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THE IMPACT OF BEHAVIOURAL AND BIOMEDICAL ADVANCE ON HEALTH TRENDS OVER THE NEXT 25 YEARS

Introduction

Recent decades have seen a significant improvement in the health status of citizens in Western Europe and the USA. This is evident from death rate statistics which fell in the USA from 10.6 to 5.4/1000 between 1940 and 1990, from improvements in life expectancy, and from the near elimination of the acute conditions which were the major public health concern early this century. This progress has arisen from a combination of public health measures, improved health education, preventative medicine, screening programmes and advances in treatment. In parallel with these trends healthcare expenditure has increased, doubling in the past 30 years within the Organisation of Economic Co-operation and Development (OECD), reaching 9.0% of gross domestic product (GDP) by 1990. In the UK, expenditure increased from 3.9% to 6.6% within this time frame, totalling almost £38 billion in 1991 (OECD, 1993).

By the '90s focus had shifted from acute diseases towards chronic conditions of the middle aged and elderly such as heart disease, cancers, and cerebrovascular disease—today's principal killers and primary causes of morbidity. The ensuing pressures on national healthcare resources has created an atmosphere of cost containment which, in turn, has increasingly raised questions as to the value or benefit to be derived from alternative policy options. The determination of benefit is itself complex: it may be measured, for example, in terms of lives saved, quality of life improvements for patients, or the hidden elements of cost-containment which flow from maximising the working-life economic contribution of each individual while minimising the healthcare dependency of senior citizens post retirement.

To assess the benefits of alternative policy options it is essential to have the clearest possible vision of the future health of the population. Retrospective studies of healthcare statistics, though of value in establishing trends and baseline data, are of limited prospective value: only by looking forward is it possible to inform future policy. To assist balanced and informed decision making, relevant, accurate and comprehensive forecasting is vital. Already such activities are a major occupation for both governments and private organisations. In the healthcare arena such forecasts are most often based on one of two independent approaches, the **quantitative planning method** which employs current trends in disease and demography as a basis for linear future projections, and the **group decision model** that uses expert opinion to build and select future scenarios. Both of these have significant limitations, the former an intrinsic inflexibility to accommodate the impact of discoveries and technological change and the latter, a lack of quantitative rigour and inevitable subjectivity.

Since 1990, the Battelle Institute has published four studies which uniquely combine these two methods of forecasting in an interactive fashion. By doing this, it was anticipated that a more accurate estimate of the future disease burden within society should be possible, permitting in turn more accurate estimates of the potential for reducing the burden through behavioural and biomedical advance. The reports addressed these specifically, firstly health gains (and, to the extent possible, cost savings) likely to arise from behavioural modification (e.g. reduced smoking on lung cancer; safer sex on AIDS) and secondly those likely to arise from biomedical advances. These latter were further subdivided into pharmaceutical innovations (i.e. new medicines) and other biomedical advances including improved preventative screening, diagnosis and surgical techniques.

The earliest study (Brown et al, 1991) considered these issues in the USA, while later reports dealt with France, the former West Germany and the United Kingdom respectively (Andersson et al, 1992; Andersson et al, 1993; Oleksy et al, 1994). The US study was commissioned by the US pharmaceutical company, Schering-Plough, those for France and Germany by the Pharmaceutical Manufacturers Association (PMA) and that for the UK by The Association of the British Pharmaceutical Industry (ABPI). The diseases considered were not identical in each report (see Table 1) though there is considerable overlap.

Table 1 *Diseases considered in the Battelle Institute reports*

Disease	*UK*	*USA*	*France*	*Germany*
Coronary heart disease	✔	✔	✔	✔
Cerebrovascular disease (Stroke)	✔	✔	✔	✔
Lung cancer	✔	✔	✔	✔
Breast cancer	✔	✘	✔	✔
AIDS	✔	✔	✔	✘
Asthma	✔	✘	✘	✘
Other: [1]	✘	✔	✘	✘

[1] Leukaemia, Colorectal cancer, Arthritis, Alzheimers disease

The **specific purposes** of the UK study were to (i) estimate the extent to which advances in biomedical technology and changes in health-related behaviour will affect the future health status of UK citizens and (ii) predict the number of cases and deaths from six major diseases that may be avoidable. The **underlying objective** was to help policy-makers make rational decisions regarding investment in public health measures and technology development aimed at improving health in the UK population.

In this briefing we:

- discuss the methods employed in the Battelle studies, including caveats to interpretation,
- summarise the data presented and the conclusions drawn from the UK study, identifying areas where there appears to be the greatest opportunity for behavioural change and biomedical advance,
- compare the UK results with those from other studies,
- consider the value of this approach for healthcare planning.

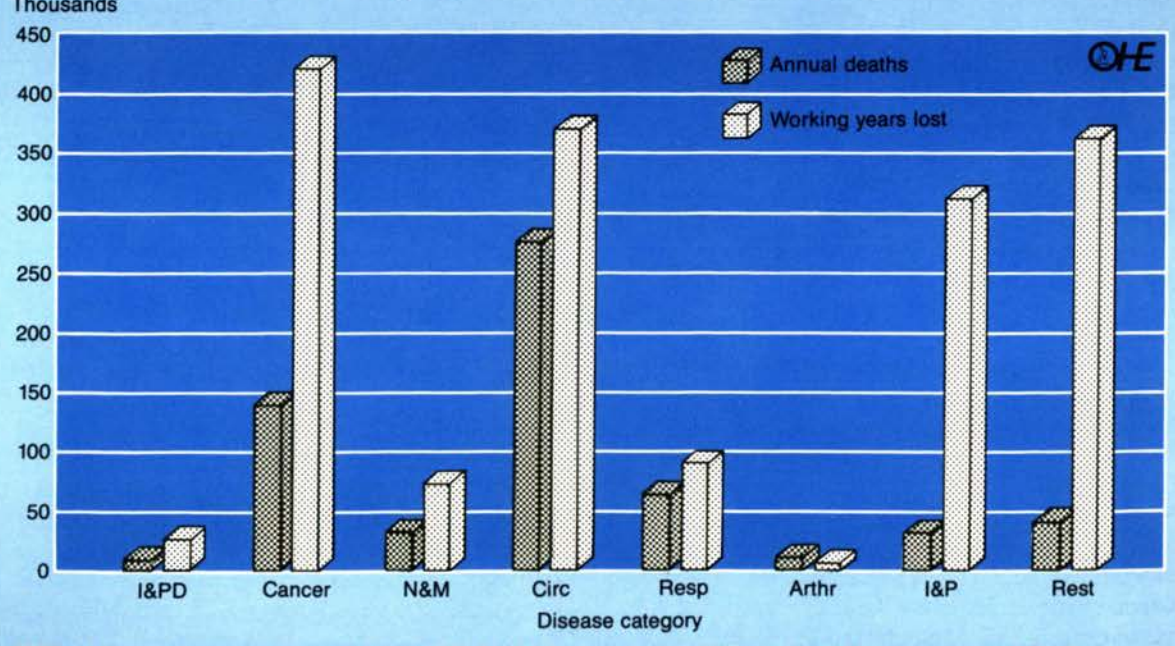
Methodology and Definitions

All studies focused on diseases which have or are likely to have a major national impact (see Figure 1). The burden on society was estimated using four indices, (i) incidence or prevalence, (ii) mortality, (iii) number of life-years lost and (iv) direct medical costs.

Each study employed the same fundamental methodology, consisting of the following steps:

1. Collection of national population projections, morbidity, mortality and economic data (see Box 1 for further details).
2. Projection of these data forward for each disease for 25 years assuming no further progress in preventative, diagnostic, or therapeutic medicine and no changes in life-style patterns, referred to as the **STANDARD PROJECTION,** [SP], (N.B. a 10 year time frame was used for AIDS because of the extreme uncertainty surrounding this disease).
3. Identifying a panel of experts in each disease area. Each expert was given the standard projection and a list of potential therapeutic advances and realisable behavioural changes and asked to assess likely improvements in morbidity and mortality over the same time-frame. Each expert was then given an opportunity to revise their forecast in the light of the average view expressed by the whole panel. The **final average views** are termed the **FORECAST PROJECTION** [FP]. A sensitivity analysis giving the most and least optimistic scenario was also prepared.
4. The difference between each Standard Projection and the Forecast Projection with regard to future morbidity, mortality and economic impact was calculated and related to changes in biomedical

Figure 1 *Annual deaths and working years lost due to various causes in the UK. Assumed retirement age, 65. Based on OPCS data for 1985*



I&PD = Infectious and parasitic disease, including AIDS; N&M = Nervous and mental diseases; Circ = Circulatory diseases including coronary heart disease and stroke; Resp = Respiratory diseases including asthma; Arthr = Musculo-skeletal disorders including arthritis; I&P = Injuries and poisoning; Rest = all other diseases

Box 1 *National data sources and selection of experts*

USA (Brown et al, 1991): Estimates of the population size and distribution for the year 2015 were based on the Census Bureau's middle series of projections (Spencer, 1984) adjusted for under-enumeration in the 1980 census. Incidence and prevalence of **cardiovascular disease** and **arthritis** were estimated from the 1988 National Health Interview Survey of almost 50,000 households conducted by the Census Bureau. Estimates of **cancer** incidence were based on trends over a 14 year period, recorded in the Cancer Statistics Review from 1973-1987. This data was prepared by the Surveillance Programme for the National Cancer Institute of the USA. For **AIDS** cases and deaths, 1990 data from the Centers for Disease Control were used. For the purposes of projection, the incidence of new cases was taken as 30,000 per year rather than the rates of increase observed in earlier years. Official data on **Alzheimer's disease** is sparse in the USA and prevalence is based on the research of Evans et al (1989). Economic projections were based on cost data in published research literature updated to 1989 using the medical care component of the Consumer Prices Index for direct costs and the manufacturing wages index for indirect costs. Indirect costs were *reported* as the net present value of lost productivity resulting from morbidity and mortality and *calculated* using average income by age and sex. Both direct and indirect costs were discounted at a rate of 5%.

The selection of an initial expert group was made on the basis of advice given to The Institute for Alternative Futures (IAF) by the National Institutes of Health and specialist interest groups such as the Arthritis Foundation. This initial group made further suggestions to provide a balance between experts in therapy, epidemiology, diagnosis and surgery. The checklist of potential future developments was developed by conducting a search of therapeutics under development (Battelle Institute) and by interviews with experts and opinion formers (IAF).

FRANCE (Andersson et al, 1992): Population size estimates were derived or extrapolated from the official data of the Institut National de la Statistique et des Etudes Economiques (INSEE) to the year 2016. Disease data was collected by CREDES (Centre de Recherche d'Etude et de Documentation en Economie de la Santé). Prevalence data for **coronary heart disease** (CHD) and **stroke** was available only for the year 1986 (Levy & LePen, 1990). Hence, as no 'trend' data is available, prevalence for 2016 accounts only for population change for these two diseases. Incidence data for **lung** and **breast cancer** does not exist for France as a whole and is available only for the region of Bas-Rhin for the years 1975-1984. This has been extrapolated to the whole of France. Mortality data was collected from INSERM (Institut National de la Santé et de la Recherche Medicalé) for the period 1980-89. For **AIDS**, incidence and mortality data and projections are based on data from CISIH (1990).

The method for the selection of the French expert group was similar to that used for the USA though in this case initial contacts were selected by CREDES and the Battelle Institute.

GERMANY (Andersson et al, 1993): Due to complexities in data collection and interpretation, the Battelle report on Germany is restricted to the former West German territories. Current population statistics and projections for 1991-2016 were based on data from the official Federal Statistics Office (Statistiches Bundesamt). Disease data was collected for the Battelle Institute by the Instute für Gesundheitssystemforschung (IGSF) in Kiel. Prevalence data for **CHD** came from a study by DHP and covers the years 1984-1986: average data from this period is used (DHP, 1990). Mortality data was provided by the Statistiches Bundesamt. Projected prevalence for **stroke** is based only on a single value for a three year period (1984-1986) and accounts, therefore, only for population growth. Germany has no central register for cancer incidence. Thus, the data was derived from the Saarland Cancer Registry (a local register for a small region of the former West Germany) extrapolated to the whole population.

The German expert panel was selected in the same manner as that for France by IGSF and Battelle with the help of the Institute for Alternative Futures.

UNITED KINGDOM (Oleksy et al, 1994): Official UK statistics (Government Actuaries Dept, 1993) were used for population data and projections to the year 2017. Disease and economic data was collected by the Battelle Medical Technology and Policy Research Centre, London (MEDTAP). Prevalence data was available for **CHD, CVD** and **asthma** and incidence data for **cancer** and **AIDS.** The **cancer** data used was from the Cancer Registries for England, Wales and Scotland for the period 1978-1987. Estimates of UK morbidity and mortality from **AIDS** are based on data collected by the Public Health Laboratory Service, and published as the Communicable Disease Report (1993). Because of uncertainties in this area, published projections up to 1997 were accepted and extended to 2002. Prevalence data for **CHD, CVD** and **asthma** is limited in the UK and was derived from the OPCS GP Morbidity Survey (1986). No 'trend' data was available. Mortality data was obtained from OPCS for the period 1982-1991 and included Northern Ireland. Projections of incidence and death rates were made using Ordinary Least Squares regression of the last 10 years of data. Prevalence data projections were based on the 1981-2 patient consulting rates per 1000 at risk applied to the estimated population for 2017.

The expert panel was assembled by Battelle identifying 6-10 leading specialists. They were assisted in this exercise by the Association of the British Pharmaceutical Industry (ABPI) and by suggestions made by the experts themselves. Scope for innovation was assessed using disease-specific questionnaires similar to those used in the three previous studies. These were made available a week before a telephone interview by Battelle staff. Interviews were carried out by the same individual in the interests of consistency and panel members did not know the answers of other experts.

technology or behaviour patterns. Some relationships between SP and FP are discussed further in Box 2.

Mortality was projected using 10 year trend death rates.

Life-years lost per case was computed by subtracting the average age of death for each disease from the average life expectancy computed for each country and gender. This figure, multiplied by the projected numbers for premature mortality, provides the total life-years lost for a given disease.

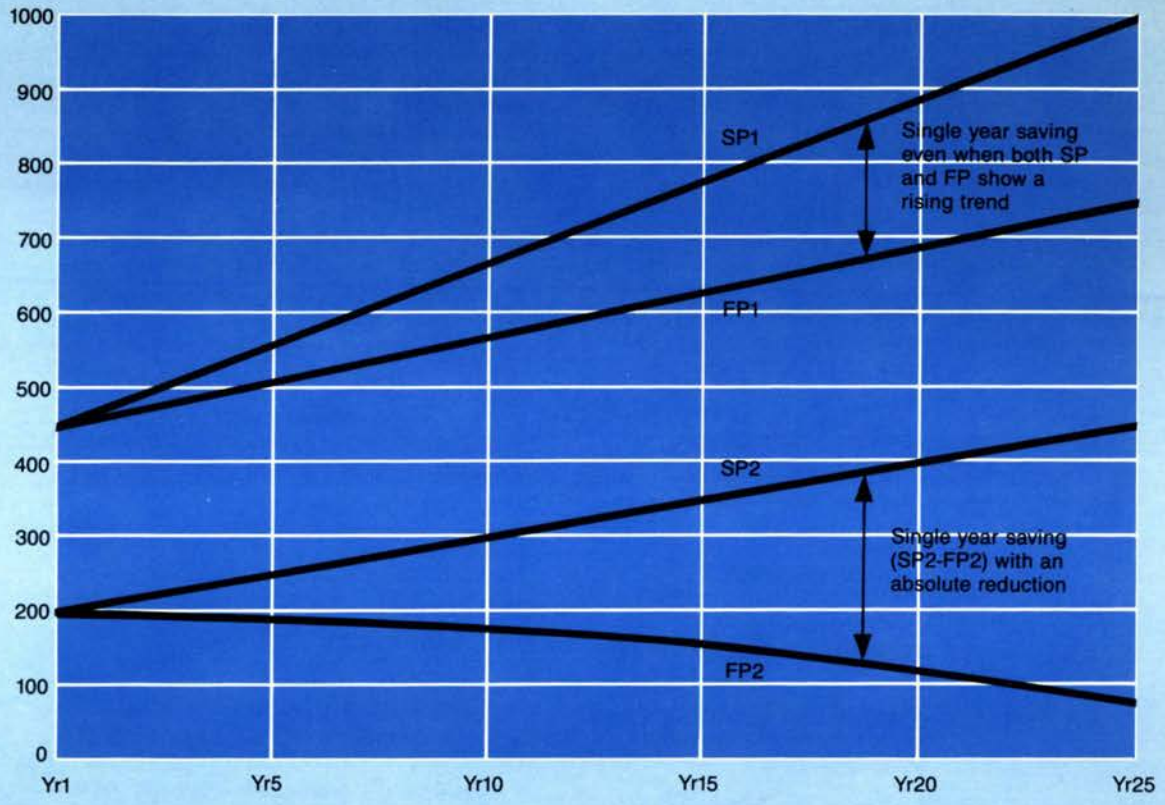
Morbidity was computed for the Standard Projection using the 10 year trend growth of **incidence** (defined as the number of new cases that occur over a given period, usually a year) applied to the projected population. In the absence of incidence rates, **prevalence** rates (defined as the current number of persons afflicted with a given condition at one point in time) were applied to projected population, accounting for population changes, but not change in incidence.

Economic impact was calculated using the **direct costs** of each disease (drugs, treatment, transport, etc.)

Box 2 *Some relationships between the Standard Projection and the Forecast Projection in the calculation of potential savings*

In the examples below the y-axis could be cases or deaths. SP1 and SP2 both show a linear increase over time. FP1 represents a situation in which the experts predict an increase in cases or deaths which are less than the SP.

It should be appreciated that although the FP indicates an absolute increase in numbers, there is still a year-on-year saving (SP - FP) and a cumulative saving [i.e. Σ (SP - FP)].



The lower curves show an example in which there is a decline in cases or deaths (FP2) over time below the SP and therefore an absolute reduction in numbers. In the diseases studied in the Battelle reports, most follow the upper example. One which does not is lung cancer in the UK (Figure 2): the curves for male plus female show the SP rising over the 25 years but the FP falling slightly for 10-15 years and then rising. The curves for female only are similar to SP1 and FP1 above while those for males show both SP and FP declining over the 25 years, but with FP falling at a faster rate.

In the case of AIDS, and of asthma morbidity, the FP is above the SP. This means that the experts believe that the incidence of these diseases will grow more rapidly than forward projections of recent trends suggest.

obtained from a variety of published sources. An assessment of **indirect costs** (i.e. production losses due to morbidity and premature mortality) could not be made for coronary heart disease (CHD), cerebrovascular disease (CVD), Asthma and AIDS in the UK as the underlying statistics were not available. For Germany and France, indirect costs were not available for most diseases. Only US sources permitted calculation of indirect costs for all diseases, though they were not made for Alzheimer's as almost all patients are post-retirement. Calculations for the USA were made using average income earnings by age and sex. For individuals not working (identified using labour statistics), one-half of the average income earning was used as a proxy measure of work (Cooper & Rice, 1976).

In this Briefing, it is only possible to summarise the extensive data in the Battelle reports and to draw out key conclusions and observations. Some of the data presented has been recalculated from the original as percentage change on the standard projection to enable comparisons between the reports to be made.

UK Trends and Projections

Diseases were selected on the grounds of their actual or potential socio-economic consequences (Figure 1). Within the UK, death rates from cardiovascular disease (almost 50% of all deaths) are among the highest of all the OECD countries. This category includes coronary heart disease (CHD), of which angina pectoris, acute myocardial infarction and sudden cardiac arrest are the commonest, and stroke. Together these conditions impose a major socio-economic burden on the country, estimated to be the equivalent of over 1.6% of GDP (direct plus indirect costs). Cancer is the second leading cause of death in the UK. Within this, lung cancer and breast cancer are the major malignancies of men and women respectively and often affect individuals pre-retirement. Asthma is especially prevalent in childhood as well as adulthood where the associated morbidity leads to lowered productive capacity: as such it is one of the most important chronic conditions in the UK. AIDS is a growing chronic problem affecting mainly young productive individuals and is potentially

serious in terms of life-years lost.

The population of the UK is projected to rise from 57.8 million to 61.7 million in the 25 years to 2017. Based on the available data sources the Standard Projection (SP) suggests a rise in the number of cases and deaths in all disease categories over the study periods. The figures derived from extrapolation of the SP for the year 2017 are shown for the four countries in Table 2. The Forecast Projections (FP) of the UK expert panel (Table 2) suggest that considerable potential exists by the end of the study period for avoiding or delaying new cases and avoiding premature deaths from CHD and CVD with lesser though still significant potential in breast cancer, and for reducing mortality from asthma. However they project a significant worsening in the number of asthma cases (up 18.3%) and in both morbidity and mortality from AIDS (up 32% and 37.5% over SP respectively). Over 25 years the projections, if realised, offer a cumulative potential reduction of 44,000 cases of breast cancer but imply an increase of 4,300 cases of AIDS. The total *cumulative* reduction or increase in cases and deaths is shown in Tables 3a and 3b, ranging from a saving of 534,000 premature deaths from CHD to an increase of 4,000 from AIDS.

Deaths from lung cancer in the UK warrant closer examination, for although the FP suggests a potential for savings in cases and deaths (Table 2) there is a significant divergence in the trends for males compared to females. The SP for both sexes shows a significant rise in death rate between 1992 and 2017 while the FP shows a small decline to the year 2007 and then a rise in the following decade (Figure 2). However, when the data is separated out on the basis of gender, it is apparent that although the 1992 death rate for males is twice that of females, by 2007 deaths are equalled and by 2017 female deaths outnumber males by 30-50%. The overall

Table 2 *Numbers of cases and deaths from the standard and average forecast projections for four countries in the 25th year of each study period. The difference between the SP and the FP is also shown as a percentage fall or rise*

Disease	Numbers ('000s) of	UK (2017)			France (2016)			Germany (2016)			USA (2015)		
		SP	FP	% Rise (+) or Fall (−)	SP	FP	% Rise (+) or Fall (−)	SP	FP	% Rise (+) or Fall (−)	SP	FP	% Rise (+) or Fall (−)
CHD	Cases	1281.8	972.0	−24.2	3249.5	2453.4	−24.5	5578.8	5132.5	−8	30000	9800	−67
	Deaths	149.7	109.7	−26.7	65.9	45.3	−31.3	162.1	174.3	+7.5	1200	400	−67
CVD (Stroke)	Cases	5050.7	4411.0	−12.7	754.2	603.4	−20	2269.8	2042.8	−10	4000	1300	−67
	Deaths	63.2	46.7	−26.1	21.1	18.5	−12.3	38.6	39.8	+3.1	232	70	−70
Lung Cancer	Cases	69.7	57.9	−16.9	161.1	143.6	−10.8	60.3	70.2	+16.4	174.7	117.5	−32.7
	Deaths	51.2	41.2	−19.5	51.5	44.1	−14.4	48.9	43.5	−11.0	358.7	196.5	−45.2
Breast Cancer	Cases	39.7	35.8	−9.8	106.0	100.2	−5.5	38.5	37.5	−2.6	–	–	–
	Deaths	21.2	18.8	−11.3	17.0	12.8	−24.7	21.8	19.1	−12.4	–	–	–
Asthma	Cases	1080.4	1278.5	+18.3	–	–	–	–	–	–	–	–	–
	Deaths	2.9	2.7	−6.9	–	–	–	–	–	–	–	–	–
AIDS	Cases	2.5	3.3	+32	6.9	4.6	−33.0	–	–	–	470*	420*	−10.6
	Deaths	2.4	3.3	+37.5	7.0	5.7	−18.6	–	–	–	283*	ns	–

SP, FP = Standard and Forecast Projection respectively
CHD = Cardiovascular disease
CVD = Cerebrovascular disease
** cumulative 10 year data*

Tables 3a and b *Cumulative reduction or increase (negative values) in number and percentage of cases and deaths from six disease categories in the UK over a 25 year time span from 1992-2017 (10 years for AIDS to 2002). The figures are the difference between SP and FP*

Table 3a

Disease	Time span (years)	Cumulative total reduction during time span in: No. cases, '000s and (%)	No. deaths, '000s and (%)	Undiscounted life years lost '000s
CHD	25	ns	534 (13)	5059
CVD	25	ns	227 (12.5)	1675
Breast Cancer	25	44 (5.2)	28 (6)	427
Asthma	25	ns	2.6 (4)	41
AIDS	10	−4.3 (−16.5)	−4.0 (−17)	–

Table 3b

Lung Cancer – males	25	82.6 (11.6)	79.3 (12.9)	873
Lung Cancer – females	25	47.0 (7.4)	39.3 (7.8)	652
Lung Cancer – total	25	129.7 (9.6)	118.7 (10.6)	1525

FP indicates that both cases and deaths from lung cancer would undershoot the SP by 16.9% and 19.5% respectively (Table 2). However a sensitivity analysis suggests that a much greater potential exists for reducing mortality. The 'most optimistic scenario' (i.e. if the best projections for both behavioural change and medical advances were realised) envisages a reduction in both cases and deaths from lung cancer in the UK of 55% in males and 25% in females (Table 4)—endorsing the view that this is one of the most 'preventable' of all diseases. The difference between the male and female scenario reflects the pessimism with which the experts viewed the future impact of increased smoking habit in women compared with men where it is declining.

Relative Contribution of Behavioural Change and Biomedical Advances to Reduced Morbidity and Mortality in the UK

The experts in each therapeutic area were asked to assess how much of the forecast reductions in morbidity and mortality over the SP could be attributed to (i) probable changes in lifestyle (smoking, diet, exercise, other risk factors)—termed behavioural changes, (ii) pharmaceutical advances (mainly new therapies in the R&D pipeline) and (iii) advances in other biomedical technologies such as screening, imaging, radiotherapy, diagnosis, surgery etc.

Figure 2 *Standard and Forecast Projections for deaths from lung cancer for males, females and both sexes to the year 2017 in the UK*

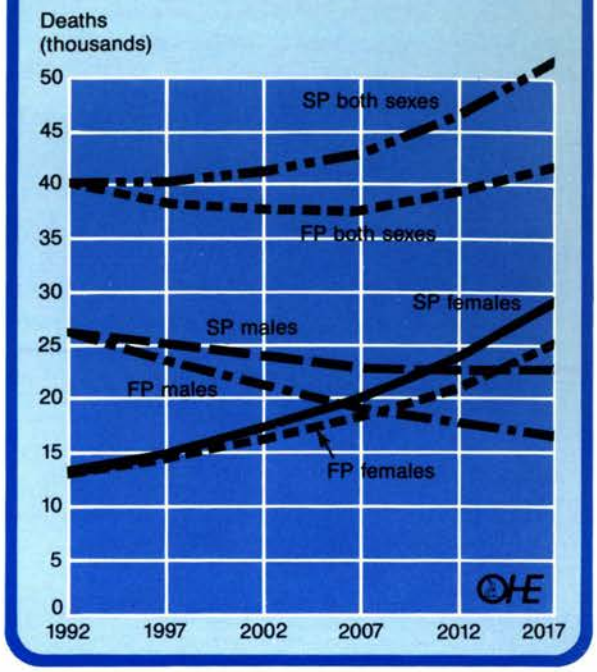


Table 4 *Sensitivity analysis showing the best and worst case scenarios for lung cancer calculated from the average projection by experts. The figures are % reduction in cumulative cases and deaths from the standard projection for each country. Figures in brackets are projected increases*

	Cases		*Deaths*	
	Best estimate	*Worst estimate*	*Best estimate*	*Worst estimate*
UK – males	55	5	55	5
– females	25	5	25	5
France	22	7	23	7
Germany	30	(100)	40	(5)
USA*	57	10	83	10

** US data for cases and deaths in the year 2015 only*

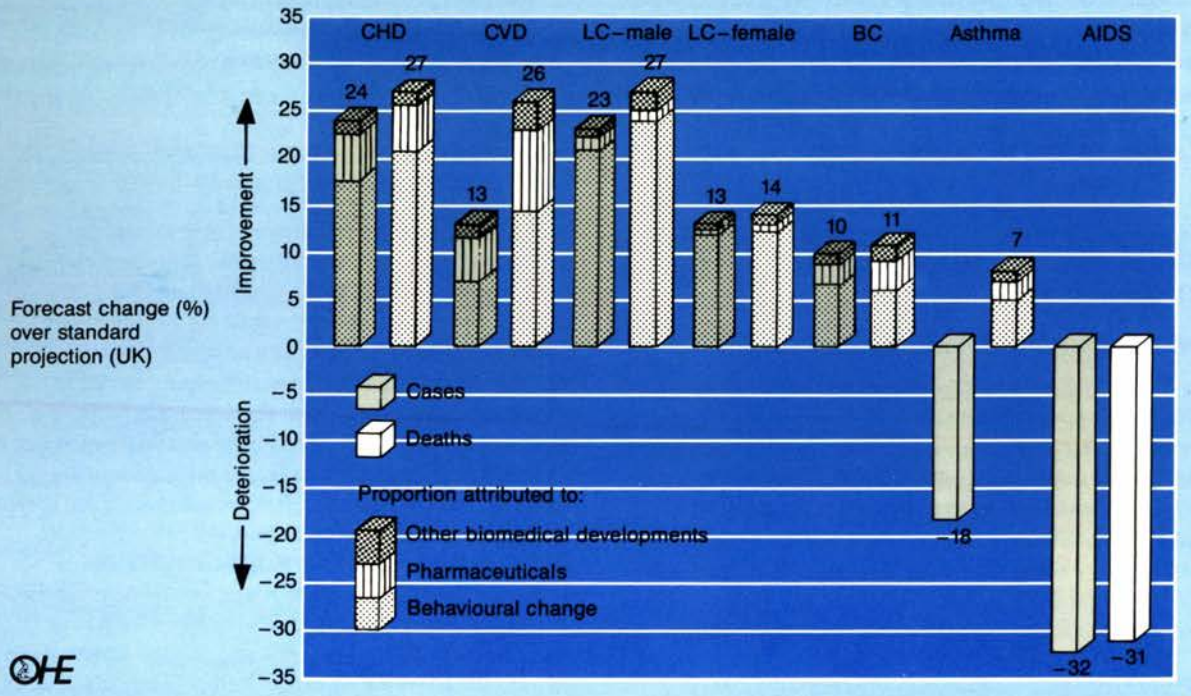
The percentage change for the UK in prevalence (CHD, CVD, Asthma) or incidence (Lung Cancer, Breast Cancer, AIDS) is re-presented graphically in Figure 3 to show the proportion attributed to the three factors above, and shown numerically in Table 5 relative to the other countries. The cumulative reduction in life years lost attributable to the three factors in the UK is set out in Table 6.

Behavioural change is seen as potentially the major contributor to improvements in morbidity and mortality over the Standard Projection in all disease categories. An estimated 76% of potentially avoided premature deaths from CHD are attributed to behavioural modification and 19% to pharmaceutical innovations. In the case of CVD, a significant contribution, 58%, is expected from behavioural change with an important input from pharmaceutical advances of 31%.

In the case of lung cancer, overwhelming importance was attached to behavioural modification with 90% of avoided deaths and 95% of avoided cases resulting from reduced smoking. Relatively little advance in therapy was anticipated. A major opportunity was identified to modify breast cancer by behavioural change with as many as two-thirds of avoidable cases and almost as many early deaths attributed to this factor. Pharmaceutical innovation was expected to contribute 25-30%.

The reduction in mortality due to asthma predicted by six experts ranged from zero (i.e. no change from SP) to 25% with a mean of 7% (Figure 3). Some 62% of this was attributed to behavioural change and to health education leading to the avoidance of allergens, to good asthma management programmes and to better use of medicines, partly through improved recognition of early signs of an incipient attack. Pharmaceutical advances were expected to account for 25% of the reduction—some 660 cumulative deaths—over the 25 year period. All experts predicted a worsening in asthma morbidity

Figure 3 *Percentage difference between SP and FP for six diseases in the UK. The proportion attributable to behavioural change, pharmaceutical innovation and other biomedical developments is shown where overall improvement is projected*



(5-40%, average 18%). In a follow-up questionnaire they indicated that without further behavioural change and biomedical advances, morbidity would increase by 35% to 378,000 total cases by 2017. They predicted that behavioural change would contribute 50% towards restricting future growth, pharmaceutical advances, 45%, and other biomedical advances, 5%.

For AIDS, the epidemic was considered largely behaviour-driven: both morbidity and mortality were forecast to rise by some 30% (range 20-100%) between now and 2002 despite significant advances in biomedical technology. Without these advances the rise would be even greater.

Trends and Projections in France, Germany and the USA compared with the UK

The figures are set out in Table 2.

Coronary Heart Disease (CHD)

The study of Andersson et al (1992) concluded that the potential for avoiding cases and deaths from CHD in France was very similar over the next 25 years to those for the UK. Both were in marked contrast to Germany (Andersson et al, 1993) where only a modest potential for reducing cases was foreseen while mortality was actually projected to rise by 7.5% by 2016 compared

Table 5 *Percentage contribution of three factors to avoidable cumulative deaths due to four diseases in the UK, France, Germany and the USA over a forecast 25 year period*

	Coronary Heart Disease				*Cerebrovascular Disease*			
Factor	*UK*	*France*	*Germany*	*USA*	*UK*	*France*	*Germany**	*USA*
Behavioural change	76	35	50	50	58	25	47	50
Pharmaceutical advances	19	32	21	40	31	38	15	40
Other biomedical advances	5	33	29	10	11	37	38	10

	Breast Cancer			*Lung Cancer*				
Factor	*UK*	*France*	*Germany*	*UK*	*France*	*Germany*	*USA to 2000*	*post-2010*
Behavioural change	57	19	30	90	68	20	most	little
Pharmaceutical advances	28	65	41	3	26	19	little impact	increased impact
Other biomedical advances	15	16	29	7	6	61		

* *Cases in 2016, cumulative data not available*

Table 6 *Forecast versus standard projections: cumulative reduction in life years lost in the UK*

	Undiscounted thousands of years				
Factor attributed to	*CHD*	*CVD*	*Lung cancer*	*Breast cancer*	*Asthma*
Behavioural	3830	963	1366	241	26
Pharmaceuticals	971	522	52	121	10
Other biomedical technologies	258	190	107	65	5
Total	5059	1675	1525	427	41

with the SP. The most optimistic outlook came from the USA where the difference between SP and FP was 67% for both cases and deaths.

Cerebrovascular Disease (CVD)

For CVD, the French perceive greater scope for reducing the prevalence of stroke relative to the UK but less opportunity for reduced mortality. In Germany, the potential for reducing cases was similar to that envisaged for the UK but was in marked contrast to mortality which was foreseen to rise against SP by 3.1% compared to a reduction in the UK by 26.1%. Again the USA provided the most optimistic outlook for both cases and deaths, with a potential to fall by two-thirds.

Breast Cancer

For breast cancer in women, the difference between SP and FP suggested a similar modest reduction in case incidence in the UK, France and Germany over the 25 year time span, but a somewhat greater opportunity to reduce mortality (range 11.3% to 24.7%). Data on breast cancer was not collected for the USA.

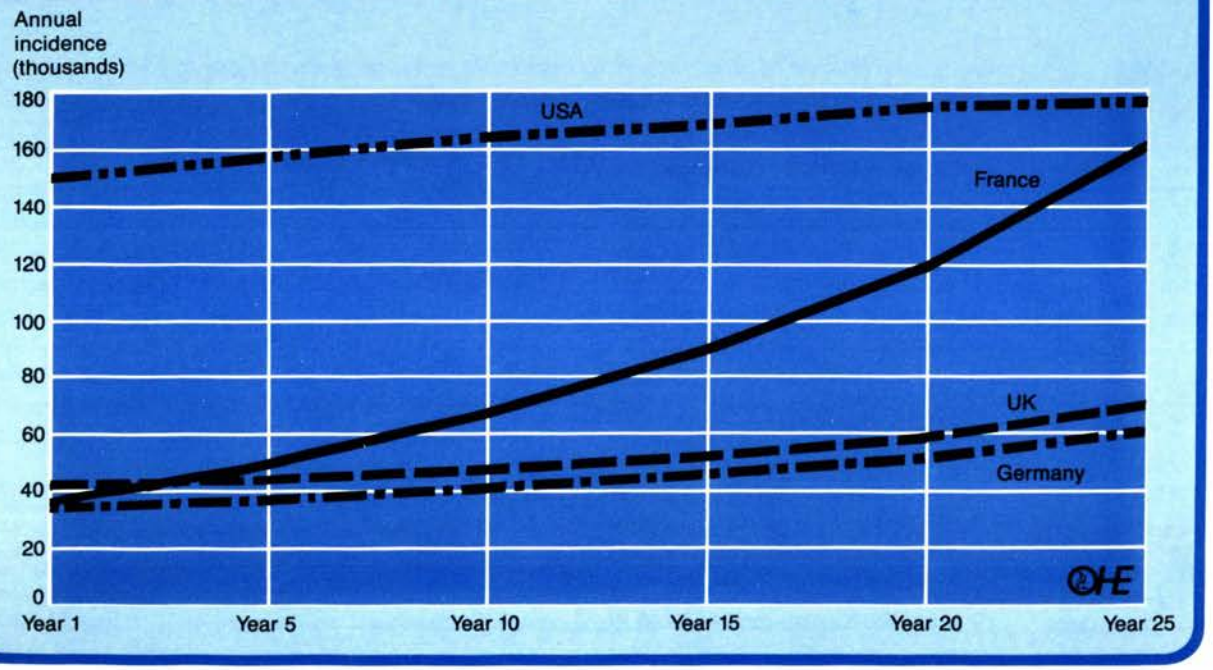
Lung Cancer

The only study to analyse separately lung cancer data by gender was that conducted in the UK. Hence the only comparisons possible are for total case incidence and mortality. The SP for incidence of lung cancer in the four countries is shown in Figure 4. A gradual upward trend is apparent in the UK, Germany and the USA, which is in marked contrast to that for France which climbs by some 300% between now and 2016. Nevertheless, the FP for France shows a potential for a percentage reduction of both cases and mortality of a similar order to the UK, though the absolute numbers are much greater. In Germany, the SP and trend are similar to the UK, but the FP is for case incidence to rise by an average of 16.4% more than the SP by the year 2016 (c.f. fall in the UK by 16.9%) while mortality declines. The USA envisage scope for saving an average of a third of the cases and 45% of deaths by the year 2015. The best and worst case lung cancer scenarios for all four countries are shown in Table 4: German experts are easily the most pessimistic for both cases and deaths.

AIDS

Relative to the somewhat pessimistic view in the UK, the French experts foresaw a reduction in both cases and deaths from AIDS over the 10-year SP. In the USA cumulative AIDS cases over the decade to the year 2000 were forecast to be almost 11% below the Standard Projection. Data on AIDS was not collected in Germany.

Figure 4 *Standard Projections for the incidence of lung cancer in four countries projected forward from National epidemiological and demographic data for 25 years.*



Relative Contribution of Behavioural Changes and Biomedical Advances to Reduced Morbidity and Mortality compared with the UK

A comparison of the percentage reduction in mortality attributed by the different national expert panels to behavioural change, pharamceutical advances or other biomedical advances compared with the UK, is shown in Table 5.

For diseases of the heart and circulatory system, the influence of behavioural change on CHD is seen as a significant factor in all four countries, though this is perceived as the most important in the UK and lowest in France. Notably, both the French and US reports anticipate a greater role for pharmaceutical advances than the UK while the French and Germans anticipate a significantly greater contribution from other biomedical technologies compared to the UK for both CHD and cerebrovascular diseases. In CVD, the expected pharmaceutical contribution is more evenly spread though German experts anticipate a smaller contribution here compared to the other three nations. Possible pharmaceutical and other biomedical technology advances are outlined in Box 3.

A marked difference is apparent between the two malignant diseases examined. In lung cancer there is more opportunity to reduce mortality by behavioural change (though German experts assigned this component only 20%) and less perceived scope for a contribution from the pharmaceutical industry. Perhaps surprisingly, the Germans believe that 61% of the 'gain' in this disease will arise from other biomedical technologies. In contrast, it is expected in all three countries that the pharmaceutical industry will make a very significant contribution to the reduction in mortality due to breast cancer (average 45%) than is likely in lung cancer. In the USA, experts see little contribution to a reduction in lung cancer mortality from industry or other biomedical technologies until after the year 2010. After that medical advances are expected to increasingly contribute. Areas where advances may be expected are summarised in Box 4.

Box 3 *Potential for advances in cardiovascular medicine: the next 25 years*

The term 'cardiovascular medicine' spans coronary heart disease as well as cerebrovascular disease. In both areas advances may be assigned to one of three broad categories, (a) influencing behaviour—strictly primary prevention, (b) treating or controlling symptoms or (c) pharmaceutical or surgical interventions to reduce disability. The Battelle reports identify an extensive list of approaches, each of which was considered by the expert panels. The level of overall agreement on the significance of items on this list was high, though certain specific items received only one or two mentions. Extensive knowledge would be necessary to appreciate the true significance and implications of many of the advances considered and the summary below is little more than a list of key areas. Readers seeking a more detailed exposé should consult publications in the OHE 'current health' series which in turn provide a more extended bibliography (OHE, 1990; O'Brien, 1991; Dale, 1988).

Behavioural Change: The perceived contribution of behavioural change to reducing the societal burden from these diseases ranged from 35-76% for CHD and 25-58% for CVD (Table 5). Despite these variations there was a high level of agreement on the factors involved. Reduced smoking, improved diet and greater exercise were identified in all reports while control of diabetes (a known risk factor for cardiovascular disease), control of obesity, and reduction in the level of alcohol consumption and stress were factors specified in one or two of the reports.

Diagnosis and Surgery: These areas were anticipated to contribute 5-33% in reducing the burden from CHD and 11-38% of that from CVD (Table 5). There was unanimity in all reports that genetic advances (DNA fingerprinting to identify predisposing genes) would play a major role towards the end of the 25 year period and that improved methods for detecting plaque build-up and arterial blockage (angiography, magnetic resonance imaging, echocardiography) would begin to contribute within 10 years. Advances in electrocardiography could help to detect 'silent ischaemia' before overt disease symptoms developed. Diagnosis is also likely to be aided by the identification of additional biochemical markers of disease such as apolipoprotein B, the protein component of low density lipoprotein (LDL). LDL is the major source of cholesterol which accumulates in atherosclerotic plaque (see O'Brien, 1991). Surgical advances are thought likely to focus on improved by-pass surgery such as the removal of plaque (atherectomy), an increased use of 'assist' devices in place of heart transplant and the development of more effective immunosuppressive drugs which will enhance graft survival.

Pharmaceutical Advances: These were projected to contribute 19-40% and 15-40% respectively to the improvement in CHD and CVD mortality over the next 25 years (Table 5). Improvements in drug categories known to reduce risk factors were seen as highly important by all four Battelle studies, in particular better agents for (i) reducing cholesterol absorption or synthesis and (ii) controlling elevated blood pressure. Of the former, a series known as HMG-CoA reductase inhibitors were considered by US experts to have the potential to reduce heart disease by 40-50%. Already there is some evidence that reducing cholesterol initiates a process of plaque resorption which, if confirmed, may reopen partly blocked blood vessels and render more drastic surgical approaches unnecessary. Improved agents in category (ii) including 'better' angiotensin converting enzyme (ACE) inhibitors, calcium channel blockers (which may also have applications in arrhythmia and angina), and diurectics. Mentioned in some reports were newer agents such as inhibitors of renin, an enzyme secreted by the kidney which is involved in the control of blood pressure, and thrombolytic drugs which are able to 'dissolve' blood clots and may have applications immediately post-myocardial infarction and in post-operative control of thrombosis.

In the medium to long term, several of the expert panels expected significant advances in the use of non-lipid based approaches to prevent plaque. In particular the use of growth factory antagonists (PDGF antagonists), antagonists of platelet aggregating factor (PAF) and drugs to modulate the behaviour of the layer of cells lining blood vessels (the endothelium) on which a family of new adhesion molecules has been identified in the past decade. Finally, the prospect of preventing the expression of potentially harmful genes using, for example, antisense nucleotides may have a role on the 25 year horizon.

Box 4 *Potential for advances in certain cancers over the next 25 years*

All three European reports considered breast and lung cancer. The US study did not cover data on breast cancer but instead carried an analysis of leukaemias and colon cancer. A detailed list of potential advances or therapeutic approaches in the research pipeline, prepared in advance by the Battelle Institute, were considered by each national expert panel. Their potential for reducing morbidity and mortality through (a) behavioural change, (b) improved diagnosis and surgery and (c) improved therapy were each separately assessed. Their views are summarised below: for a fuller account of the prevention and treatment of cancer see Souhami & Tobias (1987). In contrast to cardiovascular disease (Box 3) there was a wider range of emphasis between expert panels in this disease area (Table 5).

Behavioural Changes: Behavioural changes were anticipated to contribute 20-90% and 19-57% respectively to the potential reduction in mortality from lung cancer and breast cancer (Table 5). UK experts regarded this as the most important contributor for both diseases. In the case of lung cancer, the link with smoking was overwhelmingly endorsed by all panels, including the US. Despite this there were very divergent views on the percentage reduction in deaths this could bring, ranging from 90% in the UK to only 20% in Germany. This may relate to current smoking attitudes in different nationalities and the time lag between giving up smoking and derived benefit. For example the decline in smoking habit already apparent in the UK and USA is expected to have its greatest overall impact on mortality within the next decade but a rather smaller contribution thereafter (Table 5) due (in the UK) to rising mortality among female smokers—Figure 2. The German panel made reference to environmental factors in lung cancer (traffic fumes and asbestos) but these fall into the realm of public heath rather than individual behaviour as most people cannot avoid them. Less opportunity for influencing breast cancer by behavioural change was perceived though the UK panel specifically mentioned the beneficial effect of a low animal fat diet, high in fruit and vegetables, while the UK and US panels made specific reference to the inclusion of anti-carcinogens (such as natural substance ß-carotene) in diet as a preventative measure (termed chemoprevention).

Diagnosis, Radiotherapy and Surgery: Advances here were expected to make a modest contribution to reduced mortality in breast cancer (15-29%), largely through wider screening programmes. In lung cancer, the UK and French panels saw only a minor contribution (7% and 6% respectively) through earlier detection or advances in fibre-optic surgery, contrasting markedly with the 61% forecast in the German study. This was due to the greater potential envisaged by German experts for developments in screening (e.g. sonography and cheaper access to magnetic resonance imaging) and genetic engineering, both of which would aid diagnosis or allow the earlier detection of 'at-risk' individuals. An example of the latter is the development of methods for the detection of p53, a suppressor gene present in lung, colon and breast cancer, seen as potentially important in 15-25 years. US experts also saw an increased impact around the turn of the century from lung cancer-specific diagnostic monoclonal antibodies.

Pharmaceutical Advances: The contribution of pharmaceuticals was expected to be higher in breast cancer (28-65%) than lung cancer (3-26%), Table 5. For lung cancer, the UK panel anticipate new chemotherapies including anti-oestrogens (treatment and prevention), cytokines (notably interleukins) and, in 20-25 years time, agents modifying the stroma/epithelial interaction, and anti-sense oligonucleotides which may suppress cancer-causing genes (oncogenes). French and US experts also considered interleukins to be potentially important especially IL-3, a growth factor which stimulates bone marrow. IL-3 and other growth factors such as G-CSF and GM-CSF, are already finding use as adjuvants during chemotherapy or bone marrow transplantation. The French and US panels drew attention to the many compounds in development which may have improved efficacy and reduced toxicity – though generally these were targeted more towards leukaemia, colon and breast cancer than lung cancer. The French were the most optimistic regarding the role of pharmaceuticals and drew attention to therapeutic monoclonal antibodies targeted to breast cancer and lung cancer, and potentially important cancer-specific vaccines. These views concurred with those from the US who additionally referred to 'chemosensitisers' designed to break drug resistance in cancer cells and interferons which are already significant in the treatment of leukaemia: notably interferon-alfa is predicted to be a 'block-buster' drug soon after the year 2000 with an earning potential of $1-2 billion (PharmaPipelines, 1994). An increasing role for psychoneuroimmunology was envisaged by German and US experts.

Some Economic Implications of the Battelle Reports

Although the potential for reducing suffering and premature death identified above is to be primarily welcomed on humanitarian grounds, significant cost savings or economic benefits are also implicit. The ease with which savings can be computed depends on the accuracy and completeness of the underlying demographic and epidemiological data available, on the way it has been collected (e.g. incidence vs. prevalence), and on certain caveats regarding the design of the Battelle studies—discussed further below.

The costs per case of the six disease considered in the UK study (Oleksy, 1994) are shown in Table 7. It is important to note, however, that data on indirect costs are not generally available in the UK. Hence the total costs (direct plus indirect) are undoubtedly substantially higher than those shown in Table 7.

Only the data presented for the US allowed the calculation of cumulative potential savings over the 25 year period to 2015 on both direct and indirect cost. These are set out in Table 8. The only exceptions were the direct costs for CHD and CVD which could not be determined. On these figures, very substantial savings could be achieved if the behavioural, therapeutic and technological advances are realised. The largest potential for saving in direct costs identified in the US study is in Alzheimer's disease (£48 billion) of which 90% is expected to arise from pharmaceutical advances, with lung cancer and colon cancer contributing lesser though still significant sums. The serious impact of indirect costs, however, is apparent from the projected data on CHD and CVD, which total £333 billion. It is notable that 100% of the avoided direct and indirect costs in rheumatoid arthritis are expected to arise from the pharmaceutical industry. AIDS direct costs in the USA are expected to rise by £4.1 billion in the 10 years to 2000 but the potential for avoiding indirect costs is significant

Table 7 *Total costs and costs per case of diseases studied in the UK*

Disease	*Cost type (year)*	*Cost (£m)*	*Cost per case (1992 price in £)*	*Reference*
Coronary heart disease	Direct Medical costs, England & Wales (1985)	389.9	798	OHE, 1987
Cerebrovascular disease	Direct Medical costs, England & Wales (1985)	546.02	2,846	OHE, 1988
Lung cancer	Cost of NHS hospital discharges and deaths, England (1991)	85.0	1,542	OHE, 1992
Breast cancer	Cost of NHS hospital discharges and deaths, England (1991)	58.0	1,443	OHE, 1992
Asthma	Direct Medical costs, UK Indirect costs Total costs (1987)	99.62 223.0 322.62	146 473	OHE, 1990
AIDS	Direct Medical costs, UK (1992)	147.9	4,058	Battelle, 1993

Source: Oleksy et al (1994), Battelle Institute

at £9.5 billion, 74% of which is anticipated to arise from pharmaceutical advances preventing the progression of AIDS.

Conclusions

Certain key assumptions were made in preparing the Battelle reports which need to be borne in mind when drawing conclusions from the data. They are that:

- no changes in the mechanism of national healthcare delivery is made during the forward projection periods,
- the forecast advances are linear over the study periods,
- the costs of researching, developing and using new technologies or promoting behavioural change are not included, and
- the morbidity and mortality forecasts were made independently for each disease—hence the data does not take account of the additional population at risk from one disease due to lowered mortality from the others.

Table 8 *Cumulative potential savings on direct and indirect costs in the USA over a 25 year period (10 years for AIDS). Exchange conversion, $1.58 = £1*

	USA (£ billions)			
	Cumulative savings on direct costs		*Cumulative savings on indirect costs*	
Disease	*Total*	*API*	*Total*	*API*
CHD	–	–	278	111
CVD	–	–	55	22
LC – all	5.7	0.63	38	6.3
AIDS	(4.1)*	–	9.5	7.0
Leukaemia	0.13	–	2.4	2.3
Colon cancer	2.3	0.5	0.44	0.23
Rheumatoid arthritis	1.3 to 2.5	1.3 to 2.5	4.4 to 9.5	4.4 to 9.5
Alzheimer's	48.0	43.0	–	–

API = Attributable to Pharmaceutical Industry advances
** See text*

The objective of these studies was to try to assess the potential future impact of further behavioural change and new technologies rather than simply identify the direction of behavioural change and technological trends. This is especially difficult in healthcare because the baseline is not static: technologies introduced 10 years ago will be modifying case and death rates today. Similarly, introductions or behavioural change made in the next few years may not have a material impact on morbidity and mortality until towards the end of the 25 year study period or even beyond.

It should also be appreciated that in common with all forecasting studies there is a high degree of uncertainty. The expert views are the best judgements of specialists but even so often display wide variation. This may reflect limits on the data available for some diseases and differences in the quality of information available between the four countries studied. The variations across countries may reflect varying degrees of optimism between the national panels regarding the likely potential of existing technology or new innovations: US experts in particular appear to place greater faith in 'high-tech' solutions than Europeans. Yet again, they may reflect the extent to which individual national health education programmes have reached their target audience. The long lead-time for such programmes to impact may explain the somewhat different emphases between the US and UK compared with France and Germany.

Despite these uncertainties, it is clear from the individual data presented that in most diseases the experts believe that the impact of behavioural change and potential new technologies will be to reduce, sometimes significantly, morbidity and mortality figures well below the standard projections. In almost all cases, behavioural change offered the greatest potential for health gain. Achieving behavioural change and obtaining the benefit of new technologies in turn implies both health gain and a reduced societal burden in avoided direct and indirect costs which, in cumulative terms, may run to millions if not billions of pounds. Even in diseases where the forecast is worse than the standard projection (e.g. asthma morbidity and, in some studies, AIDS and lung cancer) without behavioural change and new technological developments, costs

would be much higher.

Of course we must note that the costs of promoting behavioural change and achieving technological advance are not identified in the studies. Cost effective policies to promote health gain and economic benefit need to have considered these costs.

We conclude with the words of Bezold et al (1991), '. . . future work is not attempting to predict specific events or conditions so much as it is trying to anticipate the range of potential events or conditions and to enable people on the one hand to prepare for them and on the other to make some informed choices about them.' The four reports considered here fulfil to a large extent this definition and demonstrate in particular:

- that we have the ability to ensure the future need not necessarily be the same as the past, and
- cost-effective policy choices supporting health promotion and research and development into biomedical advance are likely to bring significant health gain to society.

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