2.
The Cost-Effectiveness Analysis: Data, Methods, and Results

2.
The Cost= Effectiveness Analysis; Data, Methods, and Results

INFLUENZA

Clinical Description

Influenza is an acute infectious disease caused by influenza viruses. A case of influenza usually begins abruptly with fever and usually includes frequently recurring short chills; headache; malaise; pain behind the eye; a hacking, irritating cough; and severe muscle aches and pains (75). The manifestations of influenza can vary widely. In up to 25 percent of influenza infections, there is no clinical evidence of illness. However, in some cases, the disease can rapidly progress to overwhelming pneumonia and may cause death within hours to days.

Other potential complications of influenza include middle ear infections (94), acute encephalopathy (inflammation of the brain) (22), Reye's Syndrome (a rare, potentially life-threatening syndrome occurring in children) (61), renal failure (32), and rejection of kidney transplants (58). Further, influenza can lead to a deterioration of an existing disease (e. g., heart disease) that can be fatal.

The extent to which influenza leads to such complications is not known. In general, however, those individuals with certain types of chronic illnesses (e. g., lung, heart, or kidney disorders) and those with selected major illnesses (e.g., certain cancers) appear to be at greatest risk of incurring severe medical complications including death as a result of influenza.

Diagnosis and Treatment

A case of influenza is often diagnosed on the basis of clinical and epidemiologic information and the laboratory-confirmed absence of bacterial infections. When presented with a case of upper respiratory tract infection (URI), physicians may order laboratory tests (e. g., a throat culture) to help rule out bacterial causes. When bacterial causes are ruled out, on the basis of a patient's medical history, physical examination, or laboratory findings, viruses are generally assumed to be the cause of infection. During an influenza epidemic, validated by surveillance data reported by the Centers for Disease Control (CDC) or local public health laboratories, a case of viral URI is likely to be diagnosed as influenza. Outside of an epidemic period, e.g., during summer months, a viral URI is usually not attributable to influenza, although such infections are often referred to as "the flu. "

Influenza is treated largely through supportive measures. Clinical relief is obtained by resting in bed, drinking lots of liquids, and taking drugs that relieve symptoms of the disease (e.g., pain relievers, fever reducers, and decongestants). Unless a case of influenza leads to a secondary bacterial infection, antibiotics have no role in treatment of influenza. However, evidence demonstrates that the drug amantadine can help prevent certain types of influenza, help reduce the severity of a case of influenza, as well as serve as effective treatment for influenza in some cases (82).

Influenza Morbidity and Mortality

CDC has recently estimated that influenza contributed to approximately 127,000 excess deaths during the period from 1970-71 through 1977-78 (see app. E).

INFLUENZA VACCINE

The preferred method of reducing the incidence, morbidity, and mortality of influenza is by preventing the disease through vaccination. Various forms of inactivated (killed) influenza virus vaccines have been used for this purpose in the United States since the 1940's. Many factors affect the impact of such vaccines on influenza, including:

- vaccinees' prior exposures to influenza viruses and their antibody response to such exposures;
- the efficacy and duration of immunity acquired from vaccination;
- the percentage of individuals (especially those at high risk) vaccinated (see table 1, table 2); and
- the degree to which the virus(es) in the vaccine matches the virus(es) causing disease.

The influenza viruses present a peculiar problem for those who formulate, develop, produce, and distribute influenza vaccine. The extent to which these viruses circulate varies from year to year, and the composition of antigens (chemicals) on the virus surface changes with irregular frequency to unpredictable new forms (27).

Within the 6 to 9 months needed to manufacture influenza vaccine, influenza viruses can change their surface chemicals faster than vaccine manufacturers can change their product's formulations. As a result, in some years, the producers and promoters of influenza vaccinations have distributed vaccines that contained viruses that did not exactly match the circulating influenza viruses (see app. C). However, small changes in the circulating viruses do not appear to have substantially altered the efficacy of the vaccine (see app. B).

The safety of influenza vaccine became a major issue during the 1976-77 swine flu vaccination program (see app. D). Approximately 500 recipients of swine flu vaccine developed a disorder characterized by paralysis called Guillain-Barre Syndrome (GBS) (112). Although there is a strong correlation between GBS and the swine flu vaccine, such a relationship has not been documented between the use of other influenza vaccines and GBS in subsequent years, notwithstanding relatively intense surveillance of GBS cases by CDC (66). GBS might have been an adverse reaction peculiar to swine flu vaccine. Aside from GBS, influenza vaccines produce mild to moderate local reactions (e. g., pain, swelling, and redness at the injection site) as well as systemic reactions (e. g., fever and malaise) and rare allergic reactions (see app. B).

Table I.–Size of the General and High-Risk Populations Vaccinated With influenza Vaccine, 1970-71 Through 1977-78 (by age group)

Year	Size of general population (in thousands)				Size of high-risk population
	1-19 years	20-64 years	≥ 65 years	Total	≥ 20 years
1970-71	5,319	10,374	3,399	19,092	NA
1971 -72....	4,951	9,320	3,300	17,571	NA
1972.73	4,050	8,608	3,210	15,868	3,316
7973-74	4,511	8,975	3,628	17,114	3,964
1974 -75....	3,469	10,616	4,601	18,686	5,003
1975-76	3,426	9,055	4,621	17,102	4,764
1976.77	4,678	30,120	8,436	43,234	10,151
1977 -78....	3,872	11,170	5,381	20,423	5,975
Total	34,276	98,238	36,576	169,090	33,173
Average (excluding 1976-77). .,	4,228	9,731	4,020	17,979	4,604

NA = not available.

SOURCE: US. */mmunization* Survey, 1970-78 (124).

Table 2.—Percentage of the General and High.Risk Populations Vaccinated With influenza Vaccine, 1970.71 Through 1977-78 (by age group)

Year	Percent of general population				Percent of high-risk population
	1-19 years	20-64 years	≥ 65 years	Total	≥ 20 years
1970-71	6.6%	9.80/0	17.5%	9.60/0	NA
1971-72	6.8	8.6	16.5	8.7	NA
1972-73	5.6	7.8	15.8	7.8	16.40/,
1973-74	6.3	8.0	17.4	8.4	17.7
1974-75	4.9	9.3	21.5		21.0
1975-76	4.9	7.8	21.1	8.2	19.6
1976-77	6.8	25.5	37.7	20.9	36.4
1977-78	5.7	9.3	23.5	9.7	20.8
Average/year (weighted)	6.0%	10.9°/0	21.6%	10.3%	22.50/o
Average/year (excluding 1976-77)	6.09%	9.00/0	19.1 0/0	9.0 "/0	19.3%

NA = not available.

SOURCE: U.S. ***Immunization*** Survey, 1970-78 (124)

INFLUENZA VACCINATION STRATEGIES

There are three basic strategies used to prevent influenza through vaccination. Each strategy—medical risk, socioeconomic risk, school children—is distinguished by the target population intended to be vaccinated.

Medical Risk Strategy

People with certain demographic characteristics and medical conditions are at the greatest risk of being seriously affected (either dying or becoming severely ill) by influenza during an epidemic. People over 45 years of age, for example, tend to be at greater risk of dying from influenza than do those under 45. Other so-called risk factors include selected chronic diseases (e.g., selected ailments of the heart, lungs, and kidney) and possibly certain types of cancer (l).

The premise of the medical risk strategy is that those persons most vulnerable to influenza mortality and severe morbidity should be protected through vaccination. This strategy is employed in the United States (56,57) and has been used in the United Kingdom (116).

Socioeconomic Risk Strategy

This strategy is designed to prevent influenza among those persons who are deemed to be essential to either the social or economic life of a country or community. This strategy targets in general the working population, and in particular, persons in selected occupations such as health professionals, armed forces personnel, and certain public servants (e. g., police, firemen, and postal workers). In the United States, this strategy has been combined to a minor extent with the medical risk strategy.

School Children Strategy

This strategy is designed to vaccinate school children as the primary method of preventing influenza epidemics. It is based on the premise that school-age children comprise a large, susceptible segment of the population and regularly have a high influenza-attack rate (52,74). School children also appear to be responsible for bringing influenza into the home, and therefore are important disseminators of influenza viruses (6,20,73).

The Government of Japan has sponsored a national program for immunizing school children as a public health measure for more than 15 years (28).

COST-EFFECTIVENESS ANALYSIS

In this cost-effectiveness analysis, influenza vaccination is compared to treatment of the disease if it occurred. Changes in health effects and medical care costs produced by influenza vaccination during 1971-72 through 1977-78 were estimated. The analysis is limited to events within the medical care sector. Quantification of health effects and costs was based on data relating to the morbidity, mortality, and medical care costs associated with influenza and on data relating to the safety, effectiveness, use, and cost of influenza vaccine. Costs incorporate both medical care expenditures and savings. Effects consist of changes in years of healthy life.

Costs and health effects are viewed primarily from a societal perspective, which includes all medical care costs and health effects, regardless of who paid for them. They are viewed in a later section from the perspective of the medicare program.

In addition, the effects of vaccination on influenza-related work, school, and housekeeping losses were calculated separately.

MEASUREMENT OF HEALTH EFFECTS AND MEDICAL CARE COSTS ASSOCIATED WITH INFLUENZA VACCINATION

Simulating the Effects of Influenza Vaccinations for Years 1971-72 Through 1977=78

OTA constructed a computerized simulation model that quantified the health effects and medical care costs associated with influenza for years 1971-72 through 1977-78. The health effects of influenza measured were:

- restricted activity:
  - bed disability days,
  - nonbed disability days; and
- premature deaths.

The primary factors calculated to determine the health effects associated with influenza vaccine were:

- mortality from influenza;
- morbidity from influenza;
- vaccine effectiveness rate; and
- incidence of vaccine side effects.

The medical care costs measured were:

- hospitalization expenditures;
- expenditures for ambulatory cases (including physician visits, ancillary services, and drugs);
- vaccination costs (including treatment of vaccine side effects); and
- costs of treating GBS associated with vaccination.

In determining the effects and costs associated with influenza, it was assumed that excess morbidity and mortality occurred only in the unprotected (i.e., unvaccinated plus the not effectively vaccinated) portion of the population. Higher than average morbidity and mortality rates were estimated for the unprotected population, but the overall average values for the entire general population were not altered from those observed each year.

The changes in health effects and medical care costs were then calculated between two closed populations: one vaccinated and the other unvaccinated. Cost-effectiveness ratios based on these changes were developed for each epidemiologic year (July l-June 30), for an average year, and for all 7 years combined.

Quantifying Morbidity and Mortality Related to Influenza

Quantifying the degree of morbidity and mortality caused by influenza is a difficult task, primarily because influenza is seldom diagnosed definitively in routine medical practice. Over 100 types of viruses have been associated with URI. At least for the last 4 years, in a given geographical location, there have been either none, one (influenza A (H1N1 or H3N2) or influenza B), or a combination of these viruses causing influenza. Diagnostic technologies are either not available or not commonly used in general medical practice to differentiate which virus is causing a person's URI. It is common medical practice to differentiate between certain bacterial and viral infections, but not to differentiate among viral URIS. Techniques currently available to diagnose influenza (e.g., isolating influenza viruses from nasal secretions or measuring serum antibodies to influenza viruses) are usually reserved for research and" surveillance purposes, such as the reporting of influenza viruses by certain laboratories to CDC.

Because of the lack of definitive diagnostic criteria, influenza, as reported in surveys of physicians and the lay public, can become a "catch-all" term used to identify several types of viral URIS. In the absence of clinical diagnostic criteria, physicians often base their diagnosis of influenza on indirect evidence. For example, a person's URI may be diagnosed as influenza when the following situations exist:

- URI occurs during an influenza epidemic validated by CDC's influenza surveillance system;
- the patient exhibits influenza-like symptoms, e.g., fever and generalized muscle aches; and

. a bacteria] infection has definitely been ruled out by laboratory findings or clinical diagnosis.

To attribute morbidity to influenza, OTA used a technique developed by Kavet (55). OTA selected 1970-71 to serve as a nonepidemic influenza year—i.e., a year in which there was no influenza epidemic, were few reports of either influenza A or B viruses in circulation, and was no excess mortality attributed to influenza. During that year, however, influenza was reported as a cause of morbidity in surveys conducted by the National Center for Health Statistics (NCHS). OTA subtracted all influenza and pneumonia morbidity (measured in terms of hospitalization, physician visits, days of disability, work loss, and school loss) reported in 1970-71 from each of the following years, i.e., 1971-72 through 1977-78 (see app. E). The amount of excess morbidity remaining was attributed to influenza.

OTA selected influenza (ICDA codes[1] 470-474) and pneumonia (ICDA codes 480-486) combined as the primary diagnostic category by which to measure morbidity. Most illness attributed to influenza during an epidemic would be reported in these two diagnostic categories by physicians, hospitals, and patients. Because influenza leads to increases in pneumonia rates, data concerning the two illnesses are difficult to separate.

Mortality was measured in "excess deaths" due to all causes as calculated by CDC. Excess deaths are calculated by subtracting "estimated" or "expected" mortality from observed mortality during an influenza epidemic period (see app. E).

Health Effects

Changes in health effects from influenza vaccination are expressed in years of healthy life,[2] an index that incorporates days of illness and days of death related to influenza and to side effects of influenza vaccine. Different disability states are assigned rankings in terms of their relationship to the extremes of full functioning, on the one hand, and death, on the other. For example, on a scale where a year of full functioning is 1 and a year of death is O, a year with a minor health problem might rank as 0.9, and a year with a major health problem might rank as only 0.2. Rankings of different degrees of health can be thought of as representing preferences between more years of unhealthy life and fewer years of healthy life (86).

For purposes of this analysis, degrees of health were divided into four categories: death, disability days with confinement to bed, disability days without confinement to bed, and full functioning. Weighings for these different states were drawn from an analysis by Kaplan, Bush, and Berry: O for a year of death, 0.4 for a year of bed disability, 0.6 for a year of nonbed disability, and 1.0 for a year of full functioning (54).

This scale of weights was applied to years of life at whatever age changes in health status might be expected to occur. Thus, a year of health or life gained by a 5-year-old was weighted the same as a year gained by a 65-year-old. This simplifying assumption was made despite the fact that individuals and society may well value years of extra health or life differently depending on the age at which the additional years occur.

Medical Care Costs

In this analysis, costs, expressed in 1978 dollars, measure changes in medical care expenditures that likely resulted from influenza vaccination. Included as costs are increases or decreases in the medical expenditures incurred by all payers—patients, private third-party payers, and governments—for the treatment of influenza, the cost of influenza vaccine, the treatment of vaccine side effects, and (in the sensitivity analysis) total medical care expenditures in extended years of life yielded by influenza vaccination (see app. E).

[1]Eighth Revision, International Classification of Disease.

[2]The entity "years of healthy life" has been used for over a decade by several researchers, including Bush and associates (16,18, 19,54), Zeckhauser and Shephard (127), and Weinstein and Stason (126).

Health Effects and Medical Care Costs Over Time

Influenza vaccination not only affects illness and medical costs related to influenza, but also has implications for other health effects and medical costs over time. Some vaccinees, for example, avoid death from influenza and gain extended years of life. These added years, adjusted for disability, are included in this model, as described previously.

The health benefits gained—added years of life and reduced disability—have implications that reach beyond the medical care sector, but such implications are not included in this analysis. Added years of life, for example, may imply increased production and income as employed survivors continue their occupations, or increased social welfare as survivors continue their personal and family relationships. The cost-effectiveness ratios do not include such effects because they lie outside the medical care sector. Some productivity changes are calculated separately.

Another implication for a person who gains extended years of life is that the person will incur substantial medical expenses in each additional year. As secondary effects of vaccination, medical care costs in extended years of life do not appear in the base case because including one secondary and costly financial effect of vaccination, while excluding other secondary and beneficial financial effects, such as improvements in production, could be confusing. For example, in 1978, a person age 65 or older had average medical expenditures of about $2,000. If medical care costs in extended years of life were included in the cost-effectiveness analysis, the addition of an extra year to that person's life would worsen (increase) the cost-effectiveness ratio by increasing annual medical care costs by $2,000. The sensitivity analysis shows the effect of including these medical costs. Some previous cost-effectiveness studies have included medical costs in extended years of life (86,126).

All health effects and medical care costs were discounted in the base case using a S-percent rate (see app. E.)

Work, Housekeeping, and School Loss

Days lost from work, housekeeping, and school because of influenza were calculated. These three measures of influenza morbidity were not included in the cost-effectiveness analysis of influenza vaccination; however, the impacts of influenza vaccination on these measures were calculated separately. These lost days are already included as disability days in the cost-effectiveness model. A 1978 dollar value was assigned to work and housekeeping losses (see app. E).

COST-EFFECTIVENESS EQUATION AND MODEL

Cost-effectiveness ratios (C/E) for influenza vaccination, expressing the net medical expenditure per year of healthy life gained by vaccination, were computed with the following model:[3]

$$\frac{\text{net medical costs}}{\text{net health effects}} = \frac{C}{E} = \frac{(C_p - C_t + C_{se} + C_i)}{(E_{LY} + E_m - E_{se} - E_i)}$$

C_p = Expenditure for vaccination
C_t = Saving in costs of treating influenza
C_{se} = Cost of treating vaccine side effects
C_i = Cost of treating future illnesses not prevented by vaccination among vaccinees whose lives are prolonged as a result of vaccination (in sensitivity analysis only)
@ = Increased years of life from vaccination
E_m = Increased health from preventing influenza morbidity
E_{se} = Reduced health from vaccine side effects
E_i = Reduced health from future illness not prevented by vaccination among vaccinees whose lives are prolonged as a result of vaccination.

Separate cost-effectiveness ratios were calculated for vaccinating people in each of six different age groups: under 3, 3 to 14, 15 to 24, 25 to 44, 45 to 64, and 65 years and older. The model is applied to high-risk groups in a subsequent section of this chapter.

[3]The model used in this analysis is similar to that used by Weinstein and Stason in their analysis of a hypertension treatment program. One difference is that the term E_i has been added to account for illnesses in extended years of life (see 126).

BASE CASE AND SENSITIVITY ANALYSIS

In the base case, values assigned to all variables were based on the best estimates available. A sensitivity analysis was used to test the importance of values assigned to selected variables and hence to identify those variables that significantly affect the cost-effectiveness ratio of influenza vaccination. The sensitivity analysis is particularly useful in determining the importance of those variables for which data are uncertain or missing. The sensitivity analysis is also helpful in identifying important topics for future biomedical research and policy analysis.

Assumptions used in both the base case and the sensitivity analysis are listed in table 3. Values altered for the following variables in the sensitivity analysis are displayed in table 4:

- cost of vaccination,
- vaccine efficacy rate,
- discount rate,
- excess deaths, and
- medical care costs for treatment of illnesses (other than influenza) in extended years of life.

Table 3.—Assumptions Employed in Both the Base Case and Sensitivity Analysis

1, Duration of immunity from vaccination was 1 year.

2. An ambulatory case of influenza-related illness consisted of 1.10 to 3.66 physician office visits (depending on patient's sex and age); during each visit, 0.16 clinical lab test, 0.17 X-ray, and 0.75 prescription were ordered. The total cost per ambulatory case ranged from $23.38 to $51.60 (depending on patient's sex and age). (See app. E.)

3. For persons 65 years and older, medicare paid for 55.6 percent of all physician charges, 74.6 percent of all hospital expenditures, and 44.1 percent of all medical care expenditures (37, 24).

4. A hospitalized case of influenza-related illness consisted of 3.92 to 12.5 days of hospitalization (depending on patient's sex and age and year of illness), one initial comprehensive physician visit, and subsequent daily routine followup brief hospital visits. The cost of a hospital case ranged from $657 to $2,031 (depending on patient's sex and age).(See app.E.)

5. The incidence of adverse reactions other than Guillain-Barre Syndrome (GBS) was as follows: (See app. D and E.)
   - Local or mild systemic reactions which resulted in a physician visit (at $10.36/visit):
     - — 5 percent of vaccinees 18 years and over,
     - — 13 percent of vaccinees under 18 years;
   - Severe systemic allergic reaction (anaphylaxis) (at $725/case):
     - — 1 case per 4 million vaccinees.

6. Guillain-Barre Syndrome (GBS) occurred as a statistically significant side effect of influenza vaccination only in 1976-77. The effects of GBS were quantified according to data generated from 1976-77 and 1977-78. (See app. D and E.)

7. A day of nonbed disability was weighted at 0.6 and a day of bed disability was weighted at 0.4 (54).

8. The vast majority of treated influenza was reported to the National Center for Health Statistics as either influenza (ICDA codes 470-474) or pneumonia (ICDA codes 480-486) (unduplicated, all listed diagnoses).

SOURCE: Off Ice of Technology Assessment

Table 4.—Values Assigned to Uncertain Variables in the Base Case and Sensitivity Analysis[a]

Variable	Base case value	Sensitivity analysis: Low value	Sensitivity analysis: High value
Cost of vaccination:			
Vaccinees ≥ age 25	$6.00	$1.55	$9.39
Vaccinees < age 25	$11.09	$4.50	$19.60
Vaccine efficacy rate	600/0	30 "/0	90 "/0
Discount rate	5%	o	—
Excess deaths	Excess deaths calculated by CDC	Based on excess deaths calculated by NIH (Ailing, et al.)	—
Medical care costs for treatment of illnesses not prevented in extended years of life	Not included		Included

aFor explanations of the data sources, calculations, and assumptions used to derive these values, see aPP. E

SOURCE: Office of Technology Assessment.

RESULTS

Most of the results are presented as "per vaccination. " Costs and effects per vaccination are not affected by the number of people vaccinated. This relationship reflects the following two assumptions made in the analysis.

- The price of vaccination is not changed by the number of vaccinees.
- Vaccination rates during the period 1971-72 through 1977-78 were below those necessary for unvaccinated people to derive herd immunity from vaccinees.

Base Case

Cost-effectiveness ratios for influenza Vaccination, derived using base case assumptions, are represented in table 5. With base case assumptions (see table 4), influenza vaccination would result in a net improvement in health for vacci-

Table 5.—Base Case Analysis: Per Vaccination Cost Effectiveness of Annual Influenza Vaccination,1971 -72 Through 1977-78[a]
(by age group[b])

	Under 3 years	3-14 years	15-24 years	25-44 years	45-64 years	≥ 65 years	All ages
Per vaccination costs and health effects of vaccination							
Net cost	$ 10	$ 11	$ 8	$ 5	$ 3	—c	—d
Net health effect (days of healthy life gained)	15 days	20 days	17 days	30 days	49 days	28 days	—d
Cost-effectiveness ratio (cost per year of healthy life)	$258/ year of healthy life	$196/ year of healthy life	$181/ year of healthy life	$64/ year of healthy life	$231 year of healthy life	—c	$63/ year of healthy life

aAverage cost-effectiveness ratios per vaccination are based on data from years 1970-71 through 1977-78; the impacts of annual vaccination from 1971-72 through 1977-78 were calculated over the lifetimes of vaccinees.
bAges as of 1971-72. Vaccinated and unvaccinated populations were followed as a cohort over time.
cIn these instances, vaccination resulted in negative costs — or savings. However, because they can be misleading, such savings are not displayed.
dPer Vaccination net costs and net health effects were not calculated for all ages combined.

SOURCE: Office of Technology Assessment.

nees of all ages, and would result in savings in medical expenditures (associated with influenza) for vaccinees 65 years and older.

In general, the cost-effectiveness of influenza vaccination, expressed in net medical costs (or savings) per year of healthy life gained, improves with increasing age of the vaccinee at the time of vaccination. Net medical cost per year of healthy life gained for a vaccinee under 3 years old is about $258. This ratio drops to $196 for ages 3 to 14, $181 for ages 15 to 24, $64 for ages 25 to 44, and $23 for ages 45 to 64. For vaccinees aged 65 years and older, vaccination produces a net savings. The net cost per vaccination ranges from a high of about $11 for vaccinees aged 3 to 14 years to an actual savings for vaccinees over 65 years. The gain in net health effects ranges from a low of 15 days of healthy life for vaccinees aged less than 3 to a high of 49 days of healthy life for vaccinees aged 45 to 64.

For all ages combined, the overall cost-effectiveness ratio per *vaccination* is about $63 per year of healthy life gained. This overall ratio illustrates by contrast the difference in the cost effectiveness of a vaccination program that can be achieved by targeting vaccination to specific subgroups of the population—namely, the lower cost-effectiveness ratio for vaccinating the elderly (a net savings per year of healthy life gained) and the higher cost-effectiveness ratio for vaccinating the very young ($258 per year of healthy life gained among vaccinees less than 3). It should be noted that even the highest ratio, i.e., $258, is a very low price to pay for a year of healthy life.

Even when a program is not actually cost saving, it may be deemed cost effective. The determination that a program or intervention is cost effective is a value judgment that can be made by either an individual or by society at large. A majority of people would be willing to pay something to gain a year of healthy life, and there exists a consensus that most people would willingly spend several thousand dollars for each healthy year gained (126). In terms of their economic efficiency, alternative programs or interventions with low cost-effectiveness ratios might be more easily justified than those with high ratios (e.g., those costing over $50,000 per year of healthy life gained) (126).

Net costs and effects of influenza vaccination for the *total population* are shown in table 6. Total population costs and effects depend on the number of people vaccinated. The results shown in table 6 are based on actual influenza vaccination rates from years 1971-72 through 1977-78 (124). Influenza vaccination generally is targeted to high-risk people (see app. E) and generally confers protection for a single year.

The numbers in table 6 demonstrate the degree to which per vaccination costs and health effects of an influenza vaccination program are magnified when considered for the population as a whole. Results in table 6 are based on the age-specific vaccination rates shown in tables 1 and 2.

For all ages combined, influenza vaccinations administered between 1971-72 and 1977-78 generated net medical costs (associated with influenza vaccination and medical treatment) totaling $808 million and yielded a net gain of 12.9 million years of healthy life.

Sensitivity Analysis

The importance of five variables in the cost-effectiveness model is shown by the results of the sensitivity analysis in table 7. Except for the "best case" and "worst case" analyses, the values of the five variables were altered one at a time; the variables that were not being tested were assigned their base case values. In the "best case" and "worst case" analyses, the values of four variables, (i. e., vaccine efficacy rate, vaccination costs, medical costs in extended years of life, and influenza mortality rates) were altered simultaneously. In both analyses, the discount rate remained at the base case value of 5 percent.

An influential variable for the cost-effectiveness ratio is the cost of *vaccination (see* table 7). The cost per dose used in the base case was $6.00 for vaccinees age 25 and older and $11.09 for vaccinees under age 25 (see app. E). These costs represent the estimates of vaccination costs when influenza vaccine was administered in the

Table 6.—Base Case Analysis: Cumulative Population Costs and Health Effects of Annual Influenza Vaccination, 1971.72 Through 1977-78[a] (by age group[b])

	Under 3 years	3-14 years	15-24 years	25-44 years	45-64 years	≥ 65 years	All ages
Population costs and health effects of **vaccination**							
Net costs	$41,800,000	$205,300,000	$229,400,000	$200,600,000	$112,600,000	–C	**$807,800,000**
Net health effects (years of healthy life gained)	160,000 years	1,000,000 years	1,300,000 years	3,100,000 years	4,800,000 years	2,000,000 years	12,900,000 years
Coat-effectiveness ratio (cost per year of healthy life)	$258/ year of healthy life	$196/ year of healthy life	$181/ year of healthy life	$64/ year of healthy life	$23/ year of healthy life	—c	$63/ year of healthy life

[a]The Population costs and effects of annual influenza vaccination were calculated based on the age-specific vaccination rates reported for years 1971-72 through 1977-78 in the U.S. *Immunization* Survey (see table 2, app. E) (124). It was assumed there would be no economies of scale in costs and no herd immunity
[b]Ages as of 1971-72. Vaccinated and unvaccinated populations were followed as a cohort Over time.
[c]In these instances, vaccination resulted in negative costs — or savings

SOURCE: Office of Technology Assessment.

private sector. Using lower vaccination costs —i. e., $1.55 for vaccinees age 25 and older and $4.50 for vaccinees under age 25 (low public sector estimates), improves the cost effectiveness of vaccination for every age group. Using higher private sector vaccination cost estimates—i.e., $9.39 for vaccinees age 25 and older and $19.60 for those under age 25—however, reduces the cost effectiveness of vaccination for every age group; and among vaccinees aged 65 and older, vaccination generates a small net cost.

The variable with the most profound impact on the cost effectiveness of influenza vaccination is the inclusion of medical *care costs in extended years of life (see* table 7, app. E). These medical care costs are incurred by people whose lives are saved as a result of influenza vaccination. Such costs were left out of the base case for conceptual reasons. When such costs are included, they completely overshadow the importance of changes in all other variables combined in the sensitivity analysis. Their inclusion elevates the cost of gaining a year of life to a minimum of $1,745 (age group less than 3 years) to a maximum of $2,084 (age group 45 to 64). For all ages combined, the cost of gaining a year of life becomes $1,956.

When no *discount rate* is used, the cost-effectiveness ratios improve for vaccinees of all ages.

Altering the *vaccine efficacy rate* had minimal effect on the cost-effectiveness ratios for any age group (see table 7). Among vaccinees over age 65, influenza vaccination generated medical care savings when the vaccine efficacy rate was varied between 30 percent and 60 percent.

The use of excess *influenza death estimates* generated by Ailing and associates at the National Institute of Allergy and Infectious Diseases (2), instead of those estimates calculated by Chow and Thacker at CDC had virtually no effect on the cost-effectiveness ratio for all ages combined (see table 7). Vaccination still yielded net savings in costs per year of healthy life (associated with influenza vaccination and medical treatment) for vaccinees aged 65 and over. The cost of gaining a year of healthy life was somewhat less among younger age groups, because of the allocation of excess influenza deaths to the lower age groups.

In the "best case" analysis—i.e., lowest vaccination cost, highest vaccine efficacy rate, exclusion of medical care costs in extended years of life, and NIH mortality rates—the overall cost of gaining a year of healthy life for all ages combined is $1.00. Under these conditions, influenza vaccination yields cost savings for age groups 45 and older,

In the "worst case" analysis—i.e., highest vaccination cost, lowest vaccine efficacy rate, inclusion of medical care costs in extended years of life, and CDC mortality rates—the overall cost of gaining a year of healthy life for all ages combined is $2,018. Under these conditions, influenza vaccination does not yield cost savings for any age group.

table 7.—Sensitivity Analysis: Per Vaccination Cost Effectiveness of Annual Influenza Vaccination, 1971-72 Through 1977-78

		Per vaccination cost per year of healthy life by age group[a, c]						
Variable	Assigned values[b]	Under 3 years	3-14 years	15-24 years	25-44 years	45-64 years	≥ 65 years	All ages
cost of vaccination	Public sector - Low /accinees ≥ age 25 - $4.50 Vaccinees < age 25-$1.55	$ 118	$ 90	$ 73	$ 18	–d	–d	$ 11
	• private sector - Low /accinees ≥ age 25 - $11.09 Vaccinees < age 25-$6,00	$ 258	$ 196	$ 181	$ 64	$ 23	–[d]	$ 63
	Private sector - High /accinees ≥ age 25 - $19.50 Vaccinees < age 25-$9.39	$ 439	$ 332	$ 306	$ 99	$ 45	$ 34	$ 112
Vaccine efficacy **rate**	30 percent.	$ 262	$ 198	$ 183	$ 66	$ 33	$ 74	$ 74
	● 60 percent.	$ 258	$ 196	$ 181	$ 64	$ 23		$ 63
	90 percent.	$ 253	$ 194	$ 178	$ 61	$ 14	–[d]	$ 52
Discount rate applied to costs and effects occurring after 1971-72	No discount rate	$ 9	$ 9	$ 13	$ 9	$ 7	–[d]	$ 8
	• 5 percent.	$ 258	$ 196	$ 181	$ 64	$ 23	–[d]	$ 63
Excess death rate	NIH (Ailing, et al,).	$ 187	$ 146	$ 146	$ 58	$ 26	–[d]	$ 61
	• CDC ... , ...	$ 258	$ 196	$ 181	$ 64	$ 23	–[d]	$ 63
Medical care **costs in extended years of life**	Included	$1,745	$1,880	$2,010	$2,027	$2,084	$1,782	$1,956
	• Not included. ., ...	$ 258	$ 196	$ 181	$ 64	$ 23	–[d]	$ 63
Best case situation (5 percent discount)	—Excess deaths - NIH (Ailing, et al.) —Vaccine efficacy rate -90 percent —Medical care costs in extended years of life - not included —Vaccination costs - low public sector	$ 83	$ 66	$ 57	$ 14	–d	–d	$ 1
Worst case situation (5 percent discount)	—Excess deaths - CDC —Vaccine efficacy rate -30 percent —Medical care costs in extended years of life - included —Vaccination costs - high private sector	$1.937	$2,022	$2,143	$2,068	$2,118	$1,842	$2,018

• Base case values

[a] Ages are those in 1971.72 Vaccinated and unvaccinated populations were followed as a cohort over time

[b] For information regarding the data sources and calculation of the values used in this sensitivity analysis, see app E

[c] Actual calculated values were rounded off to the nearest $1.00

[d] In these instances, vaccination resulted in negative costs—or savings Such Savings are not displayed, however, because they can be misleading

SOURCE Off Ice of Technology Assessment.

EFFECT OF INFLUENZA VACCINATION ON PRODUCTIVITY

An implication of illness from influenza is the inability of those affected to carry on their usual major activities in the workplace, in housekeeping activities, or in school. Work days lost because of influenza reduce productivity in the economy. In fact, often raised in policy discussions is the question of whether or not influenza vaccination should be recommended for working people in the general population in order to reduce productivity losses (100).

Table 8 shows self-reported medically attended excess *work loss* from 1971-72 to 1977-78. During this period, such work loss averaged 15 million days per year—7 million days for females and 8 million for males, Almost

Table 8.—Self-Reported Excess Work Loss Related to Medically Attended Influenza, 1971-72 Through 1977.78[a]

Year	Work loss in days by age group: 17-24 years	25-44 years	45-64 years	≥65 years	All ages
1971.72					
Male	566,560	2,527,748	2,513,321	1,145,913	6,753,542
Female	1,638,361	5,979,464	3,867,125	610,412	12,095,362
Total	2,204,921	8,507,212	6,380,446	1,756,325	18,848,904
1972.73					
Male	2,425,252	4,813,922	4,352,705	1,753,318	13,345,197
Female	3,503,367	2,608,446	1,097,946	325,628	7,535,387
Total	5,928,619	7,422,368	5,450,651	2,078,946	20,880,584
1973.74					
Male	1,914,235	3,105,884	530,791	1,038,803	6,589,713
Female	1,139,066	3,874,346	0	284,252	5,297,664
Total	3,053,301	6,980,230	530,791	1,323,055	11,887,377
1974-75					
Male	2,192,063	950,182	1,196,434	409,319	4,747,998
Female	3,440,273	4,195,904	0	0	7,636,177
Total	5,632,336	5,146,086	1,196,434	409,319	12,384,175
1975.76					
Male	552,808	6,693,126	1,689,008	204,613	9,139,555
Female	3,017,422	4,645,739	2,010,055	0	9,673,216
Total	3,570,230	11,338,865	3,699,063	204,613	18,812,771
1976-77					
Male	0	0	0	413,241	413,241
Female	1,942,255	4,336,791	298,460	0	6,577,506
Total	1,942,255	4,336,791	298,460	413,241	6,990,747
1977.78					
Male	4,898,327	6,806,237	3,966,569	0	15,671,133
Female	85,763	882,767	0	0	968,530
Total	4,984,090	7,689,004	3,966,569	0	16,639,663
Average number of excess days of work loss/year					
Male	1,792,749	**3,556,728**	**2,035,547**	**709,315**	**8,094,340**
Female	2,109,501	3,789,065	1,039,084	174,327	7,111,977
Total	3,902,250	7,345,793	3,074,631	883,642	15,206,317

[a]These data were based on unpublished work loss data related to influenza [8th Revision ICDA Codes 470-474) and pneumonia (8th Revision ICDA Codes 480-486) supplied by the Health Interview Survey at the National Center for Health Statistics (see app E). "Excess" work loss was derived by subtracting days of work loss (due to influenza and pneumonia) in 1970-71 from work loss (due to Influenza and pneumonia) for each subsequent year through 1977.78.

SOURCE: Office of Technology Assessment.

half of this work loss, an annual average of 7 million days, is reported by workers aged 25 to 44.

Table 9 reports *productivity lost* from these work days. Productivity loss was valued according to age- and sex-specific earnings (15). From 1971-72 to 1977-78, average *annual* Productivity lost was about $764 million. The age group from 25 to 44 years experienced the greatest productivity loss in each year, an annual average of almost $400 million.

Table 10 reports the effect that influenza vaccination had on reducing work loss related to influenza from 1971-72 through 1977-78. With vaccination rates that existed, about 5 million work days were gained for the overall work force, and these productivity gains were valued at about $250 million during that 7-year period.

Table 11 reports comparable figures for people who reported housekeeping as their major activity. The reduction in *housekeeping days* lost was also substantial. The gains rose with in-

Table 9.—Productivity Loss Related to Self-Reported Excess Work Loss From Medically Attended Influenza, 1971-72 Through 1977-78[a]

Year	Productivity loss by age group (thousands of dollars)				
	17-24 years	25-44 years	45-64 years	≥ 65 years	All ages
1971.72					
Male	22,100	174,400	183,500	68,800	448,800
Female	49,200	236,200	150,800	18,300	454,500
Total	$71,300	$410,600	$334,300	$87,100	$ 903,300
1972.73					
Male	94,600	329,800	317,700	105,200	847,300
Female	105,100	103,000	42,800	10,094	260,994
Total	$199,700	$432,800	$360,500	$115,294	$1,108,294
1973-74					
Male	74,700	212,800	38,700	62,300	388,500
Female	34,200	153,000	0	8,800	196,000
Total	$108,700	$365,800	$38,700	$71,100	$ 584,500
1974-75					
Male	85,500	65,100	87,300	24,600	262,500
Female	103,200	165,700	0	0	268,900
Total	$188,700	$230,800	$87,300	$24,600	$ 531,400
1975.76					
Male	21,600	458,500	123,300	12,300	615,700
Female	90,500	183,500	78,400	0	352,400
Total	$112,100	$642,000	$201,700	$ 12,300	$ 968,100
1976-77					
Male	0	0	0	24,800	24,800
Female	58,300	171,300	11,600	0	241,200
Total	$58,300	$171,300	$11,600	$24,800	$ 266,000
1977-78					
Male	191,000	466,200	289,600	0	946,800
Female	2,600	34,900	0	0	37,500
Total	$193,600	$501,100	$289,600	$ 0	$ 984,300
Average income loss/year					
Male	**69,900**	**243,800**	**148,600**	**42,600**	**504,900**
Female	63,300	149,700	40,500	5,300	258,800
Total	$133,200	$393,500	$189,100	$47,900	$ 763,700

[a]Productivity loss was calculated by multiplying excess days of self. reported work loss (see table 8) by age-specific daily earnings for full-time workers as reported by the Bureau of the Census (see app. E) (15)

SOURCE: Off Ice of Technology Assessment.

84-329 0 - 81 - 5

Table 10.—Base Case Analysis: Effects of Vaccination on Reduction in Work Loss and Productivity Loss From Influenza, 1971-72 Through 1977-78° (by age group[b])

	3-14 years	15-24 years	25-44 years	45-64 years	≥ 65 years	Total
Per vaccination						
Work days gained.	0.01	0.05	0.05	0.03	0.02	–
Productivity gained.	$ .36	$2.10	$2.60	$1.60	$1.20	–
For work force						
Work days gained.	198,100	1,452,000	1,922,000	945,000	576,200	5,093,300
Productivity gained.	$6,965,000	$57,030,000	$101,000,000	$56,340,000	$31,520,000	$252,855,000

[a]Changes in work loss and productivity loss for the work force were based on influenza vaccination rates reported for 1971-72 through 1977-78 in the *U.S Immunization Survey* (124).
[b]Ages as of 1971-72. Vaccinated and unvaccinated populations were followed as a cohort over time.

SOURCE: Office of Technology Assessment.

Table 11.—Base Case Analysis: Effects of Vaccination on Reduction in Housekeeping Loss and Imputed Productivity Loss Related to Influenza, 1971-72 Through 1977=78 (by age group[a])

	3-14 years	15-24 years	25-44 years	45-64 years	≥ 65 years	Total
Per vaccination						
Housekeeping days gained.	0.003	0.01	0.02	0,02	0.06	—
Imputed productivity gained.	—b	—b	—b	—b	$1.86	—
For general population						
Housekeeping days gained.	57,300	296,000	824,600	899,300	1,490,000	3,567,200
Imputed productivity gained.	—b	—b	—b	—b	$46,190,000	$135,553,600

[a]Ages as of 1971-72. Vaccinated and unvaccinated populations were followed as cohorts over time. Productivity loss was imputed on basis of average female earnings.
[b]Not imputed.
[c]Based on influenza vaccination rates reported for 1971-72 through 1977-78 in the *U.S. Immunization Survey* (124).

SOURCE: Office of Technology Assessment.

creasing age at the time of vaccination. From 1971-72 through 1977-78, housekeeping days gained totaled about 3.5 million, with an imputed value of about $135.5 million based on average earnings for women.

Vaccination also reduced *school loss.* An estimate based on actual vaccination rates is that about 780 thousand school days were gained.

MODIFICATION OF THE MODEL FOR THE HIGH-RISK POPULATION

Influenza vaccination is most often recommended for those persons with certain medical conditions or demographic characteristics that render them at greater risk of complications if they contract the disease. Such persons are referred to as the influenza "high-risk" population. According to the Immunization Practices Advisory Committee, formerly the Advisory Committee on Immunization Practices, which advises the Federal Government on national vaccination policies, persons with the following conditions or characteristics are deemed to be at "high risk" and should receive influenza vaccinations annually (l):

- 65 years of age or older;
- selected types of acquired or congenital heart disease;
- any chronic disorder with compromised pulmonary function;
- chronic renal disease;

- diabetes mellitus or other metabolic diseases with increased susceptibility to infection;
- chronic, severe anemia, such as sickle cell disease; and
- other conditions which compromise the immune mechanism, including certain malignancies and immunosuppressive therapy.

The following analysis compares the cost effectiveness of influenza vaccination among high-risk persons to the cost effectiveness of vaccination among the general population.

Size of Vaccinated High-Risk Population

On the basis of data collected by the Bureau of the Census, CDC estimates the size of the high-risk populations. During each year from 1972-73 through 1977-78, there were an estimated 24.5 million persons over 20 years old in the influenza high-risk population (see app. E, table 12). Forty percent of all persons over 65 years old reportedly had one or more medical conditions that represent an influenza risk factor (124). Each year, an estimated 19 percent of the high-risk population (all ages combined) received influenza vaccine; during 1976-77, the year of the swine flu program, about 36 percent of the high-risk persons were vaccinated (see app. E, table 12 for age-specific rates).

Alteration of Selected Characteristics Describing the High-Risk Population

The values of the following variables were altered in the cost-effectiveness analysis for influenza vaccination among high-risk persons (see app. E):

- probability of a person's dying—from all causes as well as from influenza or pneumonia—within a given year,
- probability of a person's either being hospitalized or visiting a physician's office for influenza or pneumonia,
- the length-of-stay of a hospitalized influenza case and the number of physician visits per ambulatory influenza case,
- total medical care costs per person in any extended years of life,
- probability of a person's encountering bed or nonbed disability days from all causes and from influenza, and
- probability of a person's receiving influenza vaccine.

Results

With the assumptions in the base case, vaccination of high-risk groups is more cost effective at any given age than vaccination of individuals in the general population (see table 13). Vaccination of high-risk individuals 65 years and older is cost saving. Again, cost effectiveness improves with increasing age at the time of vaccination. Cost per year of healthy life gained drops from $44 for ages 15 to 24 to $15 for ages 45 to 64.

The inclusion of medical costs in extended years of life substantially changed the results for the high-risk population, as it did the results for the general population. The magnitude of the difference for the high-risk population, however, is relatively much greater. For example, when additional medical costs are included, the per vaccination cost per year of healthy life is $4,040 for a high-risk person 65 years or older. When additional medical care costs are excluded, vaccination of a high-risk person 65 years or older is cost saving. If medical care costs in extended years of life are included, the highest cost per year of healthy life gained occurs for a high-risk person aged 45 to 64, i.e., $4,150. Thus, cost per year of healthy life for a high-risk person 45 years or older is about twice the cost for the general population—about $4,000 compared to about $2,000, These differences stem from the greater probability that a high-risk person will become ill and from the higher medical costs in any extended years of life.

It is noteworthy that vaccination of high-risk people of a certain age may be more cost effective than vaccination of an older age group in the general population. For example, cost per year of healthy life gained for a high-risk person aged 15 to 24 is $44, a lower cost than the $64 for an average-risk person aged 25 to 44. Although these cost differences are small, they illustrate a point that has been made about the differences among members of a certain age group or

Table 12.—Size and Percent of High-Risk Population 20 Years and Older Vaccinated During Fiscal Years 1973-78[a] (by age group)

Fiscal year	20-29 years	30-39 years	40-49 years	50-64 years	≥ 65 years	All ages ≥ 20 years
1973						
Size of high-risk population (000's)	1,878	1,647	2,665	6,938	7,131	20,259
Percent of total relevant population.	5.71%	6.970/o	11.60/0	22.60/o	35.1%	15.50/0
Percent of high-risk population vaccinated.	10.1%	8.9 '/0	10.7%	16.1 '/0	22.2%	16.40/o
1974						
Size of high-risk population (000's).	1,995	1,928	2,848	7,601	7,964	22,336
Percent of total relevant population.	5.93%	7.880/o	12.4%	24.40/o	38.20/o	16.8%
Percent of high-risk population vaccinated.	10.5%	11.0 'J/o	12.70/o	17.1%	23.60/o	17.70!0
9 5						
Size of high-risk population (000's)	2,098	2,179	3,192	8,029	8,321	23,819
Percent of total relevant population.	6.000/0	8.690/o	14.1%	25.50/o	38.90/o	17.60/o
Percent of high-risk population vaccinated.	10.5%	12.1%	15.0'?!0	20.0%0	29.20/o	21.0%
1976						
Size of high-risk population (000's) . . . ., . . .	2,222	2,260	3,183	8,108	8,549	24,322
Percent of total relevant population.	6.1 70/0	8.760/o	14.1%	25.50/o	39.0%	17.6%
Percent of high-risk population vaccinated.	7.40%	10.8 '/0	11 .80/0	1 9.0%0	28.60/o	19.60/o
1977						
Size of high-risk population (000's)	2,313	2,636	3,676	9,171	10,089	27,885
Percent of total relevant population.	6.360/o	9.650/o	16.40/o	28.70/o	45.1 %0	19.80/o
Percent of high-risk population vaccinated.	24.2 '/0	26.0 '/0	29.90/o	36.70/o	44.00/0	36.40/o
1978						
Size of high-risk population (000's)	2,383	2,672	3,570	9,603	10,432	28,660
Percent of total relevant population.	6.440/o	9.380/o	15.9%	29.80/o	45.60/o	20,00/0
Percent of high-risk population vaccinated.	10.0%	10.4%	1 4.7%	19.40!0	29.50/o	20.80/o
Total high-risk population (000's), fiscal years, 1973-1978	12,889	15,200	19,137	49,450	52,486	147,281
Average high-risk population per year(000's)	2,148	2,533	3,189	8,242	8,748	24,547
Average percent of total population 20 years and older considered to be high-risk	6.11 '/0	9.820/o	14.1%	26.1 '/0	40.50/0	1 7.9%0
Average percent of high-risk population vaccinated per year . . .	12.3 0/0	12.0%	16.30/o	23.80/o	30.20/o	22.50/o
Average percent of high-risk population vaccinated per year excluding 1976-77 ......, ...	9.65%	9.11%	13.1%	20.90/o	26.90/o	19.3%

[a]The high-risk population comprises persons with one or more of the following medical conditions: diabetes, selected types of lung disease, selected types of heart disease.

SOURCE: *U.S. Immunization Survey*, 1973-78 (124).

Table 13.—Per Vaccination Cost-Effectiveness Ratios for Annual Influenza Vaccination Among High-Risk Persons Compared to Ratios Among the General Population, 1971-72 Through 1977-78

	Cost per year of healthy life gained by age group[a]				
	15-24 years	25-44 years	45-64 years	≥ 65 years	All ages combined
High-risk population					
Base case.	$ 44	$ 23	$ 15	–b	$ 10
Including medical care costs in extended years of life.	$3,050	$3,620	$4,150	$4,040	$3,880
General population					
Base case.	$ 181	$ 64	$ 23	—b	$ 63[c]
Including medical care costs in extended years of life.	$2,010	$2,027	$2,084	$1,782	$1 ,956[c]

[a]Ages as of 1971-72 Vaccinated and unvaccinated populations were followed as a cohort over time.
[b]In these instances, vaccination resulted in savings, However, because they can be misleading, such savings are not displayed.
[c]All ages for the general population includes children < 15 years.

SOURCE: Office of Technology Assessment.

among members of the general population (114). High-risk people may experience greater benefits from vaccination than others, because the incidence and severity of the disease and the costs of treating it are higher for those at high risk. Therefore, the inclusion of high-risk people in the general population raises the average level of benefits to be obtained from vaccinating the general population. In fact, a non-high-risk member of the general population would realize a lower level of benefit and have a higher cost-effectiveness ratio than the average, which includes high-risk people.

As shown in table 13, the relationship is not so predictable when medical care costs in additional years of life are included. Medical care costs in extended years of life may be so much greater for high-risk people that their cost per year of healthy life gained may be greater than the same calculation for average-risk people.

These differences in results for high-risk people and for the general population indicate that efforts should be made to identify heterogeneity within a population. Analyses are most valuable that, to the extent that is feasible and manageable, take the differences in risk status into account.

MODIFICATION OF THE MODEL FOR MEDICARE

From a societal perspective, influenza vaccination for persons 65 years or older is cost saving in the base case. Even with worst case assumptions, notably the inclusion of medical costs in extended years of life, the net cost per year of healthy life gained was only about $1,800 for those 65 or older. These results for the elderly raise the issue of medicare coverage for influenza vaccination. The Social Security Act now prohibits medicare payment for influenza vaccination.

The societal model was modified to evaluate the effect on medicare expenditures of covering influenza vaccination. After copayments and deductibles, medicare insures about 75 percent of the hospital costs and about 56 percent of the physician costs for the treatment of influenza (37). In addition, it was estimated that medicare pays about 44 percent of medical costs in extended years of life (37). It was assumed that medicare would pay 100 percent of vaccination costs.

As shown in table 14, full coverage of influenza vaccination from 1971-72 through 1977-78 would have cost medicare $791 per year of healthy life gained by vaccinees 65 years and older. *Per vaccination* costs to medicare would have totaled $61: $6 for the original vaccination and treatment of any side effects; a negligible amount for treating GBS; $4 saving in reduced influenza treatment costs; and $60 for additional medical costs in extended years of life. **A** vaccination improved the health of an elderly person by 28 additional days of healthy life. In summary, every influenza vaccination among medicare beneficiaries would have generated about 1 month of healthy life at a cost of about $60 to the medicare program.

With the vaccination rates that existed from 1971-72 through 1977-78, coverage of influenza vaccination by medicare for that entire period would have cost the program about $1.6 billion for vaccinations that yielded about 2 million years of healthy life. Of this cost, $145 million would have been spent for vaccinations and treatment of their side effects, while savings from reduced influenza treatment costs would have been about $104 million. The additional medical costs due to survivors' living longer lives would total approximately $1.5 billion and thus represent the major costs.

Other effects of influenza vaccination on the Social Security program were not quantified in this analysis. Such effects would include:

- increased payments to Social Security by vaccinees remaining in the work force longer as a result of reduced morbidity and mortality, and
- increased payments to beneficiaries resulting from people's living longer.

Table 14.—Effect on Medicare Costs of Annual influenza Vaccination for Persons 65 Years and Older,” 1971-72 Through 1977-78

Per vaccination costs		Health benefits	
Cost of vaccination and and side effects	$ 6	Days of healthy life gained	28
Cost of treating Guillain-Barre Syndrome[b]	—[c]		
Reduced influenza treatment costs	– 4		
Medical costs in extended years of life	60		
Total cost	$61[d]		
Cost/year of healthy life = $791			
For population[e] costs		**Health benefits**	
Cost of vaccination and side effects	$ 145,000,000	Years of healthy life gained	2,003,000
Cost of treating Guiliain-Barre Syndrome	296,000		
Reduced influenza treatment costs	– 103,800,000		
Medical costs in extended years of life	1,541,800,000		
Total costs	$1,583,226,000		
Cost/year of healthy life = $797			

[a] Those persons 65 years and older in 1971-72.
[b] Assumes medicare pays 44 percent of total medical costs (37).
[c] Cost is about $0.01.
[d] Column does not sum because of rounding.
[e] Based on vaccination rates reported for 1971-72 through 1977-78 in the *U.S Immunization Survey* (124).

SOURCE: Office of Technology Assessment.