Appendix A

Estimating Value of Investment in Health Care: Methods and Data Sources

The calculation of the value of investment (VOI) in health care for the report took a prevalence-based perspective, comparing changes in annual health care costs with changes in annual population health outcome measures.

Specifically the VOI was estimated by:

- Comparing a monetized value of gains in annual population health outcomes for 2000 computed using 2000 and 1980 health outcomes rates;
- Comparing the increased annual health care expenditures (including prevention, diagnosis, and treatment) for 2000 computed using 2000 and 1980 per person expenditures; and
- Computing the value of the population health gains for every additional dollar invested in health care services using 2000 rates compared to 1980.

In our base case analysis, we have assumed that all improvements in health observed in 2000 compared to 1980 are attributable to the increased expenditures on health care services. However, changes in other characteristics such as eating and smoking patterns, public health measures, changes in disease incidence not attributable to health interventions, and occupational, traffic, and other accidents might also impact population health outcomes. The justification for our base case assumption was based on a review of several data sources that indicated that changes from 1980 to 2000 in some of these characteristics would be expected to improve health outcomes and in others would be expected to worsen health outcomes, thus justifying our "no net change" assumption for these other characteristics. For example, while rates of hypertension have decreased, obesity and diabetes have increased so that the net effect on cardiovascular disease (CVD) in the absence of health care interventions is uncertain.

The VOI analysis used data from multiple sources including "Health United States: 2002", data from the US Census 2000, and data from other US National Health Surveys and data from published sources. The data sources were identified through web searches using Google, and through journal searches using MEDLINE.

The results of the VOI analysis are presented in four sections:

Improvements in Health: 1980 to 2000

Investments in Health Care: 1980 to 2000

Health-Related Characteristics of the US Population: 1980 to 2000

Value of Investment Analysis: 1980 to 2000

Table 1 ■ **Infant Mortality Rates 1980 to 2000**

	1980	1990	2000
Infant Mortality (per 1000 live births)	12.6	9.2	6.9

Source: Health United States 2002

Table 2 ■ **Deaths and Death Rates 1980 to 2000**

	1980	1990	2000
Deaths – crude	1,989,841	2,148,463	2,403,351
Death rates – age-adjusted (per 100,000)	1,039.1	938.7	872.0
Death rates – 85 years and older (per 100,000)	15,980.3	15,327.4	15,321.5
Death rates – 75–84 years (per 100,000)	6,692.6	6,007.2	5,688.4
Death rates – 65–74 years (per 100,000)	2,994.9	2,648.6	2,428.6

Source: Health United States 2002

Improvements in Health: 1980 to 2000

Mortality rates declined in both the very young and the elderly population between 1980 and 2000. Infant mortality decreased by 45% from 12.6 per 1000 live births in 1980 to 6.9 per 1000 live births in 2000 (Table 1). Several health interventions have contributed to this decline, including better access to prenatal care and post-natal care, antenatal corticosteroid treatments to prevent premature labor and promote lung maturation, and surfactants to prevent or treat respiratory distress syndrome.

Adult mortality also declined during the period between 1980 and 2000 (Table 2). Age-adjusted annual death rates per 100,000 decreased from 1,039.1 in 1980 to 872.0 in 2000. Much of this decrease is due to decreased mortality rates for those aged over 65 years with a reduction of 19% in the annual death rate for those 65 to 74 years, 15% for those 75 to 84 years, and 4% for those over age 85 years. Health care interventions have been largely responsible for this decline in mortality, including changes in the prevention, diagnosis, and treatment of coronary heart disease and many different types of cancer.

The reduction in annual death rates translates into an increase in life expectancy at birth as well as at the older ages (Table 3). The life expectancy from birth for males has increased more than for females, with a gain from birth of 4.1 years for males and 2.1 years for females. The same pattern of life expectancy gains is observed for life expectancy gains throughout the life span, including over age 65 years.

There have also been declines in disability and institutionalization rates during the period 1982 to 1999 for those who are over 65 years (Table 4). The percent disabled has declined by 19% and the percent institutionalized has declined by 23%. This decline may be partly due to the compression of morbidity in these older ages that has been described in the literature (Fries 1980).

In contrast to disability rates in the elderly, the disability rates for people aged 25 through 61 has stayed relatively constant during the period 1982 to 1999 (Table 5).

Table 3 ■ Life Expectancy 1980 to 2000

		1980	1990	2000
Life expectancy at birth	**Male**	70.0	71.8	74.1
	Female	77.4	78.8	79.5
Life expectancy at 20 years	**Male**	51.9	53.3	55.2
	Female	59.0	59.9	60.0
Life expectancy at 40 years	**Male**	33.6	35.1	36.7
	Female	39.8	40.7	41.0
Life expectancy at 65 years	**Male**	14.2	15.1	16.3
	Female	18.4	19.0	19.2
Life expectancy at 75 years	**Male**	8.9	9.4	10.1
	Female	11.6	12.1	12.1

Source: National Vital Statistics Reports 2002

Table 4 ■ Disability Rates 1982 to 1999 for People Aged 65+ Years

	1982	1989	1994	1999
Total Disabled	26.2%	24.4%	22.5%	19.7%
Institutionalized	6.8%	6.1%	5.7%	4.7%

Source: Manton et al. 2001

Table 5 ■ Disability Rates 1982 to 1999 for People Aged 25 through 61 Years

	1982	1989	1994	1999
Work Limitation*	7.9%	7.2%	8.4%	7.9%

Source: Houtenville 2001

**Work limitation is defined as those who report a health problem or disability which prevents them from working or limits the kind or amount of work that they can do.*

Table 6 ■ Productivity Gains Due to Treatments for Selected Conditions

Condition and treatment (source)	Productivity Measures	Financial Measures
Influenza – Vaccine (Rubin 2003)	43% fewer lost workdays than the group receiving placebo	$4,600 net savings per 100 vaccinations
Influenza – Vaccine (Nichols et al. 2003)	18% fewer lost workdays and 18% fewer days of reduced effectiveness than the group receiving placebo	$4,434 savings in productivity losses per 100 vaccinations
Migraine – Medication (Cady 1998, 1999)	49% less productivity loss per headache during the work shift	$850 gains in productivity a year per migraine sufferer
Diabetes – Glipazide (Testa 1998)	Number of workdays lost per 500 workdays were less with glipazide (5 days) versus placebo (24 days)	$91 a month reduction in absenteeism costs per worker with diabetes per month
Diabetes complications (Ng 2001)	Presence of diabetes reduced probability of being in the workforce by 3.5% compared to those without diabetes plus complications reduced the probability of being in the workforce by 12% compared to those with diabetes without complications.	Potential productivity gains from preventing or delaying complications of diabetes range from $3,800–8,700 per person with diabetes per year
Depression (Simon 2000)	Patients achieving remission after treatment missed 10 fewer days of work compared to those with persistent depression.	N/A
Depression (Kessler 1999)	Depressed workers experienced 1.5 to 3.2 times more short-term disability days in a month than non-depressed workers.	Up to $182–$395 a month in additional costs are projected to be saved with treatment per person with depression

Many health care interventions are targeted at reducing morbidity including reducing productivity losses attributable to diseases. The national impact of these interventions has not been determined but studies in individual diseases, including influenza vaccination, migraine, diabetes, and depression, have shown these benefits (Table 6). Many studies in individual diseases have also shown improvements in quality of life for people receiving health care interventions introduced between 1980 and 2000.

Investments In Health Care 1980 to 2000

Health care costs rose by 80.8% between 1980 and 1990 and by 42.3% between 1990 and 2000 when costs are expressed in 2000 U.S. dollars (Table 7).

However, some of this rise in costs was attributable to an increase in population size over this same time period. Thus the age-adjusted per person annual health care costs only rose by 60.4% between 1980 and 1990 and by 26.0% between 1990 and 2000 (Table 8).

During 1977 to 1997, the ratio of annual health care costs for those over 65 years to those under 65 years increased from 3.63 in 1977 to 4.60 in 1997 (Table 9).

More detailed data on the distribution of health care expenditures by age for 1996 and 1999 indicate that annual health care costs are lowest for children aged 6 to 17 years and then increase through age 85 and above (Table 10).

Table 7 ■ Total U.S. Health Care Expenditures, 1980 to 2000 (2000 U.S. $)

	1980	1990	2000
U.S. Population (rounded to nearest 1000)	226,546,000	248,710,000	281,422,000
U.S. health expenditures (in millions)	$487,969,650	$882,212,060	$1,255,500,000
	1970–1980	**1980–1990**	**1990–2000**
Increase in U.S. health expenditures		80.8%	42.3%

Source: Health United States 2002

Table 8 ■ Age-Adjusted Per Person U.S. Health Care Expenditures 1980 to 2000 (2000 U.S. $)

	1980	1990	2000
Per person health expenditures	$2,207	$3,541	$4,461
Increase in per capita health expenditures from prior period		60.4%	26.0%

Source: Health United States 2002

Table 9 ■ Ratio of Annual Per Person U.S. Health Care Expenditures by Age (65+ years: <65 years) in 1970 to 1995

Age Group	1977	1987	1995
Ratio 65+ to <65	3.63	4.16	4.60

Source: Lubitz et al. 2001

Table 10 ■ Annual Per Person Health Care Expenditures by Age 1996 and 1999

	1996	1999
<6 years	$1,211	$912
6 to 17 years	$871	$868
18 to 44 years	$1,622	$1,525
45 to 54 years	$2,669	$2,454
55 to 64 years	$4,018	$3,564
65 to 74 years	$4,763	$5,420
75 to 84 years	$7,644	$6,975
85+ years	$8,768	$7,771

Source: MEPS Surveys 1996 and 1999

Health-Related Characteristics of the U.S. Population Profile: 1980 to 2000

There are several characteristics of the U.S. population that might be expected to impact health outcomes. Changes in some of these characteristics are included in this section to illustrate the fact that some of these characteristics would be expected to have improved health outcomes and some to have worsened them over the 1980 to 2000 time period.

- Increase in the percentage of the population over age 65, 75, and 85 years
- Increase in percentage of the population overweight and obese
- Decrease in percentage of the population smoking and with hypertension and high cholesterol
- Increase in percentage of the population with chronic conditions such as arthritis, diabetes, asthma, and COPD
- Decrease in rate of occupational injuries with lost workdays

The aging of the population (Table 11), as the baby boomers move into the older age groups, is likely to decrease annual population health outcomes overall since the incidence of many health conditions increase with age, especially chronic conditions.

During the period 1980 to 2000, there has also been a steady increase in the number of people 20 years and older who are overweight (BMI>25) and who are obese (BMI>30) as well as in the number of children who are above the 95th percentile BMI chart cutoffs for their age group from the CDC (Table 12). High BMI is associated with poorer health outcomes.

Other characteristics that are associated with poorer health have declined in the U.S. population during the period 1980 to 2000, including smoking rates, hypertension, and hypercholesterolemia (Table 13). These declines are likely to result in decreased morbidity and mortality.

However, many chronic diseases have increased during the period 1980 to 2000 including arthritis, diabetes, asthma, and COPD (Table 14). These chronic conditions are generally associated with increased morbidity and mortality.

The rate of occupational injuries with lost workdays has declined between 1980 and 2000, which should improve the health outcomes for the working age population (Table 15).

In summary, the changes in the U.S. population profile between 1980 and 2000, with more people living to older ages and with the associated increase in chronic conditions, has put a greater burden on the health care system in its attempts to maintain and improve the health of the population. Some behavioral changes, such as reductions in smoking and fat and salt intake, as well as reductions in occupational injury rates have reduced overall risks for poor health, while the increased incidence of obesity has increased the overall risks for poor health.

Table 11 ■ U.S. Population and Age Distribution*

		1980		1990		2000	
		Number (in thousands)	% of population	Number (in thousands)	% of population	Number (in thousands)	% of population
Total		226,546		248,710		281,422	
Total by Gender	Male	110,053		121,239		138,054	
	Female	116,493		127,471		143,368	
<15 years	Male	26,217	23.8%	27,570	22.7%	30,854	22.4%
	Female	25,073	21.5%	26,283	20.6%	29,399	20.5%
15–24 years	Male	21,418	19.5%	18,915	15.6%	20,079	14.5%
	Female	21,068	18.1%	18,098	14.2%	19,105	13.3%
25–34 years	Male	**18,383**	**19.5%**	21,564	15.6%	20,121	14.6%
	Female	**18,700**	**16.1%**	21,596	16.9%	19,771	13.8%
35–44 years	Male	12,570	11.4%	**18,510**	**15.3%**	22,448	16.3%
	Female	13,065	11.2%	**18,925**	**14.8%**	22,701	15.8%
45–54 years	Male	11,009	10.0%	12,232	10.1%	**18,497**	**13.4%**
	Female	11,791	10.1%	12,824	10.1%	**19,181**	**13.4%**
55–64 years	Male	10,152	9.2%	9,955	8.2%	11,645	8.4%
	Female	11,551	9.9%	11,158	8.8%	12,629	8.8%
65–74 years	Male	6,757	6.1%	7,907	6.5%	8,303	6.0%
	Female	8,825	7.6%	10,139	8.0%	10,088	7.0%
75–84 years	Male	2,867	2.6%	3,745	3.1%	4,879	3.5%
	Female	4,862	4.0%	6,267	4.9%	7,482	5.2%
85 years or more	Male	682	0.6%	841	0.7%	1,227	0.9%
	Female	1,559	1.3%	2,180	1.7%	3,013	2.1%
Total 65 and older		**25,549**	**11.2%**	**31,079**	**12.5%**	**34,992**	**12.4%**
65 and older	**Male**	**10,306**	**9.4%**	**12,493**	**10.3%**	**14,410**	**10.4%**
	Female	**15,246**	**12.9%**	**18,586**	**14.6%**	**20,582**	**14.4%**

Source: Health United States 2002 and U.S. Census Data 2000

** Baby boomers in bold*

Table 12 ■ Percentage of U.S. Population with High Body Mass Index (BMI) 1976 to 2000

	1976–80	1988–1994	1999–2000
Overweight/ Obese (%) 20 years and older	47.4%	56.0%	64.5%
Obese (%) 20 years and older	15.1%	23.3%	30.9%
Overweight/ Obese (%) 6–19 years of age	6.5%	11.3%	15.3%

Source: Health United States 2002

Adults: BMI >25 = overweight; BMI >30 = obese

Children: BMI >95th percentile for age = overweight or obese

Table 13 ■ Percentage of U.S. Population Smoking, with Hypertension, or with High Cholesterol: 1980 to 2000

	1980	1990	2000
Smoking Rates	33.0%	25.3%	23.1%
Hypertension Rates	40.4%	23.9%	28.7%
High Cholesterol Rates	27.8%	19.7%	18.0%

Source: Health United States 2002

Table 14 ■ Percentage of the Population with Arthritis, Diabetes, COPD, and Asthma: 1980 to 2000

	1980	1990	2000
Arthritis	12.1%	12.6%	13.4%
Diabetes	2.5%	2.7%	3.4%
COPD	3.7%	4.5%	4.6%
Asthma	3.2%	4.2%	4.4%

Sources: Arthritis – applied 1990 National Health Interview Survey age-specific prevalence rates to U.S. population age-rates for 1980, 1990, 2000; Diabetes – used CDC prevalence rates but extrapolated 1990 to 1996 rates to 2000 to account for a change in survey method in 1997; COPD and Asthma from the 2002 Chart Book on Cardiovascular, Lung, and Blood Diseases

Table 15 ■ Occupational Injuries with Lost Workdays in the Private Sector: 1980 to 2000

	1980	1990	2000
Lost workdays per 100 full-time equivalents	3.9	3.9	2.8

Source: Health United States 2002

Table 16 ■ Value of Investment Analysis: 1980 to 2000

	2000 at 1980 rates*	2000 at 2000 rates**	Difference
Annual Per Capita Cost	$2,207	$4,461	$2,254
Annual Costs	$621 billion	$1,255.4 billion	$634.4 billion
Annual Deaths	2,924,255	2,453,999	-470,256
Annual Value of Avoided Deaths***			$1.9 trillion
VOI of $1 Based on Avoided Deaths			**$3.0**
Average Gain in Life Expectancy (Years)****			2.18 (0% discount) 0.64 (3% discount)
Annual Value of Increased Life Expectancy†			$1.5 trillion
VOI of $1 Based on Life Expectancy Gain			**$2.4**
Annual Value of Increased Life Expectancy‡			$1.4 trillion
VOI of $1 Based on Life Expectancy Gain			**$2.1**
Annual Number of People over Age 65 Years with a Disability	9,290,300	6,985,455	-2,304,845
Annual Number of Hospital Days	365 million	159 million	-206 million

** Costs and outcomes estimated for the 2000 population size (281,421,906) and age distribution (12.43% >65 years) but using rates from 1980*

*** Costs and outcomes estimated for the 2000 population size and age distribution using rates from 2000*

****Value of an avoided death is assumed to be $4 million*

*****Computed as the weighted average gain in life expectancy across all age groups using the age distribution for the 2000 U.S. population*

†Assuming a net present value of a 1-year gain in life expectancy of approximately $100,000, which is equivalent to a $2,455 annual consumption value per person per 1-year gain in life expectancy and is computed assuming a 0% discount rate (using a method similar to that used in Nordhaus 2002)

‡Assuming a net present value of a 1-year gain in discounted life expectancy of approximately $173,000, which is equivalent to a $7,509 annual consumption value per person per 1-year gain in life expectancy and is computed assuming a 3% discount rate (using a method similar to that used in Nordhaus 2002)

Value of Investment (VOI) Analysis: 1980 to 2000

Table 16 presents the value of investment analysis based on the health care cost and mortality and morbidity changes estimated for the time period 1980 to 2000.

In this chart the observed costs and health outcomes for the 2000 U.S. population are compared with costs and health outcomes that would have been observed for the 2000 U.S. population if the age-adjusted per person expenditure rates, age-adjusted death rates, and disability and hospitalization rates had remained at the 1980 levels. The application of the age-adjusted 1980 rates to the 2000 population allows us to adjust for these differences.

The differences in annual costs, deaths, number of people with disability, and the number of hospital days are assumed to represent the incremental costs and health gains were experienced in 2000, attributable to changes in health care interventions since 1980.

In order to compute the VOI, the health gains are monetized using dollar values that have been derived from the published literature (e.g., Blomquist 2001, Nordhaus 2002). The values used in our calculation are $4 million per death avoided, $100,000 per year of life expectancy gained, and $173,000 per discounted year of life expectancy gained. The sources for these estimates are described in Appendix B.

The VOI is calculated as the value of the gains in health for every additional $1 invested in health care. The estimated VOI is between $2.40 and $3.00. This VOI is only based on the dollar value of avoided mortality or increased life expectancy. It does not include estimates of the value of increased productivity or improved quality of life and, thus, is likely to underestimate the value of health care interventions.

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Appendix B

Literature Overview on Value of Life and Value of Investment in Health

The primary purpose of this appendix is to examine literature that addresses the question, "Is health care a good investment?"

The reviewed articles illustrate how an investment in health care has a return that can be measured monetarily, and show that when this is done the return is greater than the investment. The first step using this approach is to place a value on a life. The value of a statistical life (VSL) is an inference made by evaluating individuals' preferences (expressed in monetary units) to avoid risk or improve their situation. The second step is to use the VSL to estimate the monetary value of improved health care and compare this with increased health care spending. Finally, we include a brief discussion of the compression of morbidity and its value to the U.S. population.

Methodology

The value of life literature was identified using PubMed. A key source was a paper by Kip Viscusi. Another key source was a recent paper by Richard Hirth and colleagues.

The primary paper used to describe previous work on health care as an investment was identified by the AHA and is "The Health of Nations: The Contribution of Improved Health to Living Standards" by William Nordhaus (2002). This seminal report was sponsored by the Lasker Foundation and provided estimates of the returns gained from investing in health care. Within this article several key articles by Murphy and Topel and Lichtenberg were cited. Searches were done on PubMed on these authors to locate peer-reviewed articles that estimated the value of health care. Lichtenberg, in particular, published numerous articles about the value of pharmaceuticals and return on investment in them.

The articles by Lichtenberg, Cutler, and Nordhaus were originally published and distributed by the National Bureau of Economic Research at www.NBER.org. This site was therefore searched for additional articles published by the authors listed above as well as searched on the general topic of returns on health care investment. The search of the NBER publications provided an article by another author, Bloom, on a longitudinal study of the returns on health care investments using international data.

Finally, PubMed was searched, to find publications by Fries and others on the compression of morbidity and its implications for health care costs in the aging population.

Overview of Results

The first part of the summary examines the literature on the value of life. This literature derives estimates of the value of a statistical (unidentified) life (VSL) by estimating a person's willingness to pay (or willingness to accept compensation) for a reduction (or increase) in the risk of a fatal event. There are numerous ways to evaluate the VSL. The most commonly used method is using estimates from market choices that involve implicit tradeoffs between risk of a fatal event and money (Viscusi 2003). These estimates are based on either willingness to pay to reduce risk of fatal events (e.g., better car safety), willingness to accept payment to compensate for an increased risk of a fatal event (e.g., higher wages for risky jobs) (Hirth et al. 2000). A human capital approach (estimating the value of lost earnings and leisure time) has also been used to estimate the value of avoiding premature death (Hirth et al. 2000). In addition to the work by Kip Viscusi and Hirth et al., the estimates by Nordhaus (2002), Murphy and Topel (1999), and from the International Encyclopedia of the Social and Behavioral Sciences are presented (Blomquist 2001). The first part of the summary concludes with comments on the need for the value of life to change with inflation and other factors over time (Ubel 2003).

The second part of the summary provides an overview of several key articles that address the primary question, "Why is health care a good investment?" Each of the relevant articles is broken down into the relevant components of methods, results and conclusion. The first three by Nordhaus (2002), Murphy and Topel (1999), and Bloom et al. (2001), respectively, examine the overall value of increased longevity and its value to the economy. Lichtenberg (2001) examines the value that new pharmaceuticals add to the economy, and specifically, how they can help decrease overall medical expenditures. An article by Cutler (2001) illustrates the gains from technological advancement in selected health conditions – heart attacks, low birth-weight babies, depression, cataracts and breast cancer.

One important limitation to note is that the changes discussed in this section are based on increases in longevity and its effect on the value of health. The impact and added value of morbidity and associated quality of life improvements are not included. Several of the authors mention the omission and the difficulty of quantifying these particular gains. This omission results in underestimates of the value of health care interventions.

The third part of the summary looks at the compression of morbidity originally suggested by James Fries in 1980. The ideas encompassed by compression of morbidity offer some hope of reduction of medical expenditures, especially in the older component of the population. A reduction in end-of-life medical expenditures at older ages is supported by a recent article Yang et al. (2003). Another recently published article examines the effects of life expectancy increases on the cost of Medicare and concludes that increased life expectancy over age 65 may not translate into an increase in Medicare expenditures (Lubitz et al. 2003).

Part 1 – Value of a Stastical Life (VSL) and of a Life Year

"Estimates from risk-compensating wage differences, consumption activity which affects risk, and hypothetical markets yield values of life which are typically in a range between $1 million to $9 million" (Blomquist 2001).

Background

The Value of a Statistical Life (VSL) is an important component in public policy decision-making. The VSL has frequently been used in governmental decision making processes. Recently, the Environmental Protection Agency (EPA) formalized its use in setting limits to harmful materials, i.e., air pollution and Superfund cleanups. Many other governmental agencies also use the concept of a VSL in their cost benefit analyses of all types. For example, the Food and Drug Administration Center for Food Safety and Applied Nutrition has used the VSL as the basis for its estimates of the benefits of food safety regulations for the past 10 years.

Methods

The VSL estimates have been obtained from three main study types:

- Estimates of willingness to pay for reduced risks of fatal events from observed willingness to pay for safer cars, safer cigarettes, houses in less-polluted areas, and smoke detectors, for example;
- Estimates of willingness to accept compensation for increased risks of fatal events from observed willingness to accept higher wages for risky jobs; and
- Estimates of the human capital value of lost earnings and leisure time associated with premature mortality.

Results

Several authors have presented values of a statistical life (VSL) based on estimates of willingness to pay or willingness to accept payment for changes in risk of death (Table 1).

Table 1 ■ Literature Review of Values of a Statistical Life

Author (Year)	Value of a life	Notes
Nordhaus (2002)	$3 million (1990)	
Murphy/Topel (2001)	$5 million	
Viscusi (2003)	$7 million (2000)	Median from labor based estimates
	$3 million (1996)	Federal Aviation Administration (FAA)
	$5.5 million (1996)	Food and Drug Administration (FDA)
	$6.3 million (1999)	EPA
Blomquist (2001)	$1 million to $9 million	
Hirth et al. (2000)		
Human capital	$460,000 to $2 million	
Willingness to pay	$680,000 to $26 million	
Willingness to accept	$920,000 to $19 million	

Most studies to estimate the VSL have been conducted using data from people aged between 30 to 40 years. There is no consensus on whether or how the value of life varies by age. A recent survey by Krupnick et al. (2002) found that willingness to pay for reductions in mortality risks remained constant with age up to age 70 and was about 30% lower for those over age 70. Murphy and Topel (1999) assumed a VSL starting at $5 million at birth, rising to over $6 million at age 30 and then declining with age after that to $1 million at age 75. In our study, we have used a VSL of $4 million, in the middle of Blomquist's range, and have applied it uniformly to all the deaths avoided in 2000 compared to earlier time periods without regard to the age of death.

Starting from the value of a statistical life, attempts have been made to evaluate the value of a life year, or a quality adjusted life year (QALY), by dividing the VSL by the discounted or undiscounted remaining life expectancy for the surveyed population. Mauskopf et al. (1991) estimated a value for a life year of $222,000 based on $5 million per VSL. Utilizing the results of a MedLine search, Hirth et al. (2000) estimated the value of a QALY using VSL estimates from 3 different sources: human capital approach, willingness to pay, and job risk studies. They estimated values for a QALY that ranged from $24,777 to $428,286 (Table 2).

The value of a life year or a QALY and the annual consumption value of a one-year gain in life expectancy is computed from the value of a statistical life as follows (Mauskopf 1991, Hirth et al. 2000, Nordhaus 2002) using the $4 million VSL used in our study:

- VSL = $4,000,000
- Age at which VSL is estimated = 39 years
- Remaining life expectancy at 39 years = 40.4 (undiscounted using the 2000 U.S. lifetable)
- Remaining life expectancy at 39 years = 23.1 (discounted at 3% using the 2000 U.S. lifetable)
- Net present value of a life year = $4,000,000/40.4 = $99,092 (undiscounted)
- Net present value of a life year = $4,000,000/23.1 = $173,300 (discounted at 3%)
- Annual consumption (annuity) value of 1 life year = $99,092/40.4 ≈ $2,455 (undiscounted)
- Annual consumption (annuity) value of 1 life-year = $173,300/23.1 ≈ $7,509 (discounted at 3%)

The annual consumption (annuity) value is defined as the amount in additional consumption each year (measured in $s) for the person's remaining lifetime that gives a net present value equal to the value of 1 life-year (Nordhaus 2002).

Regardless of the number that is chosen for the VSL or QALY, it is important to note that the number is just a guide that should change over time. The values for a QALY that were established over 20 years ago are often cited as $50,000 to $100,000 (Ubel 2003). Ubel suggests that the value of a QALY in 2003 is greater than $50,000 to $100,000 partly because of inflation over the past 20 years. Ubel also identifies other factors that might contribute to increases in the value of a QALY including stronger preferences for better health associated with rising incomes.

Conclusion

Estimates of the value of a statistical life have ranged from $1 million to $9 million based on the type and year of the study (Blomquist 2001). The value of investment analysis in the report uses $4 million for VSL, an estimate towards the mid-point of this range. Based on this VSL, a value of $100,000 was used as the net present value of a life year gained and $2,455 as the annual consumption value of an increase of 1 year in undiscounted life expectancy.

Table 2

Type of study	Average value of QALY
Human capital	$24,777
Willingness to Pay	$265,345
Job risk	$428,286

Source: Hirth et al (2000)

Part 2 – Is Health Care a Good Investment?

Five articles were reviewed that discuss the benefits of investing in health care.

Nordhaus (2002)

"Over the last half century, economic welfare from health care expenditures appear to have contributed as much to economic welfare as the rest of consumption expenditures."

Methods

Nordhaus defines two methods that can be used to measure the value of an economy:

- Production basis – currently, the most widely used measure to provide an overall picture of the value of the economy. This traditional form of income accounting examines the flow of consumption and income when measuring living standards; it takes into account items such as purchases of food and durable goods such as automobiles.
- Utility basis – this form of income accounting measures the amount of utility that the population gets from its current level of consumption. It allows for the enumeration of the increased value of additional longevity and better health as well as the value from consumption of the traditional market outputs and allows the consumer to trade-off between additional longevity and consumption of goods.

Nordhaus uses a utility basis to evaluate how improvements in health have affected the value of the U.S. economy. He uses the utility basis because it accounts for the benefits of improved health in raising the standard of living because of the preferences that individuals have towards living longer and living healthier.

The data used to model the value of health in the economy are per person consumption from the U.S. Commerce Department and changes in mortality or life expectancy. The basis of the valuation of life used by Nordhaus is $3.0 million in 1990 U.S. $ for each fatality prevented (Table 3).

Table 3 ■ Valuation of Life and Constant Consumption Per Person per Life Year

Valuation	Amount (1990 dollars)
Life	$3,000,000
Constant Consumption Value per person per Life Year (0% discount)	$2,600
Constant Consumption Value per person per Life Year (3% discount)	$7,600

Source: Nordhaus 2002

Table 4 ■ Annual Percentage Increases in Per Person Consumption

	1900–1925	1925–50	1950–75	1975–95
Non-Health Consumption	2%	1.80%	2.40%	2%
Health Value				
Life-years (3% Discount Rate)	2.30%	3.20%	1.80%	1.60%
Mortality (Age-adjusted)	3.20%	4%	2.60%	2%

Source: Nordhaus 2002

Results

Table 4 shows annual percentage increases in the per person values of non-health consumption and in the value of per person improvements in longevity (measured either as additional life-years or reduction in annual deaths).

An example of Nordhaus's calculation on return on investment is as follows.

- From 1980 to 1990, life expectancy increased. This increase in life expectancy was equivalent to a 1.7% or $2,292 annual increase in per person consumption.
- An alternative measure of benefits was that, from 1980 to 1990, the number of deaths declined. This decrease in mortality was equivalent to an increase in per person consumption of $3,120.
- Over the same time period annual health expenditures increased on average $1,213 per person.
- Compared to the per person annual value of the increase in life expectancy of $2,292 or the per person mortality decrease of $3,120, the return on expenditures for health is either $1.89 or $2.57 for every additional $1 spent on health care.

Nordhaus points out that this is likely to be an underestimate of the returns on investment in health since it does not take into account the portion of the increased health expenditure that went into quality of life health improvements that were not life-increasing.

Conclusion

The returns to investment in health care are positive and sizable.

Murphy/Topel (1999)

"The historical gains from increased longevity have been enormous, on the order of about $2.8 trillion annually from 1970 to 1990."

Methods

In order to assess the gains from medical research, Murphy and Topel divide the relevant period of 1970 to 1998 into 3 parts: 1970-1980, 1980-1990 and 1990-1998. Using U.S. data they estimate the economic value of improved health and increased longevity for overall and disease-specific mortality rates. Their estimate of $5 million as the value of life is based on employment-related risk studies, at the age of 20 years. Calibrations to this value are made to allow for a variety of assumptions such as differences in age and gender. Tables are developed that illustrate the economic value of remaining life at different ages; the years from 20 to 65 are assumed to have the same value but after 65 the value of a life year declines by 5% annually. The value is also assumed to vary by gender, with the value of an additional year to a 55 to 64 year old man assumed to be $132,838, and for a woman of the same age the value is assumed to be $105,988 from 1970 to 1980.

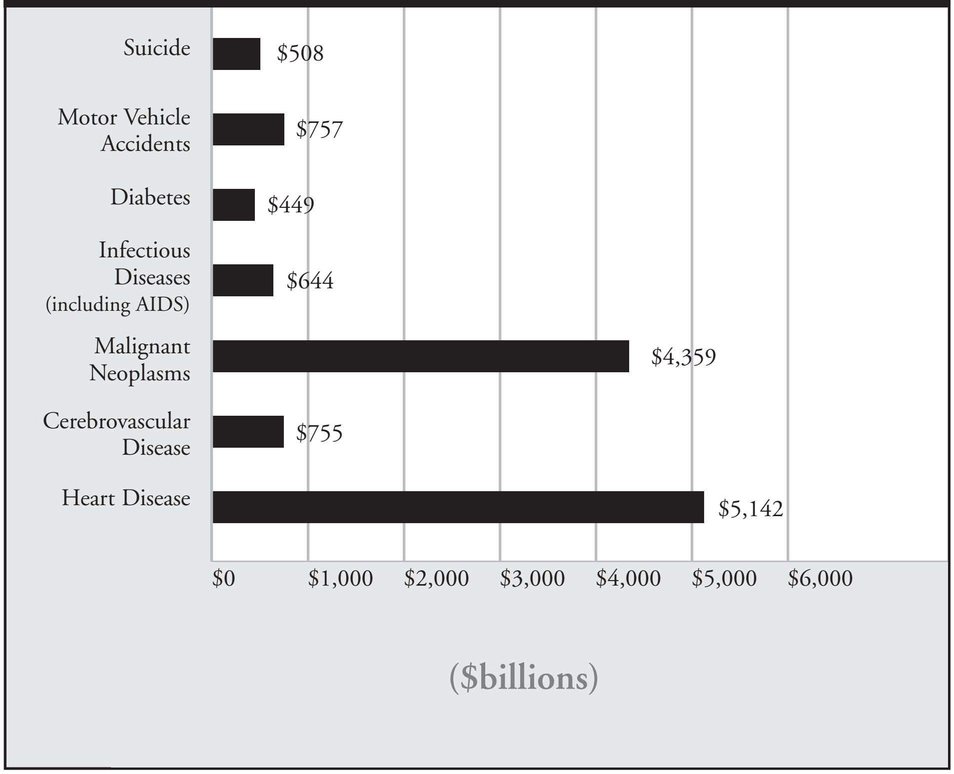
Results

When the overall life expectancy increases are aggregated for the U.S. population from 1970 to 1990 the value of gains in life is $2.8 trillion annually (Figure 1). The gains from the reduction in heart disease mortality are worth $1.5 trillion annually, during the same time period. The magnitude of this number is attributed to three factors: first, the $5 million valuation of life; second, the large reduction in mortality from 1970 to 1990; and finally, the large size of the American population.

Conclusion

Investment in medical research and subsequent improvements in health care have very large returns.

Figure 1 ■ **Prospective Gains from a 10% Reduction in Death Rates by Major Cause of Death**



Source: Murphy/Topel (1999)

Bloom et al. (2001)

"...a one year improvement in a population's life expectancy contributes to a 4 percent increase in output."

Methods

Bloom et al. (2001) used aggregate measures of health and work experience from international panel data from 1960 to 1990 in a production function. They constructed a model to show the effects that health has on aggregate output. The inputs include physical capital, labor, human capital, and life expectancy.

Data were extracted from a variety of sources: from the Penn World Tables, 1) multiplying the real per person GDP in international purchasing power parity dollars times the national population, and 2) obtaining measurements of capital stock measure output. The International Labour Office provided labor force participation rates, and the United Nations was the source for the life expectancy data.

Results

The primary result they find is that life expectancy has a positive, sizable and statistically significant effect on aggregate output. The report finds that "...a one year improvement in a population's life expectancy contributes to a 4 percent increase in output" (5). This large effect indicates that additional expenditures on health may be justified by the productivity (GDP) gains. Furthermore, they speculate that improved health also aids in the accumulation of human capital that also positively affects future growth.

Conclusion

Improvements in health contribute to economic growth, both directly and indirectly.

Lichtenberg (2001)

"The use of newer drugs tends to lower all types of nondrug medical spending, resulting in a substantial net reduction in the total cost of treating a given condition."

Methods

Lichtenberg (2001) assessed the 1996 Medical Expenditure Panel Survey. They used the data to analyze the effects of the age of the prescribed drug on total health care spending.

Results

Lichtenberg (2001) found immediate health care expenditure savings for people using newer drugs. They showed for nondrug medical spending that the use of a newer drug, which costs approximately $18 more per year per person, saves $71.09 per year in other health care costs.

Conclusion

Use of newer drugs may result in reduced overall health care expenditures.

Cutler (2001)

"We conclude that medical spending as a whole is worth the increased cost of care."

The authors reviewed studies of five conditions, heart attacks, low-birth weight infants, depression, cataracts and breast cancer that evaluated the costs and benefits of improved technology.

Results

Cutler and McClellan identified two primary modes of improved technology, treatment substitution and treatment expansion. In the first, new technology is implemented as a replacement for older, less effective treatments. An example of this is the improvements that allow cataract surgery to be performed on an outpatient basis, while previously it required 3 nights of inpatient care, and with much improved visual acuity. Treatment expansion is when more people are treated with new technology. For example, since the operation for cataracts is so much less traumatic and easier to perform, more individuals are having cataract surgery.

The authors suggest two possible benefits of improved medical technology. First is the benefit of better health, measured as longer lives and better quality of life. Second, they estimate the benefit that is gained by the effect on financial situations of others. The primary mechanism of this effect is through the increased productivity and ability to work that is associated with better health. Table 5 summarizes their results for the five conditions.

Table 5 ■ Net Benefits of Five Health Conditions

Condition	Years evaluated	Change in treatment costs	Change in outcome	Value of outcome *	Net benefit
Heart attack	1984–98	$10,000	One year increase in life expectancy	$70,000 [a]	$60,000
Low birth-weight infants	1950–90	$40,000	Twelve year increase in life expectancy	$240,000 [b]	$200,000
Depression	1991–96	$0 or <$0	Higher probability of remission and more people treated	$6,000 [c] + productivity gains	> $6,000
Cataracts	1969–98	$0 or <$0	Increase in quality at no cost increase and more people treated	$95,000 [d]	> $95,000
Breast cancer	1985–96	$20,000	Four month increase in life expectancy	$20,000 [a]	$0

Source: Cutler (2001)

* *Outcomes discounted at 3%; assuming a value for a QALY of $100,000*

a *Assuming no productivity benefits for the elderly; assuming $25,000 annual living costs for the elderly*

b *Assuming lifetime productivity and living costs are equal*

c *Assuming 0.4 gain in quality of life for 8 months*

d *Assuming 0.2 gain in quality of life for remaining lifetime*

Cutler and McClellan also present a calculation for the net benefits of increased total lifetime expenditures on health between 1950 and 1990 as follows:

- Between 1950 and 1990, average lifetime health expenditures increased by $35,000;
- Between 1950 and 1990, average life expectancy increased by 7 years;
- Present value of the increase in longevity, assuming a value of $100,000 per year, at a 3% discount rate is $130,000; and
- Net benefits are $95,000.

Cutler and McClellan conclude that, if health care spending accounts for more than 25% of the increase in longevity the net benefits are positive.

Conclusion

In all five conditions, heart attack, low birth-weight infants, depression, cataract, and breast cancer, the net benefit is positive. The improved technology may lead to higher costs but the benefits of the outcomes generally outweigh the costs. In addition, net benefits from increased health care expenditures between 1950 and 1990 are also positive.

Part 3 – Compression of Morbidity

"The amount of disability can decrease as morbidity is compressed into the shorter span between the increasing age at onset of disability and the fixed occurrence of death (Fries 1980)."

In 1980 a paper by James Fries was published in JAMA entitled "Aging, natural death and the compression of morbidity." The article examined how the survival curve of an average American has assumed a more rectangular form as the 20th century progressed. The average span of life increases as premature death is prevented, particularly as the rate of infant mortality and death from acute causes, accidents and infectious diseases, decline, creating a "rectangularization" of the survival curve. The author assumes that there is a finite limit to the human life based on biological limitations of cell reproduction, which impose a fixed natural life span. Death now occurs primarily from chronic conditions towards the end of one's natural life span. Improvements in health care that decrease disability until later within the natural life span create a phenomenon that Fries refers to as the compression of morbidity. This occurs as the period of disability that many experience is shortened, as one's physiology is pushed to its natural limit. Any medical improvements that eliminate or reduce disability that happens in conjunction with chronic disease and old age further compresses morbidity and improves an individual's quality of life.

The compression of morbidity is an important outcome of improved health care. The reduction of disability at the later stages of life could dramatically reduce the medical expenditures that are so prevalent in the population cohort that is more than 65 years old. The development of medical technology that minimizes disability will reduce costs and improve quality of life.

A recent paper entitled "Compression or expansion of morbidity? Trends in healthy-life expectancy in the elderly Austrian population between 1978 and 1998" (Doblhammer et al. 2001), puts Fries' paper to an objective test. What Doblhammer and Kytir find is that morbidity is decreasing in its span at the end of life and life spans continue to increase. They agree with the initial compression of morbidity hypothesis but not the corollary that states life spans are finite by nature. Instead they see increased life expectancy and a decrease in disability.

A paper by Manton et al. (1991) also supports the compression of morbidity hypothesis using data from U.S. national surveys by showing a reduction in disability rates in those over age 65 years over the last two decades, despite an increase in the number of people aged over 85 years within the elderly population.

A paper by Yang, Norton and Stearns (2003) examines longevity and its effects on health care expenditures. The conclusion that they reach is that health care expenditures increase as people get older mostly because mortality increases and health care expenditures increase as one approaches death. However, the older one is upon approaching death, the lower the expenditures in the final 3 months of life, indicating that health care costs may increase less than expected as the population ages. This is summarized in Table 6.

Lubitz et al. (2003) show that increased longevity does not change the overall lifetime health care expenditure. Through utilization of the Medicare Current Beneficiary Survey they evaluated the relationships found between longevity, disability and costs in the population over the age of 70 years. They found that people who reach the age of 70 with no functional disabilities live longer but do not have higher lifetime health care expenditures than those individuals that have disabilities at the age of 70 years and die sooner.

Conclusion

There is increasing evidence that morbidity is being postponed to later ages and that lifetime health care costs may not increase as much as has been feared as the population ages.

Table 6 ■ Relationship between Health Care Expenditures and Death

Months to Death	Age Group	Mean Monthly Expenditure
1 Month	65–74	$7,580
	75–84	$6,674
	85 and older	$5,254
2 Months	65–74	$6,390
	75–84	$5,854
	85 and older	$5,038
3 Months	65–74	$4,103
	75–84	$3,626
	85 and older	$3,582

Source: Yang, Norton and Stearns (2003)

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Appendix C

Background

Inflation-adjusted Medicare expenditures are increasing, raising the question of whether the increased cost yields commensurate benefits. This component of the study compared changes in inflation-adjusted Medicare expenditures to changes in benefits from improved survival and health, 1985-2000, focusing on treatment of acute myocardial infarction (AMI), stroke, diabetes, and breast cancer.

Methods

Observational data from the 1984, 1989, 1994, and 1999 National Long-Term Care Surveys were linked to Medicare claims. Outcome measures were five-year survival, limitations in activities of daily living (ADLs), cognitive functioning, nursing home residence, and dollar value ($2000) of five-year benefits, compared to five-year Medicare payments behalf of beneficiaries plus prescription drug and nursing home costs.

Results

Summary results appear in the Final Report. Full manuscript with detailed results has been submitted to a peer-reviewed journal and cannot be provided at this time.

Appendix D

Methods for Determining Value of Investment In Health Care for Four Conditions

The purpose of this appendix is to present the methods and results of a broad literature review that was undertaken to determine the value of investment in health care between 1970 and 2000 for the four health conditions of interest: heart attack, type 2 diabetes, stroke, and breast cancer.

Methods

Literature Search

MEDTAP conducted an exhaustive literature search to identify any study published since 1975 that included an evaluation of the cost-effectiveness or cost-utility of treatments for one of the four conditions of interest. The search was conducted using PubMed, a worldwide biomedical database of over 11 million bibliographic citations, abstracts and some full text articles from 4,600 biomedical journals, with coverage extending back to the mid-1960s.

The search terms included the four conditions of interest (using all relevant terms – for example breast cancer also searched as "breast neoplasms") as well as the following economic terms:

- Costs and cost analysis
- Pharmaceutical economics
- Cost-benefit analysis
- Health care costs

Identification of Relevant Articles

Once the literature search and article retrieval tasks were completed, MEDTAP reviewed the reference lists of all of the collected articles to identify any additional articles with possible relevance. These articles were also retrieved for the study.

Next, each retrieved article was reviewed to determine if it met all of the following criteria that were required for inclusion in the MEDTAP analysis:

1) included at least one treatment alternative that was listed as one of the key treatment innovations between 1970 and 2000 for the condition of interest;
2) utilized cost-effectiveness or cost-utility methodology[1] that would allow for an estimate of the value of health gains associated with investment in health care for the conditions under study;
   - Cost-effectiveness analysis (CEA) examines the incremental benefit of one treatment versus another (usually expressed in years of life gained, and usually a newer treatment versus an existing treatment) as well as the incremental costs of treatment. The incremental cost-effectiveness ratio is determined by dividing the incremental difference in costs between the two comparators by the incremental difference in the effectiveness measure (e.g., life years gained) [(Cost1-Cost2)/(Life years1-Life years2)]. The difference between a CEA and a cost-utility analysis (CUA) is that the effectiveness measure (life years) is translated into quality-adjusted life years (QALYs) [QALYs are discussed in Appendix B].
3) was based in the U.S. or incorporated U.S. treatment patterns and costs.

Determining Value of Investment

The following review steps were performed for each published study that met all of the inclusion criteria outlined above:

1) The treatment comparisons evaluated in the published CEA/CUA articles were identified (e.g., breast conserving surgery vs. mastectomy, statin therapy vs. no statin therapy).
2) The population receiving the treatment alternatives was identified (e.g., women ages 65 and older with breast cancer).

3) The incremental cost-effectiveness ratio (e.g., $30,000 per life year gained) or cost-utility ratio (e.g., $15,000 per QALY gained) estimated for each treatment comparison was identified, as well as the year in which costs were based (e.g., 1997 U.S. dollars).
4) The study was flagged if the authors had discounted both costs and outcome measures.

After the above information was catalogued for each published study, MEDTAP calculated the value of investment (VOI) based on the following approach:

1) All cost results were updated to Year 2000 U.S. $.
2) Based on the same theoretical framework described at the start of Appendix B, MEDTAP assigned a value of $100,000 for each life year or QALY gained when discounting was not applied in the study, and assigned a value of $173,000 for each life year or QALY gained when discounting was applied.
3) The value of health gains associated with the investment in the health care intervention under study (VOI) was calculated based on a "for every additional dollar spent, gain of X $" approach. An example calculation follows:

   Example: A published study reports that the incremental cost-effectiveness ratio for Treatment A relative to Treatment B is $45,000 per each life year gained. The study discounted both costs and outcomes, so the value assigned to the life year gained is $173,000.

   VOI = $173,000/$45,000 or "for every additional dollar spent, a gain of $3.84."

Results

The results of the VOI analysis **based on literature** are presented by disease, in the following tables.

Table 1 ■ Number of Studies Identified and Included in VOI Analysis

Disease	# of studies identified based on search terms	# of studies retrieved based on review of abstracts (and check of reference lists once articles retrieved)	# of studies included in VOI analysis
Heart attack	72	39	8
Type 2 diabetes	106	44	6
Stroke	93	34	4
Breast cancer	120	52	8

Table 2 ■ Heart Attack

Reference	Method	Comparators	Population	ICER†	VOI (in 2000 U.S. $)
Cretin (1977)[2]	Markov model	Mobile coronary care unit vs. usual care	Hypothetical cohort of heart attack patients	$4,310 per life year gained (1976 $)‡	For every additional dollar spent, gain of $10
Goldman et al. (1988)[3]	Pooled data from literature review	Routine therapy with beta-blockers vs. usual care	Patients who have survived a heart attack and begin therapy with beta-blockers	**Low-risk patients:** $13,000 per life year gained **Medium-risk:** $3,600 per life year gained **High-risk:** $2,400 per life year gained (1987 $)‡	**Low-risk patients:** For every additional dollar spent, gain of $6.49 **Medium-risk:** For every additional dollar spent, gain of $23.44 **High-risk:** For every additional dollar spent, gain of $35.16
Mark et al. (1995)[4]	Economic analysis based on trial data and epidemiologic data	t-PA vs. alternative drug therapy	Patients who have survived a heart attack and receive thrombolytic therapy	$32,678 per QALY gained (1993 $)‡	For every additional dollar spent, gain of $4.04
Kuntz et al. (1996)[5] See on Circulation journal web site	Markov model	Coronary angiography and treatment guided by its results vs. initial medical therapy without angiography	Patients with strongly positive exercise tolerance test or prior heart attack	$16,900 – $52,800 per QALY gained (1994 $)‡	For every additional dollar spent, gain of $2.62 – $8.19
Phillips et al. (2000)[6]	Markov model	Routine therapy with beta-blockers vs. usual care	Patients who have survived a heart attack and begin therapy with beta-blockers (except those with absolute contraindications)	$4,500 per QALY gained (2000 $)	For every additional dollar spent, gain of $38.44

† Incremental cost-effectivness ratios (ICER), or in many cases a cost-utility ratio such as QALYs, were estimated.

‡ Study discounted both costs and outcomes

Table 2 ■ Heart Attack Continued

Reference	Method	Comparators	Population	ICER†	VOI (in 2000 U.S. $)
Sanders et al. (2001)[7]	Markov model	Use of implantable cardiac defibrillator vs. amiodarone (preventative use)	Patients who have survived heart attack and do not have sustained ventricular arrhythmia	**Patients with ejection fraction ≤ 0.3**:** $71,700 – $73,700 per QALY gained **Patients with ejection fraction between 0.31 – 0.40**:** $128,100 – $517,100 per QALY gained **Patients with ejection fraction > 0.4**:** range of $206,400 per QALY gained to being dominated (i.e. resulted in higher costs and worse outcomes) (1999 $)‡	For every additional dollar spent, gain of $2.35 – $2.41 For every additional dollar spent, gain of $0.34 – $1.35
Cohen et al. (2001)[8]	Economic analysis alongside clinical trial	PTCA + stenting vs. PTCA alone	Patients presenting with a heart attack	$65,066 per QALY gained (assuming no difference in mortality after one year) (1998 $)	For every additional dollar spent, gain of $1.42
Tsevat et al. (2001)[9]	Markov model	Statin vs. usual care	Heart attack survivors with average cholesterol levels	$16,000 – $32,000 per QALY gained (1996 $)‡	For every additional dollar spent, gain of $4.72 – $9.44

Table 3 ■ Type 2 Diabetes

Reference	Method	Comparators	Population	ICER†	VOI (in 2000 U.S. $)
Javitt and Aiello (1996)[10]	Monte Carlo simulation model	Screening and treatment of diabetic retinopathy	All type 2 diabetics who use insulin for control	$2,933 per QALY gained* (1990 $)‡	For every additional dollar spent, gain of $36
Eastman et al. (1997)[11]	Incidence-based simulation model	Treating with goal of normoglycemia vs. standard care	Newly diagnosed, ages 19–75	$16,002 per QALY gained (1994 $)‡	For every additional dollar spent, gain of $8.65
Golan et al. (1999)[12]	Markov model	Treatment with ACE inhibitors vs. treatment with ACE inhibitors based on screening tests	Newly diagnosed patients, ages 50 or older	$7,500 per QALY gained (1998 $)‡	For every additional dollar spent, gain of $21.36
Elliott et al. (2000)[13]	Markov model	Intensified hypertension control vs. less stringent control	Cohort of patients with type 2 diabetes and high blood pressure, ages 60 or older	Savings of $1,450 per life year gained (1996 $)‡	Savings of $1,450 in treatment costs per life year gained, and life year valued at $173,000
Grover et al. (2001)[14]	Markov model	Statin therapy vs. no statin therapy	Patients with type 2 diabetes but without cardiovascular disease	$5,063 – $23,792 per life year gained (1998 $)‡	For every additional dollar spent, gain of $7 – $31
CDC (2002)[15]	Markov model	Different treatment interventions (intensive glycemic control, intensified hypertension control, reduction in serum cholesterol level) vs. standard care for each of those parameters	Newly diagnosed, ages 25 or older	**Intensive glycemic control:** $41,384 per QALY gained **Intensified hypertension control with ACE inhibitors or beta-blockers:** Savings of $1,959 per QALY gained **Reduction in serum cholesterol level with statin therapy:** $51,889 per QALY gained (1997 $)‡	For every additional dollar spent on intense blood glucose control, gain of $3.77 Savings of $1,959 in treatment costs per QALY gained, and QALY valued at $173,000, with intense blood pressure control For every additional dollar spent on lowering colesterol levels, gain of $3.00

† *Incremental cost-effectivness ratios (ICER), or in many cases a cost-utility ratio such as QALYs, were estimated.*

‡ *Study discounted both costs and outcomes*

* *Quality adjusted life year*

Table 4 ■ Stroke

Reference	Method	Comparators	Population	ICER†	VOI (in 2000 U.S. $)
Oster et al. (1994)[16]	Markov model	Ticlopidine vs. aspirin for the prevention of stroke	Patients (65 years of age at therapy initiation) who suffered a transient ischemic attack, reversible ischemic neurological deficit, amaurosis fugax, or minor stroke	$31,200 to $55,500 per QALY gained (1991 $)‡	For every additional dollar spent, gain of $2 to $4
Nussbaum et al. (1996)[17]	Markov model	Carotid endarterectomy vs. aspirin for the prevention of stroke	Patients receiving treatment for transient ischemic attacks	Savings of $3,628 per QALY gained (1995 $)‡	Savings of $3,628 in treatment costs per QALY gained, and QALY valued at $173,000
Fagan et al. (1998)[18]	Markov model	rt-PA vs. no therapy in the first three hours following stroke	Patients age 67 at time of initial stroke	Savings of $9 per QALY gained (1996 $)‡	Savings of $9 in treatment costs per QALY gained, and QALY valued at $173,000
Sarasin et al. (2000)[19]	Markov model	Clopidogrel vs. aspirin for secondary prevention of stroke	High-risk stroke patients 65 years or older	$26,580 per QALY gained (1999 $)‡	For every additional dollar spent, gain of $6

† *Incremental cost-effectivness ratios (ICER), or in many cases a cost-utility ratio such as QALYs, were estimated.*

‡ *Study discounted both costs and outcomes*

* *Quality adjusted life year*

Table 5 ■ Breast Cancer

Reference	Method	Comparators	Population	ICER†	VOI (in 2000 U.S. $)
Hillner and Smith (1992)[20]	Markov model	Tamoxifen plus adjuvant chemotherapy vs. tamoxifen alone	Post-menopausal node-positive women	$58,000 per QALY gained* (1990 $)‡	For every additional dollar spent, gain of $1.86
Hillner et al. (1992)[21]	Markov model	ABMT** following induction chemotherapy vs. standard chemotherapy	Women with metastatic disease	$115,800 per life year gained (using 5-year time horizon); using QALYs, was $96,600; $28,600 per life year gained (assuming patients free of disease at 5 years to have normal survival); (no QALYs reported) (1990 $)‡	For every additional dollar spent, gain of $1.12 For every additional dollar spent, gain of $3.78
Smith and Hillner (1993)[22]	Markov model	Adjuvant chemotherapy vs. no chemotherapy, following primary surgery	Pre-menopausal women	$14,800 – $33,100 per life year gained (1990 $)‡	For every additional dollar spent, gain of $3.27 – $7.31
Desch et al. (1993)[24]	Markov model	Adjuvant chemotherapy vs. no chemotherapy, following primary surgery	Estrogen-receptor negative, elderly (ages 60–80) women with stage 1 breast cancer	$44,400 per QALY gained (1990 $)‡	For every additional dollar spent, gain of $2.44
Lindfors and Rosenquist (1994)[24]	Markov model	Mammography screening with stereotactic core needle biopsy vs. observation only and surgical biopsy	Women in two hypothetical cohorts: one undergoing annual screening, the other no screening	$15,934 – $20,770 per life year gained (1994 $)	For every additional dollar spent, gain of $3.70 – $4.83

† Incremental cost-effectivness ratios (ICER), or in many cases a cost-utility ratio such as QALYs, were estimated.

‡ Study discounted both costs and outcomes

** Quality adjusted life year*

*** Autologous bone marrow transplant*

Table 5 ■ Breast Cancer Continued

Reference	Method	Comparators	Population	ICER†	VOI (in 2000 U.S. $)
Lindfors and Rosenquist (1995)[25]	Markov model	Various mammographic screening strategies vs. limited screening	Women in various age groups	**Biennial mammography for ages 50–59**: $16,000 per life year gained **The above strategy plus annual mammography for ages 40–49:** $20,200 per life year gained (1994 $)	For every additional dollar spent, gain of $5.30 For every additional dollar spent, gain of $4.20
Hayman et al. (1998)[26]	Markov model	Routine radiation therapy following conservative surgery vs. surgery alone	Women with early-stage breast cancer	$28,000 per QALY gained (1995 $)‡	For every additional dollar spent, gain of $5.24
Karnon and Jones (2003)[27]	Markov model	Letrozole vs. current standard of care as first-line hormonal therapy	Post-menopausal women with advanced breast cancer	UK analysis: £2,927 - £3,969 per QALY (approx. $4,700 - $6,400 per QALY gained) (2000 $)‡	For every additional dollar spent, gain of $27.03 - $36.81

† *Incremental cost-effectiveness ratio, or in many cases a cost-utility ratio as QALYs were estimated*

‡ *Study discounted both costs and outcomes*

* *Quality adjusted life year*

** *Range due to the fact that model included a range of assumed levels of efficacy for the two comparator interventions*

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