quality of life be taken into account? Methodologies have evolved which, at least in principle, allow the combination of the quantity and quality of life into a 'Quality Adjusted Life Year (QALY)'. The present study uses the most readily available of these measures, namely the Disability Adjusted Life Year (DALY)³. The authors of the study might have employed this to conduct a series of cost utility analyses of each of the public health programs and to have produced estimates of the average cost per QALY arising from each program. Rather, they have elected to multiply DALYs by an estimate of the dollar value of a life year. In principle this final step should be uncontroversial. If costs are to be compared with life years gained and if only some programs are to be funded then a decision must be made, implicitly or explicitly, concerning the cost per life year at which public funding will cease. The advantage with the approach adopted here is that the critical value is explicit and may be debated and modified. The disadvantage, of course, is that the value must be justified and the authors' justification may be challenged and deemed unacceptable.

Finally, the programs evaluated in this study consisted of a large number of sub-programs, so numerous that a careful evaluation of each would have been an impossibly complex task and especially in view of the poor quality of the data available. The authors therefore had to seek a methodology which did not require highly detailed data.

Importance of the Study: Because of the difficulties enumerated above it is important to emphasise that the study is, nevertheless, of importance. It is widely believed that public health programs have the potential to deliver significant health benefits and benefits which represent a greater return to health investments than many curative programs. However it is legitimate and desirable to be sceptical of undemonstrated assertions and these benefits are at risk if there is no attempt to quantify the RoI from public health expenditures using the best available data and methodology. The present study represents such an attempt.

Study Criteria: Two criteria are adopted by the authors. The first, appropriately, is that benefits should exceed costs when both of these are measured from a communal perspective. That is,

³ In principle there are a large number of QALY-like measures, each constructed from a different combination of attributes. For example QALY-like measures can be constructed using the time trade-off or standard gamble scaling instruments. Values can be obtained from the public, from patients or from health professionals. The subjects may be asked to imagine that they are in a particular health state or, alternatively, they may be asked to imagine other people who are in that state. The time period to be envisaged may be one year or an entire episode of illness. The DALY is defined by the use of the person trade-off scaling instrument which, necessarily, involves an impersonal perspective and, to date, respondents in DALY scaling exercises have been medically trained. Questions require the entire episode of illness to be evaluated.

the benefits and costs should, in principle include everything of relevance to wellbeing in the community. In practice it is only possible to quantify the major magnitudes but these should be judged from a communal perspective. Secondly, and at the Commonwealth's request, the authors determine the program impact upon public finances: the net increase or decrease in the budget deficit.

At best, this latter criterion is useful for political reasons. If public finances improve because a program reduces subsequent medical expenditures by more than the cost of the program then there is a compelling reason for a government to undertake the program: it would be irrational not to do so with a demonstrated win-win outcome. At worst, the criterion should carry little weight. Where there are significant demonstrated benefits an investment should be carried out and, if necessary, taxes or a government deficit increased. If budgets are totally inflexible then the relevant criterion for assessing alternative budgets is a rule which has not been explicitly considered in the study. It is that the ratio of the net present value of a program divided by the cost to budget should exceed a threshold which is sufficiently high that budget expenditures are kept below the limit. While not explicitly computed, the information provided from the first two criteria permit the calculation of such ratios.

The terms of reference of the study also make explicit that the objective is to assess the total impact of programs and not the marginal benefit to cost ratio. Over a forty year time horizon this is the appropriate study objective. Setting aside historical curiosity, the results of the present study are primarily useful to the extent that they indicate the likelihood of further benefits from a continuation of public health policies similar to those being evaluated. Of course future and past circumstances may differ but the historical performance represents a sensible starting hypothesis, viz, that future programs delivered in comparable circumstances and to comparable populations will result in comparable benefits. In contrast, an evaluation of marginal costs and benefits—the additional benefits which would have occurred if historical programs had been somewhat larger or smaller—would only be of historical interest and would not provide a sensible base line hypothesis regarding the value of future programs.

2 Summary of Methods and Results

The study methodology is described with admirable clarity in Chapter 1. It is summarised in Figure 1 below. 'Net present value'—the present value of benefits less costs throughout the study period—is equal to the cumulative value of the net benefit each year discounted by the rate of time preference, r , (Equation 1). This, in turn, is equal to the present value of benefits less the present value of cumulative costs. The latter are equated with public expenditures. In a relatively competitive market place this is a reasonable procedure to adopt (Equation 2). Program benefits—the problematical side of the net benefit equation—are equated with the saving in medical expenses because of averted illness plus the dollar value of the DALYs gained because of the programs (Equation 3). These, in turn, are equal to the years of life lost (YLL) and the years of life in disability (YLD) which would have occurred without the program but which have been avoided (Equation 4). YLL—the years of life lost (without the programs)—and YLD—the equivalent years of life lost due to ill health—are both defined as the difference between the years of life and the years of disability with and without the public program. The unobserved experience without the program represents a baseline and it is the estimation of this unobserved baseline which introduces the greatest uncertainty into the evaluation.

As it is a 'desktop study' the authors relied upon publicly available data. They employed estimates from a range of sources, including the Australian Institute of Health and Welfare (AIHW) as the basis for estimating public expenditures (Equation 2), averted medical costs (Equation 3) and the number of DALYs per episode of illness (Equation 4). The counterfactual historical experience was estimated from the decline in the incidence of the relevant diseases commencing at the base year, and from an estimate of the proportion of the decline attributable to public health programs. The estimate, in turn, was based upon the literature concerning the effectiveness and efficiency of the relevant health programs and the other concurrent historical events. The dollar value of a year of full health was likewise estimated from the literature. It is discussed further below.

Results are summarised in Table 1. They suggest that the benefits arising from the different programs have exceeded costs by a very large margin. They imply an enormously high return on investment.

Figure 1 Evaluative Framework

NPV	= $\sum_i (b - c)_i / (1 + r)^i = \sum_i b_i / (1 + r)^i - \sum_i c_i / (1 + r)^i$	1	
C _i	= costs = Public Expenditures _i	2	
B _i	= averted medical costs + (DALYs gained) * (\$60,000)	3	
DALYs	= YLL + YLD	4	
YLD	= (Ill years) * QoL		
YLL	= Baseline - Observed years lost		
YLD	= Baseline - Observed		
Baseline	= counterfactual		
where:			
NPV	= net present value	DALY	= Disability Adjusted Life Years
B _i	= benefits, year i	YLL	= Years of life lost due to premature death
C _i	= costs, year i	YLD	= Years of life lost due to ill years
r	= discount rate	QoL	= index (0 - 1) of reduced quality of life (= disutility)

Table 1 Summary of cumulative program benefits and costs

Program	Costs	Benefits	Ratio	Net Benefits	Government spending (G) and offsets (O)	
	(C)	(B)	(B/C)	(B-C)	(G-O)	(B-C)/G
Tobacco	176	8602	488	8427	-168	na
CHD	810	9289	11.5	8478	+196	43.3
HIV/AIDS	607	3105	5.1	2498	na	
1984-2010 Immunisation						
• measles (1970-2003)						
• Hib (1991-2003)	52	9200	176.9	9100	-8450	na
	155	176	1.3	10	na	
Road Safety	5300*	14000	2.6	8700	+1300	6.7
	(600)**		4700	(13400)		

* including private costs ** Gov expenditures only

Table 1a Program net present value and sensitivity analyses

	Estimate (\$ million)		
	Mean	Upper estimate (discount rate = 0)	Lower estimate
Tobacco	8,427	32,920	1975(1) (d = 5%)
CVD	8,478		2,322(2)
HIV/AIDS	2,497	17,931	1,302 (d = 7%)
Immunisation			
Roads	8,700		3,400(2) (d = 7%)

(1) Effect of tobacco reduction reduced by 50%; program contribution 5%

(2) Health benefits halved; program effectiveness halved

3 Individual Programs

3.1 Tobacco Control

Details of the analysis of tobacco control programs are summarised in Table 2. A detailed analysis of the impact of program costs and benefits was conducted for a single year, 1998. Results were then projected backwards and forwards to obtain an estimate for the cumulative effect over the study period. The results are presented in Table 2.10 of the study.

Benefits are dominated by a reduction in tobacco related deaths and the procedures adopted to estimate these illustrate the study methodology. The number of public health measures implemented to control smoking (summarised in Study Table 2.1) are too numerous to evaluate individually. Disentangling the effects of individual health warnings, regulations and media campaigns would be methodologically intractable. Consequently the authors rely upon

econometric analysis to estimate the relationship between tobacco consumption and death and, consequently, the relationship between reduced tobacco consumption and reduced mortality in the study year 1998.

A pivotal assumption is then made. This is that 10 percent of the reduction in tobacco consumption was attributable to the cumulative effect of the various public health programs. The assumption is consistent with the majority opinion in the literature. However the authors acknowledge the existence of a single study by Bardsley and Olekalns (1999) which suggests that the entire decline is attributable to the 154 percent increase in the real price of tobacco between 1971 and 1996. If this conclusion was correct then the public health programs would have had no residual impact. The authors reject this latter conclusion and concur with Borland (2000) and Chapman (2000) in criticising the Bardsley and Olekalns methodology and conclusion.

Table 2 Tobacco Programs: costs and benefits in 1998

Fall in tobacco related mortality	
• from 1971	17,421
• due to Programs (10%)	1,742
Value of benefits, all cause	
Life extension	\$9.6b
Quality of life	\$22b
H Care reduces health care costs	\$0.5b
Total	\$12.3b
Program Costs	
Benefits (= 1/10 All cause)	\$18m
Net	\$1.2b
	\$1.18b

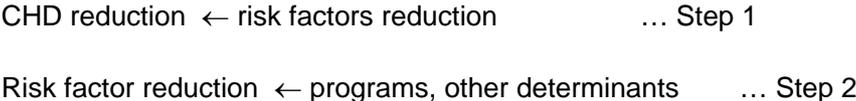
Since it is independently known that programs of the sort used in anti smoking campaigns have a significant impact on behaviour—the entire advertising industry depending upon this fact—the authors’ rejection of the Bardsley-Olekalns conclusion is justified. However this cannot be demonstrated rigorously and this problem—the estimation of the true counterfactual—illustrates the primary methodological problem associated with the evaluation of public health and disease prevention policies.

3.2 Coronary Heart Disease (CHD)

The analysis of the costs and benefits of public health programs to reduce CHD is methodologically similar to the previous study. It is noted that the number of programs in this category is exceedingly large. Only the largest of the programs run by the Commonwealth and the National Health Foundation are listed in the Study Table 3.1 and included in the costing side of the analysis. The authors note that this excludes a large number of programs and services which are not primarily designed to affect CHD but which will have a favourable effect on the incidence of the disease. As an example, the Commonwealth has funded 44 projects under the healthy seniors initiative and the AIHW lists 17 current or recent public health programs associated with nutrition which are excluded from the cost side of the analysis. Likewise the study omits State-based programs and services provided by general or other medical

practitioners. The Commonwealth programs listed in the Study Table 3.1 target diseases other than CHD and for this reason the authors, somewhat arbitrarily, assume that one third of current expenditure on the listed programs is associated with the reduction of risk factors for CHD. The rationale for the assumption is not explained and arbitrary attribution rules are problematical. However the final results are insensitive to program costs and, indeed, they would have to increase 12 fold before they reversed the conclusion drawn from the best estimate scenario.

Because of the impossibility of individually evaluating each of the multiplicity of programs the authors adopt the following analytical structure:



In sum, the decline in CHD attributable to public health programs is estimated from a two step analysis. First, the relationship between risk factors and CHD is used to estimate the effects of the known decrease in risk factors (cholesterol level, blood pressure, smoking and exercise). Secondly the relationships between these risk factors, public health programs and other determinants of the risk factors are examined. The authors conclude that overall behavioural change appears to have had little impact on blood pressure where favourable effects are almost entirely attributable to drug treatments. However 20 percent of cholesterol deaths and 10 percent of smoking related deaths are attributed to the programs. The authors conclude that there was no reduction in blood pressure as a result of a reduction in salt and alcohol intake or from physical exercise.

The cumulative impact of the programs in 1998 was, therefore, the result of fewer cholesterol related and fewer smoking related deaths. Of the estimated 6,000 such deaths, 20 percent or 1,800 were consequently attributed to the programs. Assuming that each early death reduced life expectancy by about 10 years, and adding 20 percent for the improved quality of life and also adding the benefits of lower health care costs resulted in a total benefit of \$994 million. Allowing for a program cost of \$60 million the estimated net benefit in 1998 was therefore \$934 million. From this base case, projection backwards to 1971 and forwards to 2010 resulted in an estimated net present value of \$8.48 billion.

As with the analysis of anti smoking programs the estimate depends upon a pivotal assumption concerning the impact of programs upon risk factors. While the assumption is clearly reasonable it cannot be demonstrated with scientific rigour. A significant decrease in the assumed effect does not, however, change the overall conclusion with respect to the overall beneficial effect of the programs. There is also an element of 'double counting' in the inclusion of the benefits from reduced smoking. It is legitimate to include this effect in an analysis of the impact of public health programs upon CHD. However, this implies that the total benefits of public health programs will be overstated by a simple summation of the benefits reported in each case study (Chapter). The quantitative magnitude of this upon the overall conclusion is, however, relatively insignificant.

3.3 HIV/AIDS

Estimating the costs and benefits arising from the public health programs to reduce HIV/AIDS results in a new set of challenges. Unlike programs to reduce CHD the programs and program

costs are relatively well defined and the latter have been carefully documented by Butler (1996). However the benefits arising from the needle exchange, education and marketing campaigns are difficult to isolate.

The key relationship for determining program benefits is encapsulated in the following equation for the incidence of new cases of HIV which applies each year.

$$\text{Incidence (I)} = B \cdot \left[\begin{array}{c} \text{persons already} \\ \text{infected (N)} \end{array} \right] \left[\begin{array}{c} \text{proportion of relevant} \\ \text{Pop susceptible (U/P)} \end{array} \right]$$

where B = Transmission rate (I/N) adjusted for proportion susceptible (A)

A = Proportion susceptible = U/P

N = Number infected at commencement of period

U = Uninfected but susceptible persons

P = Relevant population

$$\text{thus, Incidence, } I = \left(\frac{I}{N \cdot A} \right) (N) \left(\frac{U}{P} \right)$$

$$I = \frac{I}{N} \cdot \frac{P}{U} \cdot N \cdot \frac{U}{P} = I$$

Each of the variables in this equation poses a measurement problem. Incidence cannot be directly observed. Consequently, it is estimated by back projection from the number of notified cases of AIDS. This statistical exercise requires the assumption of a density function of time lags and this function will itself change—average time lags will increase—as medical treatments improve. The pivotal variable in the analysis is the transmission rate β which will fall if a successful program increases preventive behaviours.

A further complication is that—as with other preventive programs discussed here—the target variable changes as a result of a variety of influences. In the present case, Government programs only commenced in 1984-85. However, as shown in Study Figure 4.3, by this date the estimated transmission rate had already fallen by 63 percent from its peak level of 0.59 in 1982. The validity of the final results clearly depends upon the successful disentangling of these other influences from program effects.

Following from this, the pivotal assumption in this chapter is that half of the 25 percent decline in the transmission rate between 1985 and 1993 was attributable to government programs. This estimate, originating from Hurley et al (1996a), was justified by the observation that the prevalence of unprotected anal intercourse with casual partners declined by 25 percent over this period: there was a 25 percent reduction in this particular risk behaviour by MSM.

The dollar benefits implied by these results were estimated using the standard study methodology. That is, years of life lost (YLL) due to premature death were added to years lost due to disability (YLD) and the combined DALY loss was evaluated using a standard discount rate of 5 percent and a value for each year of life saved of \$60,000.

Two methodological points are of interest in this latter stage of the analysis. The first and lesser issue arises from the assumption of DALY disutility weights. There are four such weights associated with the four stages of HIV/AIDS, viz, AIDS asymptomatic; AIDS-related complex; AIDS; AIDS terminal phase. The weight for the first of these states—*asymptomatic HIV*—is set equal to 0.2. This implies the surprising conclusion that 5 years without symptoms is as undesirable as the loss of life for one year. The *prima facie* implausibility of this result underscores the dependence of this part of the analysis upon the invalidated DALY results derived, ultimately, from the WHO Burden of Disease study⁴.

The second methodological point of interest arises from the (normal) practice of discounting future values. In the present context the effect of this is quantitatively very large. At the point of infection the typical life expectancy is 53.9 years. In the economic analysis, the last of these years will have been discounted, using the standard discount rate, by a factor of $(1.05)^{52.9} = 13.2$. This implies that the final year of life will have a present value equivalent to 27.6 days. As death occurs, on average, 15.5 years after infection every lost year will be significantly discounted. The 38.4 years of life lost after 15.5 years will have been discounted to a present value of 22.8 years; that is, there is a 41 percent reduction in the benefit of life saving because of the 5 percent discount rate. When the discount rate is increased to 7 percent the value of the final year falls to 10 days and the 38.4 years of life lost is contracted to a present value of 5.1 years. These observations are not a criticism of the authors who have adopted normal practice in their treatment of future benefits. Rather, the consequences of normal practice are simply being noted as the basis for a further discussion in Section 4.2 below.

3.4 Immunisation: Measles and Hib

Measles and haemophilus influenzae type B (Hib) were selected for study because of the contrast between them. Measles has been, historically, a major cause of ill health. Hib disease has been more recent with vaccination only being introduced in 1993.

Immunization has the characteristics of both a public and a private good. Individuals obtain some immunity from individual immunisation. However, past a threshold there is a herd immunity effect which benefits the public.

⁴ The plausibility of this figure depends, in large part, upon what precisely is meant by 'utility' and the answer to this question is surprisingly ambiguous (Richardson 1994). If the term is used to mean 'utility' in the original sense of this term, ie the intensity of pleasure-pain experienced in 'real time' then a 20 percent reduction in utility because of an asymptomatic condition is implausible. However 'utility' may also be interpreted as meaning 'the strength of preferences as expressed before or during a health state is experienced'. This 'intellectualised' concept does not involve a reduction in the quality of life experienced in 'real time'. Consequently the 20 percent reduction in utility because of an intellectualised anxiety is more feasible. The choice between these concepts does not depend upon economic theory but upon social policy and, more specifically, upon the objective that is sought in the context of public health policy and expenditures.

While there is good clinical evidence for the effectiveness of measles vaccine, the estimation of its aggregate effects encounters two methodological problems. The first is that accurate national data on the number of cases of measles only commenced in 1991. Secondly, and in common with all preventive measures, the counterfactual—episodes of measles in the absence of immunisation—is not observed and is not readily estimated.

These twin methodological obstacles were overcome using two assumptions. The first is that the ratio of episodes to deaths from measles is the same in Australia and in the UK where both sets of data are available. The UK ratio may then be used to estimate the incidence of measles in Australia from the number of deaths (where the Australian records are complete). While there appears to be no alternative methodology, the assumption is not self-evidently true. Immunity depends, *inter alia*, upon the level of nutrition and it is likely that trends in nutrition in Australia and the UK will have diverged through time. Further, the UK has a different system of primary and secondary health care which might also alter the relationship between deaths and episodes as compared with Australia.

The second assumption is that the effect of immunisation may be estimated by subtracting actual notifications from the long term trend rate of notifications estimated from annual data before the introduction of immunisation. This methodology is adopted here and later in the study. Trend and estimated notifications since 1940 are shown in Study Figure 5.3 where it is apparent that, consistent with the implied hypothesis, actual notifications diverge from the long term trend after vaccine became available without charge in Australia in 1970.

The methodology is not, however, fully convincing. The downward trend in actual notifications does not commence in 1970 but in 1954. Consequently, the positive slope of the trend line (without immunisation) is driven by the 14 year period 1940-1954 and used to estimate notifications in the 32 year period 1970-2002: there is a 48 year gap between the end of the data series driving the trend and the end of the period of estimated notifications. An alternative methodology which computed the trend line with data from 1954 to 1969 would have resulted in a significantly smaller number of averted episodes of measles.

The remaining steps in the analysis follow the broad study methodology. The disutility of the various stages of measles are combined with the incidence of these states to calculate the value of YLD's which are then combined with estimated YLL to produce an overall estimate of the DALYs gained because of the programs. These are converted into dollar values and combined with averted medical costs to estimate total program benefits.

In contrast with the estimation of benefits, the costing of the various vaccination programs is relatively reliable. Data are available from which to estimate the doses of vaccine purchased and delivered, the cost of GP or non GP immunisation providers and the administrative costs of the Australian Childhood Immunisation Register. Results indicate that program costs are trivial relative to the magnitude of the benefits and an assessment of the net benefit of immunisation depends almost entirely upon the validity of the latter not the former estimate.

Haemophilus Influenzae Type B (Hib Disease): The methodology described above is also used to determine the impact of Hib vaccination. Consequently, the strengths and weaknesses of the analysis are similar. Cost data are good; the benefit estimates are problematical.

In contrast with measles there is a complete dataset for Hib notifications and, consequently, projections are based upon hard data. However, the information used in the analysis commences in 1991 and vaccination was introduced in 1993. The estimated trend line without vaccination is therefore based upon 2 years data. While this is subdivided into monthly notification rates the entire period includes only 866 notifications. This is a very limited evidence base from which to obtain estimates for the following 12 years (132 months). Sensitivity analysis are carried out on both the costs and benefits by increasing the former and reducing the latter by 25 percent (in separate analyses). This does not result in negative net benefits. However it is not clear that the 25 percent margin is a 'conservative assumption' (suggesting that real error is probably less than 25 percent). There is no real basis for such a judgement and the net benefit of immunisation is therefore questionable.

3.5 Road Safety and Road Trauma Programs

As with CVD and tobacco control there are so many road safety programs that individual assessment and summation is an infeasible methodology. In addition to the logistical task it is highly unlikely that the separate effects of the different programs could be isolated. In contrast with earlier studies there are, however, both good data and a significant number of reliable analyses to guide the authors' estimates of the benefits of road safety programs. On this occasion it is the costing of the programs which is relatively problematical. The authors note that there is an extremely wide range of activities which may directly or indirectly affect road safety. All of these cannot be incorporated in the study and, if an attempt was to be made, there would be a problem of attribution of costs between the various outcomes of the different programs. The authors ultimately focus upon a figure of \$300 million a year which may be identified from government spending in NSW and SA. This figure is doubled to produce what the authors describe as 'an order of magnitude estimate'. The uncertainty of this estimate is highlighted by the fact that Victoria and Queensland report expenditures of about \$60 million a year, clearly reflecting a narrower definition of 'road safety'. The difference in definitions is probably due to the inclusion or exclusion of programs with multiple objectives and, therefore, programs where the attribution of expenditures would be difficult.

The estimation of program benefits relies, initially, upon an analysis of trends and the change in trend following the widespread introduction of road safety programs. The resulting estimate is then validated by examining independent studies to determine if the order of magnitude of the inferred benefits is consistent with the results of these studies.

The chief methodological problem in the first stage of this analysis is the disentangling of the effects of road safety programs from the beneficial effects of improved road and automobile construction. This is achieved using a regression analysis of road fatalities which includes a dummy variable to detect the long term decline in road deaths and a second dummy variable to detect the shift and change in the slope of the trend after 1970. The results imply a long term decline in road deaths of 2.3 percent per annum which the authors attribute to road and automobile engineering and an additional decline of 3.6 percent per annum after 1970. This latter result implies that 60 percent of the reduction in road fatalities in the second time period was not attributable to the long term trend. The authors assume that this second influence is attributable to road safety programs and, conservatively, assume in their subsequent analysis that 50, not 60, percent of averted deaths are attributable to programs.

The validation of this assumption is thorough and convincing. The reduction in alcohol related deaths alone ‘explains’ 60 percent of the total reduction in fatalities. Henstridge et al (1997) employ a careful methodology to conclude that 30 percent of the reduction may be attributable to random breath testing. Analysis of Victorian data suggests that in the 5 years to 1994 there was a 44 percent reduction in injuries. However this time period is too short to explain such a large effect from the improvement in roads and car design. The alternative hypothesis is that road safety programs were primarily responsible for the change.

Other costs associated with accidents have also been carefully studied primarily by the Bureau of Transport Economics. While the authors argue that the Bureau’s estimates are somewhat high their analyses represents a firm foundation for an estimate of the averted costs of crashes due to vehicle destruction, repair, towing etc. The Bureau also provides estimates of the medical and long term costs arising from accidents, costs averted by their prevention and the dollar value of life. The latter is based upon a combination of the human capital and willingness to pay methodologies and is discussed further in Section 4.2 below.

4 Discussion of Methods

Throughout the report there is a succession of quantitatively significant and seemingly intractable problems arising from the lack of appropriate data, conceptual issues concerning the nature of costs and benefits and methodological obstacles to appropriate measurement. The cumulative affect of these may, for some, appear insurmountable and invalidate the entire enterprise. This conclusion is discussed further in the following section. A number of specific conceptual issues relevant to the study are discussed below.

What is public health? The authors endorse the definition that public health is ‘the organised response by society to protect and promote health and to prevent illness, injury and disability’. They note that the demarcation lines between health research, disease prevention and health care may be fuzzy and that a single action may be legitimately regarded two ways. Tobacco taxation, for example, may be regarded as a public health measure. Alternatively, it may simply be a device for raising government revenue.

The authors have wisely avoided the temptation to seek ‘clarification’ of the concept of public health. Rather, they have defined their task and its boundaries. This approach gives precision to the nature of the task. While some may have preferred a different definition of ‘public health’ to be the subject of the research nothing is gained and much may be potentially lost by the retention of vague objectives. Debating alternative definitions has little interest⁵.

⁵ Questions of the form ‘what is X?’ or ‘what is meant by X?’ generally indicate the adoption of ‘methodological essentialism’. This is the belief that there is some (correct) ‘essence’ corresponding with any general term. It is arguable that essentialism has resulted in significant confusion and the mistaken belief that conceptual progress is made by detailed linguistic analysis and the construction of ever finer differences between constructed concepts. The alternative approach—implied here and in most empirical research—adopts the tradition of methodological ‘nominalism’ in which a definition is used to summarise a concept which is of interest in a particular context. (This is discussed in Richardson (1999).) Consistent with this latter approach the study authors have defined their task and chosen to label this ‘Public Health’, at least in the context of this report.

The remaining questions discussed below deal with substantive conceptual questions, that is, questions which are potentially relevant for the acceptability or otherwise of the authors' analysis and results.

4.1 Measuring Costs

In the economic evaluation of health programs the measurement of cost is comparatively unproblematic. When markets are relatively competitive prices paid and, consequently, total expenditures represent true economic (opportunity) costs. In the present study the most serious problem by a very large margin is the difficulty encountered obtaining accurate information on expenditures. In the five program areas studied the problem varies, primarily because of the differing number of organisations, authorities, programs and sub-programs involved in service delivery. Thus, for example, the costing of immunisation programs should be comparatively reliable as there are a limited number of options for the provision of immunisation services. In contrast, the plethora of sub-programs directly or indirectly involved with road safety is so great that the authors only attempt to obtain an 'order of magnitude cost'. There is even some doubt about the order of magnitude as the reported expenditure in Victoria and Queensland is only 20 percent of the official figure for New South Wales and South Australia. In principle, the costs—expenditures—should correspond with the activities which led to the benefits included in the study. Unfortunately data do not permit this correspondence to be easily made.

The authors note a number of conceptual problems which arise in the measurement of costs. These are discussed below.

Excess Burden: Regulation and taxes to fund public health programs alter the pattern of expenditures which people would otherwise choose for themselves. From the individual's perspective the new pattern must be inferior or else it would have been chosen initially. The difference between the individual valuation of the first and the second pattern is referred to as the 'excess burden' of a tax or regulation and, in economic theory it is argued that this cost should be included with other costs when options are being evaluated.

While acknowledging this argument the authors do not attempt to quantify the excess burden. There are good pragmatic reasons for this decision. The task could not be easily undertaken with the data available and, for similar reasons, it is very unusual for the excess burden to be considered in applied economic evaluation studies.

In the context of public health there are additional reasons for doubting the relevance of such an analysis. One of the chief objectives of health promotion and illness prevention is to change people's voluntary behaviour, commonly by marketing. But the theory behind the concept of an excess burden does not permit people to change the structure of their preferences. If they do so then the excess burden calculated before the change may disappear with the revision of preferences. Likewise, more coercive policies—regulation and taxation—may alter expectations and tastes. If preferences are malleable—as the proponents of public health hope they are—then the relevance of at least some fraction of the excess burden is questionable.

Health Expenditures in Later Life: The authors also refer to an ongoing debate in the health economics literature, concerning the treatment of the health care expenditures which will be

incurred when people live longer. (See, for example, the detailed discussion by the ‘Washington Panel’ in Gold et al, 1996). The authors avoid this issue by arguing that future medical costs should, in principle, be subtracted from the value of life imputed for each future life year or DALY. If the imputed value did, indeed, take account of future expenditure this argument would be correct. However none of the studies cited by the authors (and discussed below) does, in fact, consider future medical expenditures. The pragmatic response might be that discounting reduces distant expenditures to a sufficiently low present value that they may be disregarded. But all subsequent expenditures are not distant.

The presumption that future medical costs are relevant is itself contestable. It is true that future medical expenditures will reduce the resources available for other members of the community. It is likewise true that future consumption by the retired will reduce available resources. As argued in Richardson (2001) future consumption is not included in economic analyses, not because consumption is resource neutral but because there is agreement (enshrined in law) that a person’s wealth (or right to a pension) should not be considered in a cost-benefit analysis. Using the term suggested by Olsen and Richardson (1999) certain categories of costs and benefits may be ‘socially irrelevant’: we elect to exclude them from our decision algorithms. Other examples include the benefits from sadism, envy and a range of illegal activities.

It is likely that, if consulted, there would be a near consensus in the population that life and death decisions should not include the fact that survivors will subsequently use medical resources. If this supposition is correct then the authors are justified, in principle, for adopting their approach.

Private Costs have been Excluded: Apart from some ‘order of magnitude’ estimates of the private costs associated with traffic accident prevention the study includes only government expenditures/costs. Economic evaluation normally includes all social costs irrespective of their incidence and, in principle, this approach would be appropriate here. Government is not an entity whose wellbeing should be the subject of social policy. Rather, its activities are designed to maximise the welfare—benefits less costs—of the population and this requires a consideration of private costs. However this conclusion requires at least three caveats. First, some of the private costs may be deemed socially ‘irrelevant’. For example forcing a speed limit upon drivers who would otherwise drive at dangerous speeds imposes a time (and perhaps excitement) cost upon them. However it is highly improbable that any decision body would ever recommend the inclusion of these costs in an analysis. Likewise, the redistribution of income from the wealthy to the poor by means of burglary may increase total welfare. But again it is inconceivable that this would be included in a serious social decision algorithm.

Secondly, there is the category of costs discussed above under the heading of ‘Excess Burden’. As noted, these costs are mitigated if preferences mutate.

Thirdly, and in many ways a generalisation of the case of socially irrelevant outcomes, there is debate over the social objectives which are appropriate to pursue in a national health scheme. This is formalised in health economics in the debate between ‘Welfarism’ and ‘Extra Welfarism’. The former, enshrined in orthodox welfare theory, assumes and prescribes libertarian values. Welfare is maximised if individuals are given the greatest choice and scope for expressing their own preferences. ‘Extra welfarism’ is the term coined by Culyer (1989) to describe alternative value systems such as those advanced by Sen, Margolis and Rawls. The category includes what has been described as ‘healthism’ which is the belief that the appropriate objective of a national

health scheme is the maximisation of health and not individual utility. This, in turn, implies that some of the consequences of health programs—sometimes referred to as ‘individual costs’—may be discarded and the programs judged exclusively in terms of their health impact⁶.

4.2 Measuring Benefits

Cost Offsets: The report adopts the common practice of subtracting cost offsets from net benefits. The prevention of disease removes the need for the medical and other services which would otherwise be required to treat the sick or injured individual. In principle the procedure is unimpeachable. In practice, an inferred offset may not occur. A doctor freed from the task of treating one patient may spend additional time with another. If medical and hospital costs are determined, not by an exogenous ‘need’, but by the capacity to provide care, then changing the status of one set of potential patients will have no impact upon overall costs. This so called theory of ‘supplier induced demand’ has been controversial in the economics literature but is now generally accepted. Its consequences for individual studies has not, however, been discussed in the literature and there is no consensus on its implications. Consequently the study authors are justified in following the conventional methods in this respect.

Discounting: The theory of economic evaluation unambiguously recommends that future values should be discounted. Despite this there is ongoing debate about how, precisely, this should be done and whether there are context specific features of the health sector which should affect the way discounting is carried out. The issue is quantitatively significant. In the discussion of HIV AIDS it was noted that following successful prevention, the last year of life gained will be discounted to a present value of only 28 days when the discount rate is 5 percent. Overall the present value of the future life years gained will be reduced by 41 percent as a result of discounting.

The argument for discounting in the context of an economic evaluation is generally compelling. Nevertheless in the context of the health sector there are also persuasive reasons for at least reporting undiscounted results. The fundamental rationale for discounting is that people have a ‘rate of time preference’: they have a preference for present rewards. (There is also a justification for discounting in terms of the opportunity cost in terms of capital. However the logic of this argument breaks down in the health sector⁷.)

Briefly, discounting must occur when preferences are sovereign; that is, when we wish to allocate resources according to preferences. But there are two important caveats. First, the discount rate should reflect the preferences of the appropriate decision body and this is not necessarily the body which sets the rate of return in the capital market. To the contrary, a national health scheme is established so that decisions about the allocation of resources may be made according to different rules than occurs elsewhere in the economy. Secondly, and following from

⁶ This final point is probably guilty of definitional error. Program consequences are not, according to conventional definitions, a ‘cost’. Rather they are a (negative) benefit or consequence. In more conventional terminology the third caveat refers to the exclusion of some (negative) ‘benefits’ and not ‘costs’.

⁷ (See Murray 1996). The opportunity cost argument assumes that funds may be diverted from a project, invested in the capital market and a larger sum used at some future time to obtain greater benefits. For equilibrium, adjustment must occur until larger incremental future benefits are of equal value to smaller incremental present values. This implies that discounting of future values should occur. In the health sector such a transfer of funds from a present (fixed) budget to a future budget does not occur. To the contrary, reducing present budgets would result in a smaller future budget.

this, it is possible that the decision body may decide not to adopt a positive rate of time preference in a particular context. There is, for example, an ethical argument that each member of society should achieve a 'fair innings' (Williams and Cookson 2000). This, in turn, implies the equal treatment of a life year for a present 80 year old pensioner and a life year in 50 year's time for a person who is presently 30 years old. Consequently, a government agency might either discount life years for people aged 80 or, conversely, reject discounting.

In at least one empirical study of the Australian public it was found that the population believed that governments should sometimes override the inter-temporal preferences of the population (Richardson 2002). Consistent with this, undiscounted results are presented in the study for some, but not all, of the program analyses.

The Value of Life: Across the five broad programs the value of life years gained dominated all other benefits. The result reflects the very high value placed upon a life (\$1 million) and a life year (\$60,000). While it is unsurprising that life should be assigned a high value, the particular figures adopted will almost certainly be queried. Some would challenge the legitimacy of assigning a dollar value to life at all. ('You cannot place a dollar value on life'.) Others might argue that the figure is too low ('surely we should pay an enormous amount to save a human life'). Others might argue that it is too high ('how many people could afford \$1 million to save their life?'). A more sophisticated query might concern the meaning of the dollar value. ('What, precisely, does \$1 million represent: an individual willingness to pay? A social willingness to pay? The result of a methodologically dubious extrapolation of a willingness to pay for a reduction in risk?').

The first question may be quickly dismissed. With finite resources it is unavoidable that a finite dollar value will be placed upon the value of life either explicitly in policy decisions or implicitly as a result of decisions which limit life saving activities. For example, constructing a highway to a particular engineering standard rather than a superhighway with a greater safety factor will eventually result in a fatality. The implied value of this life is (consciously or unconsciously) less than the cost difference between the two grades of highway. Decision making cannot be based upon what Victor Fuchs once described as 'the romantic view of economics'; that is, an approach which refuses to acknowledge constraints upon what is achievable.

While it should be self evident that decision making must assume a finite value of life, the basis for determining the precise dollar amount remains controversial. There are at least three conceptually distinct approaches to this task. These are based upon the concepts of (i) human capital; (ii) individual willingness to pay; (iii) social willingness to pay. The first of these equates the value of a human life with the present value of (paid or unpaid) future production (of all goods and all services) by the individual. The individual willingness to pay approach equates the value of life with the (usually inferred) willingness to pay for that life or for a reduction in the risk of death by the individual. Third, the social willingness to pay reflects some notion of the willingness of society to pay collectively to avoid the death of an individual.

Corresponding with these approaches there are alternative measurement methodologies. The human capital approach generally accepts the present value of the person's subsequent income arising from their own activities as the appropriate measure. In principle, this should be supplemented by an estimate of the value of unpaid activities. The approach is regularly criticised for two reasons. First, those with a higher future income will be valued more than others and this is discriminatory. Secondly, it is argued that people are worth more than their

contribution to the GDP (or an enhanced concept of the GDP which includes the value of unpaid production).

Willingness to pay is often said to be the gold standard as value elsewhere in the economy is determined by a willingness to pay. In transport economics, where this approach has been widely used, estimates are often based upon the observed willingness to pay for a reduction in the threat to life and the value of life is inferred from this. For example, it is argued that if a 1 percent reduction in the risk of death is worth \$10,000 to an individual then a 100 percent reduction in risk—life itself—must be worth $100 \times \$10,000 = \1 million. The approach is, of course, also discriminatory as the willingness to pay depends upon income and wealth. Further, the linear extrapolation required to obtain the value of life is known, independently, to be an invalid description of individual decision making. Inter alia, a person who can afford \$10,000 may be unable to pay \$1 million.

Finally, the social willingness to pay has often been inferred from the decisions handed down in Court as compensation for the loss of life or for the risk of death. Likewise, public decision makers 'reveal' their valuation of life through their decisions. For example, in Australia, the decisions made to accept or reject drugs for the pharmaceutical benefits scheme implies a social willingness to pay for a life year. Reviews of the PBAC by George et al (2001) suggest an implied value of a life year of about \$75,000 (1998/99 prices). Variation occurs around this figure as the relevant committee (quite properly) takes into consideration factors other than the value of life per se.

It is possible to criticise this third approach as it may (or may not) involve circular reasoning. Public decision makers commonly turn to economists to determine the costs and benefits of alternative strategies. If the benefits are determined by the implied values of the same decision makers, then apart from achieving consistency, the approach is unhelpful.

The most important point to note in this context is that, despite the assertions of orthodox economists, there is not a 'theoretically correct' approach. Rather, the concepts and subsequent measures embodied in analyses should reflect the value basis which is sought. Economic orthodoxy is based upon (the generally reasonable) assumption that individuals should be free to place their own value upon a commodity. However government intervention in the health sector of every country in the world with a functional government clearly indicates a desire to interfere with usual market valuation procedures.

The ethical arguments for individual and social willingness to pay approaches are relatively self evident. While markets may be rejected as a mechanism for allocating resources in the health sector, the ethical values underlying the concept of 'value' may be retained albeit in a modified form in a regulated market system. That is, a society may elect to distribute medical resources in a particular way but in its calculation of the costs and benefits of a particular service they may adopt the criterion of individual, self interested, valuation. The case for a social willingness to pay is likewise simple. National health schemes are a reflection of communal concern with health and health services and with their distribution. It would therefore be unsurprising if a society (by whatever collective decision process is used) elected to use some form of social valuation.

The human capital approach is the least popular basis for evaluation in the literature. Nevertheless it may be defended. The gold standard for determining 'value' elsewhere in the

economy is normally revealed preference. Thus, if an individual was to spend \$1,000 on product X then it is assumed that product X contributes to wellbeing by an amount (at least) equal to \$1,000. Summing such expenditures, the material wellbeing an individual obtains in a year is (at least) equal to their consumption expenditures. Through time (and disregarding savings and taxation) the 'value' of the material benefits enjoyed by an individual will be equal to their cumulative income and it is the present value of this that is measured by the human capital approach. (Taxation and savings result in an increase in material value for others which is determined by the numerical value of the saving and taxation). For this reason the human capital algorithm provides a minimum valuation of the benefits of life where, in this context, value is equated with material wellbeing. Despite the critical comment by the authors it is also legitimate to increase this minimum by an amount which is determined socially (through a willingness to pay) to reflect the additional social value of an individual.

Despite the unresolved nature of these issues it is possible to place a sensible 'order of magnitude' dollar value upon a life year and the authors have done this. Their approach is to review a large number of the studies which place a value upon life using any of the defensible methodologies. They have then selected a conservative figure which is consistent with, or less than, the values obtained using each of the methodologies. That is, if decision makers selected any of the three bases for evaluating life the authors' estimate would be an acceptable or a conservative lower limit⁸.

The Counterfactuals: In each of the five studies the methodology was based upon a pivotal assumption concerning the nature of the counterfactual: what would have occurred if the program had not been implemented. These assumptions are summarised in Table 3 below.

⁸ The authors have in fact omitted one excellent article. This is the review of the field by John Goss (1998). This strongly reinforces the authors' claim that their imputed value for life is conservative. Results found elsewhere generally exceed the authors' value by a significant amount.

Table 3 Pivotal Assumptions

Program	Assumption
1. Tobacco control	10 percent of the reduction in tobacco use is attributable to public health policies
2. Heart Disease	20 percent and 10 percent respectively of averted cholesterol and smoking related deaths are attributable to public health policies.
3. HIV/AIDS	50 percent of the 25 percent decline in the transmission rate is attributable to public health policies.
4. Immunisation (a) Measles (b) Hib	(i) the ratio of episodes to deaths is the same as in the UK (ii) the long term trend established from 1940 indicates what the infection rate would have been without the policies As for 3 (ii) above but the trend is based upon 2 years of observations.
5. Road Safety	The change in the trend line after the widespread introduction of road safety programs in 1970 was a result of the programs

The assumptions are pivotal as the methodology is based upon them and if they are invalid then the conclusions drawn will be also be invalid.

It is important to recognise that any evaluation implicitly or explicitly assumes a counterfactual state of the world. Even with the gold standard methodology of the Random Control Trial it is assumed that, without treatment, the outcome for patients receiving a treatment would be the same as the outcome of those in the control arm of the trial. The assumption is contestable and, indeed, it is the subject of ongoing debate. Patients in the control arm of a trial generally differ from patients entering the health system through a more normal procedure. (They will commonly be treated according to a protocol and by doctors and in hospitals which are atypical). Criticism of this study methodology must therefore focus upon the particular counterfactuals in the study rather than upon the need for a counterfactual.

The assumptions listed in Table 3 take one of two forms. In the case of tobacco control, heart disease and HIV/AIDS the authors simply estimate the strength of the key causal relationship. Methodologically, this is equivalent to a well informed guess. That is, having reviewed the relevant data and the medical and social literature the authors make an 'informed judgement' about the order of magnitude of the causal relationships.

The second type of assumption is adopted in the analysis of measles, Hib and road accidents. In these cases the authors examine the change in the trend following the introduction of the relevant policies. While this approach is data driven there is an unavoidable risk that the trend may have changed for other reasons. The problem is particularly evident in the analysis of measles. As shown in Study Figure 5.3 there was a change in the trend level of measles notifications which commence in 1954, some 16 years before the introduction of the relevant policies. The trend line commencing at this date, rather than 1940, would result in a significantly different counterfactual scenario than the one employed in the study.

The authors sought to 'validate' their pivotal assumption using published results from other relevant studies. The support obtained in this way was variable. At one extreme there are significant number of well conducted studies of road safety which indicate an effect which is very similar to the effect assumed by the authors. At the other extreme, the authors offer limited support for their assumptions concerning measles and Hib immunisation. Likewise, there is little independent evidence to support the pivotal assumption in the analysis of the study of HIV/AIDS. There are a significant number of published results concerning heart disease and the effects of tobacco control and, in the former case, the authors' assumptions appear to be conservative. The chief threat to the validity of the analysis of tobacco control programs is the study by Bardsley and Olekalns which suggests that the reduction in smoking may be entirely attributable to the increased price of tobacco. The criticisms of this study by Borland, Chatham and the authors are sufficiently persuasive that the authors' pivotal assumption should be judged to be acceptable.

5 Conclusions

Each of the pivotal assumptions is contestable. Each of the studies employs additional assumptions which may also be challenged. Further, the data employed in the different studies vary in quality from acceptable to very poor. At the latter end of the spectrum—cost data for traffic accident prevention—the data are described as being 'order of magnitude'. For these reasons it may be asked whether or not the authors' entire enterprise is credible.

The answer to this latter question should be an unambiguous 'yes'. The task undertaken by the authors is not the testing of scientific principles where the null hypothesis is that the principle is false. Consequently, the criterion for the acceptability of the study should not be the same as the criterion for scientific hypothesis testing. Rather, the question that the authors address is whether or not particular programs have provided good value for money: whether or not, with the wisdom of hindsight, these programs should have been undertaken. Subject to one caveat, the appropriate criterion for answering this question is whether or not, on balance, the community was better or worse off because of these programs; whether or not with the wisdom of hindsight they should have been carried out. After taking into account all costs and benefits the appropriate 'level of proof' is a '50 percent criterion': if there is a greater than 50 percent likelihood that the programs were beneficial then the answer to study question should be that the programs provided good 'value'; that there was an acceptable return on investment. The caveat is that the uncertainty regarding costs is generally less than the uncertainty concerning benefits: there is no doubt about some costs whereas all of the benefits could, in principle, be challenged. This implies the need for sensitivity analysis and, possibly, the addition of a risk loading to the cost side of the equation. Despite this caveat the (qualified) 50 percent criterion might have justified a less cautious set of assumptions. The fact that they did not and that, with the exception of Hib prevention, the programs appeared to be spectacularly successful should give confidence to the authors' conclusions.

In sum, the report is a fine example of how the basic concepts of economic theory, in combination with evidence based judgements, can be used to guide decision making in areas where behavioural relationships and information are complex and imperfect.

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