Benefits Due to Immunization Against Measles

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IN THE PAST, measles has been an almost universal childhood disease. Although many consider it to be rather benign, it sometimes has serious complications, such as encephalitis, otitis, and pneumonia.

Before vaccines were widely used, this disease represented a major public health problem in the United States; an estimated 4 million cases of measles, 4,000 cases of measles encephalitis, and 400 deaths occurred each year.

The isolation of measles virus in 1954 (*1*) led to the development of effective vaccines. With the licensure of the live virus vaccine in 1963, a means of protecting susceptible persons in the population through vaccination became available.

When in 1966 it became apparent that measles could be eradicated in the United States, private medicine and Federal, State, and local governments collaborated on a major program to eliminate the disease (*2*, *3*). This nationwide effort has had an unmistakable effect on the incidence of measles. In 1968 the estimated number of measles cases was 250,000 or about 6 percent of the estimated mean for the 10-year period (1953 through 1962) preceding immunization.

Our objective is to quantify the national impact of immunization against measles. The benefits derived from immunization can be translated into savings in school days, hospital days, dollars, morbidity, and mortality. This kind of information is particularly relevant today, when decision makers in the $50-billion health services industry—now one of the largest and most sensitive segments of the national economy—are all too often forced to base decisions on seriously inadequate data.

Methodology

For the period 1963 through 1968, we estimated (*a*) costs that the nation would have sustained without immunization against measles and (*b*) the actual costs of measles. The difference between these costs is the immunization benefit; that is, (*a*) estimated measles costs without immunization minus (*b*) actual measles costs equals (*c*) benefits due to immunization.

To illustrate these ideas, consider measles deaths. Suppose that in a certain period X number of persons would have died of measles had there been no immunizations. Assume in addition that only Y persons died of measles during this time. The benefit due to measles immunization is therefore X minus Y, or Z lives saved.

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When determining the net economic or dollar savings due to immunization, the cost of immunization itself must be considered. In other words, net dollar savings equal dollar benefits minus dollar costs of immunization. This relationship between costs, benefits, and net savings is depicted in figure 1.

Definition of Terms

The costs of measles must be more carefully described. They can be measured in terms of "health" and "resources" and then translated into dollars.

The items that comprise health and resource costs include morbidity, mortality, incidence of mental retardation, number of lost days in the hospital, and number of lost workdays and schooldays. Not included are important but difficult-to-measure costs such as misery and unhappiness. A few of the listed costs require minor elaboration: One measles death occurs for every 10,000 cases and is usually attributable to measles encephalitis. Encephalitis sometimes causes mental retardation and accounts for one-sixth of the measles cases requiring hospitalization of patients. Measles may result in lost workdays for the reasons mentioned, and the disease clearly results in lost schooldays.

The economic costs, measured in dollars, are either direct or indirect. Direct economic costs include medical expenses connected with measles cases and charges for institutional care of patients who are mentally retarded as a result of measles encephalitis. Indirect economic costs are an approximation of the dollar value of productivity losses related to measles. Productivity losses may arise from premature death or from mental retardation, since both prevent persons from joining the labor force. The disease can and does strike employed adults, and work losses result. In addition, parents sometimes miss work to care for their sick children.

Calculation of Benefits and Costs

We calculated benefits and costs on admittedly crude data. Our estimates are also conservative in the sense that, if anything, they understate the true magnitude of measles costs and, therefore, of savings due to immunization.

Health and resource costs. Estimates of what the annual magnitude of measles incidence

Figure 1. Economic cost and savings relationships

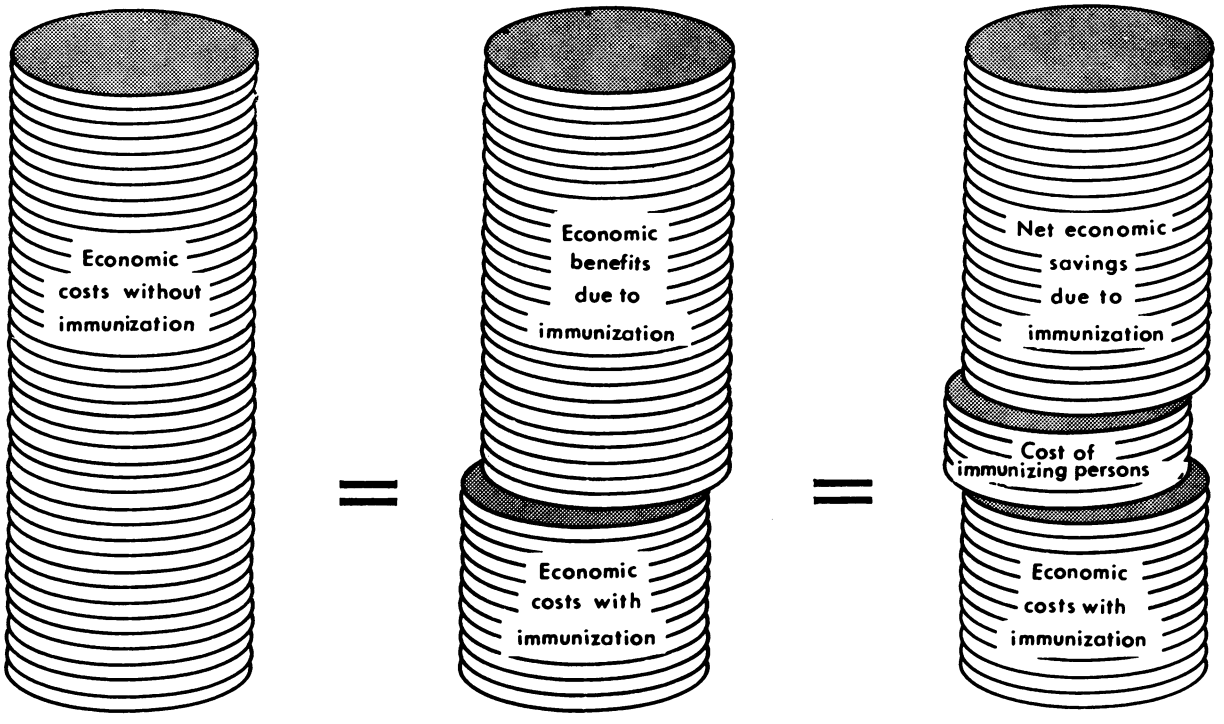
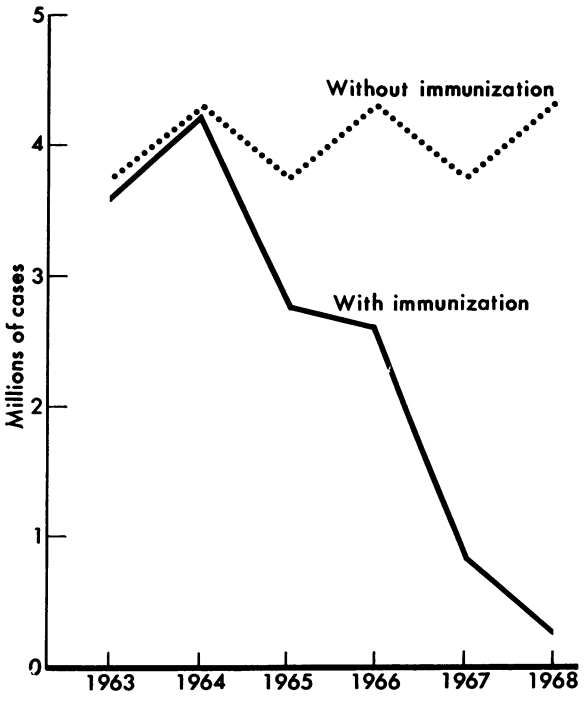


Figure 2. Estimated measles incidence in the United States, 1963 through 1968



would have been without immunization are crucial to this analysis. We considered both the magnitude of and the variance in measles incidence during the decade (1953 through 1962) preceding the immunization effort. During that decade approximately 4 million people had measles each year in the United States. This number of cases must have occurred to explain the 90 to 95 percent level of natural immunity that the U.S. population achieved regularly by young adulthood (*4*). Presumably then, during 1963–68 the average annual incidence would have been about 4 million cases if measles vaccine had not been used. We also considered the past periodicity of measles (fig. 2). Estimates of the actual incidence of measles are based on projections from reported morbidity and mortality statistics for measles.

For every 100,000 cases of measles, 100 cases of measles encephalitis can be expected to occur. Ten of the 100 encephalitis patients will die and 33 will be mentally retarded or have other central nervous system damage (*4*). Long-term intensive care or institutionalization is assumed for this group. In addition, according to unpublished data of the Immunization Branch, National Communicable Disease Center (NCDC), Public Health Service, an average of 500 more measles patients will have pneumonia, otitis, or other illness severe enough to warrant hospitalization.

Based on an estimated mean hospital stay of 14.6 days for encephalitis patients and 8.5 days for other hospital patients, the estimated number of hospital days per 100,000 cases of measles is 5,710—1,460 for encephalitis patients and 4,250 for other patients (*5*).

Calculations to determine the number of workdays lost per 100,000 cases take into account such factors as usual duration of illness from measles and distribution of measles morbidity among currently employed adults (*6–10* and unpublished data from C. S. Wilder, National Center for Health Statistics, Public Health Service). We considered similar factors in estimating the number of lost schooldays.

Economic costs: Charges for physicians' services, hospitalization, gamma globulin, and care for the mentally retarded comprise the direct economic costs associated with measles. Costs are expressed in terms of dollar values at the specified time; for example, 1963 costs are expressed in 1963 dollars, 1964 costs in 1964 dollars, and so on. If costs and benefits had been put in terms of 1968 dollars, the difference in savings would have been less than 10 percent.

We assumed that half the number of patients who were not hospitalized were attended by physicians—half of these in the physician's office and half in the patients' homes. Unpublished data from the Division of Health Interview Statistics, National Center for Health Statistics, indicated that 51 percent of measles patients were medically attended in 1964 and 65 percent in 1965.

Physicians' charges for house calls, office visits, and hospital visits are based on data from the Consumer Price Indexes (*11*) published by the Bureau of Labor Statistics (BLS). In 1962, the average charge for an office visit was $5 and for a house call $8 (*12*). We adjusted these figures by the BLS Physician Fee Index (*11*) to reflect rising medical costs for subsequent years.

A comment about the Physician Fee Index and other BLS indexes on the prices of medical care may be in order at this point. Some economists believe that the actual increase in the cost

of medical services has been even more dramatic than BLS surveys indicate. They contend that BLS probably underestimates increases in prices of medical goods and services included in its index and that these goods and services may not be truly representative of medical care today (*13*). Therefore, our adjustments in the rising costs of medical care are likely to be conservative.

Estimates of physicians' charges to patients who were hospitalized with nonencephalitic acute measles are based on the assumption that the typical patient had an initial limited hospital examination and thereafter saw his physician daily. In 1963 the charge for the hospital examination was $15 and for each followup visit, $5 (*14*). According to a study of St. Louis encephalitis (*15*), hospitalized encephalitis patients were charged $190 per patient in 1966 for physician services. To reiterate, we adjusted all physicians' charges to account for the rising cost of medical services.

Hospital expense estimates for encephalitis patients also are based on the study of St. Louis encephalitis. The 1966 daily hospital cost of $73 was adjusted appropriately for other years.

The following average daily charge at short-stay community hospitals (*16*) was used to estimate hospital expenditures of patients with nonencephalitic acute measles:

1963	$38.91	1966	$48.15
1964	41.58	1967	54.08
1965	44.48		

The 1968 estimate was based on the change from 1967 to 1968 in the BLS index of Hospital Room Rates. The daily expense figure was then multiplied by the number of patient days. We assumed that the cost of gamma globulin for measles contacts would have been $276 per 1,000 cases with no immunization program (*5*).

The cost, in excess of normal maintenance cost, of custodial care for the institutionalized has been estimated at $3,000 per year per patient and is assumed to recur each year for the next 40 years. This figure is based on unpublished NCDC data and a personal communication from Donald R. Calvert, Bureau of Education for the Handicapped, Department of Health, Education, and Welfare.

Paradoxically, it is incorrect to say that the cost to society of institutionalizing one person for 40 years at $3,000 per year is $120,000. The present value of the cost actually is $61,890 when discounted at 4 percent for the reason that a sum of money to be received or spent years into the future is less valuable or costly than that same sum today. This phenomenon only reflects the fact that money represents a claim on resources, which, if efficiently used, produce still more resources over a period of time.

Putting this in terms of dollars, one knows that if the current interest rate is 4 percent, then $100 invested on the spot will become $104 at year's end or $108.16 in 2 years. Alternatively, $100 is the present value of $104 in 1 year or of $108.16 in 2 years if discounted at 4 percent. Hence, the present value of $3,000 a year for the next 40 years is

$$\$3{,}000+\frac{\$3{,}000}{1.04}+\frac{\$3{,}000}{(1.04)^2}+\cdots+\frac{\$3{,}000}{(1.04)^{39}}=\$61{,}890$$

An interest rate of 4 percent, rather than the 5 percent suggested by the Joint Economic Committee of Congress, is used because some data (for example, lifetime earnings) have not been compiled at the 5 percent rate.

The dollar loss due to mortality—an indirect economic cost—is comprised of current and future earnings, representing the value of goods and services, foregone as a result of the premature death of persons who otherwise would have been expected to join the labor force. As explained, since losses reach into future years, the proper way to evaluate them is to discount them at 4 percent. We followed the outline described by Rice for computations (*10*). Factors such as distribution of measles deaths by different age and sex groups, participation rates in the labor force, earnings, and life expectancy were considered.

For those who would never join the labor force because of mental retardation, the economic value of the losses involved were calculated as described previously. The value of time lost from work because of measles in the adult population takes into account the distribution of measles morbidity and earnings in that group (*6–10* and unpublished data from Wilder).

Cost of immunization. We estimated the public and private cost of immunizing persons—in

the public sector, this cost includes promotion expenses as well as the cost of producing, distributing, and administering vaccine—at $3 per dose of vaccine distributed. Multiplying this figure by the number of doses distributed produces the estimated cost of immunizing persons (unpublished data of the Immunization Branch, NCDC).

Results and Discussion

A sharp decline in estimated incidence of measles (fig. 2) shows most directly the salutary effect of immunization. The estimated incidence dropped steadily from a 1963–64 level of about 4 million cases to a low of one quarter of a million cases in 1968. Reduction in other health and resource costs (tables 1 and 2) was equally dramatic.

Results of the study clearly indicate that the immunization program, in addition to improving health in the nation, released substantial medical, educational, and economic resources for other uses. The medical resources included more than half a million hospital days and more than 5 million physician visits. Among the savings in educational resources were 32 million schooldays; and because the program prevented 3,244 cases of retardation, it saved the large amounts of money associated with special schooling for the mentally subnormal. The immunization program also saved the nation 1.6 million workdays and, by preventing premature deaths and mental retardation, insured that more than 4,000 persons would be able to lead about 291,000 additional years of normal and productive life.

Significantly, about nine-tenths of the reduction in incidence was during 1966–68, the period of intensive national effort to eradicate measles by immunization. During this time many of the urban poor who could not afford to pay for the vaccine were immunized (*17*).

As with reduction of incidence, the savings in lives, cases of mental retardation, hospital days, and school days (table 1) were six times greater in the second 3-year period (1966–68) than in the first (1963–65). And the net economic savings jumped 2,000 percent between

Table 1. Summary statement of savings due to immunization against measles

Type of savings	1963–65	1966–68	Total
Health and resource:			
Cases averted	1, 140, 000	8, 590, 000	9, 730, 000
Lives saved	114	859	973
Cases of retardation averted	380	2, 864	3, 244
Hospital days saved	65, 000	490, 000	555, 000
Workdays saved	189, 000	1, 435, 000	1, 624, 000
Schooldays saved	3, 775, 000	28, 450, 000	32, 225, 000
Economic:			
Economic benefits	$63, 192, 000	$468, 351, 000	$531, 543, 000
Cost of immunizing persons	43, 500, 000	64, 800, 000	108, 300, 000
Net economic savings	19, 692, 000	403, 551, 000	423, 243, 000

Table 2. Estimated health and resource costs due to measles and benefits due to immunization, United States, 1963 through 1968

Item	Without immunization	With immunization	Benefits due to immunization
Incidence of acute cases	24, 000, 000	14, 270, 000	9, 730, 000
Deaths	2, 400	1, 427	973
Cases of mental retardation	8, 000	4, 756	3, 244
Patients hospitalized with encephalitis	24, 000	14, 270	9, 730
Other hospitalized patients	120, 000	71, 350	48, 650
Hospital days	1, 368, 000	813, 000	555, 000
Workdays	4, 013, 000	2, 389, 000	1, 624, 000
Schooldays	79, 487, 000	47, 262, 000	32, 225, 000

the end of the first 3-year period and the end of the second (fig. 3).

The fact that benefits appear to have increased with time cannot be completely ascribed to a more efficient use of resources: the proportion of immune persons in a population depends partly on the number of immunizations given in the past. As this proportion increases, the probability of a measles outbreak among a susceptible population decreases because of the diminished number of persons capable of spreading infection. In this way, the protective immunity that inoculation against measles confers on susceptible populations increases as time passes. The benefits therefore would also be expected to increase with time.

The relative size of indirect economic benefits is a salient aspect of the statistics on economic benefits. The indirect costs (table 3) constitute almost half (48 percent) of the total economic benefits. These costs are usually significant but nevertheless have been frequently overlooked as a part of the costs or benefits associated with a certain disease or control measure.

Possibly the most important aspect of the statistics is that they make explicit the full magnitude of the harm that can be done by a "mild" children's disease. For a long time, a bout with measles was regarded by many physicians as an unpleasant but not very dangerous part of life (*18*). They probably did not con-

Figure 3. Annual benefits and costs of immunization against measles in the United States, 1963 through 1968

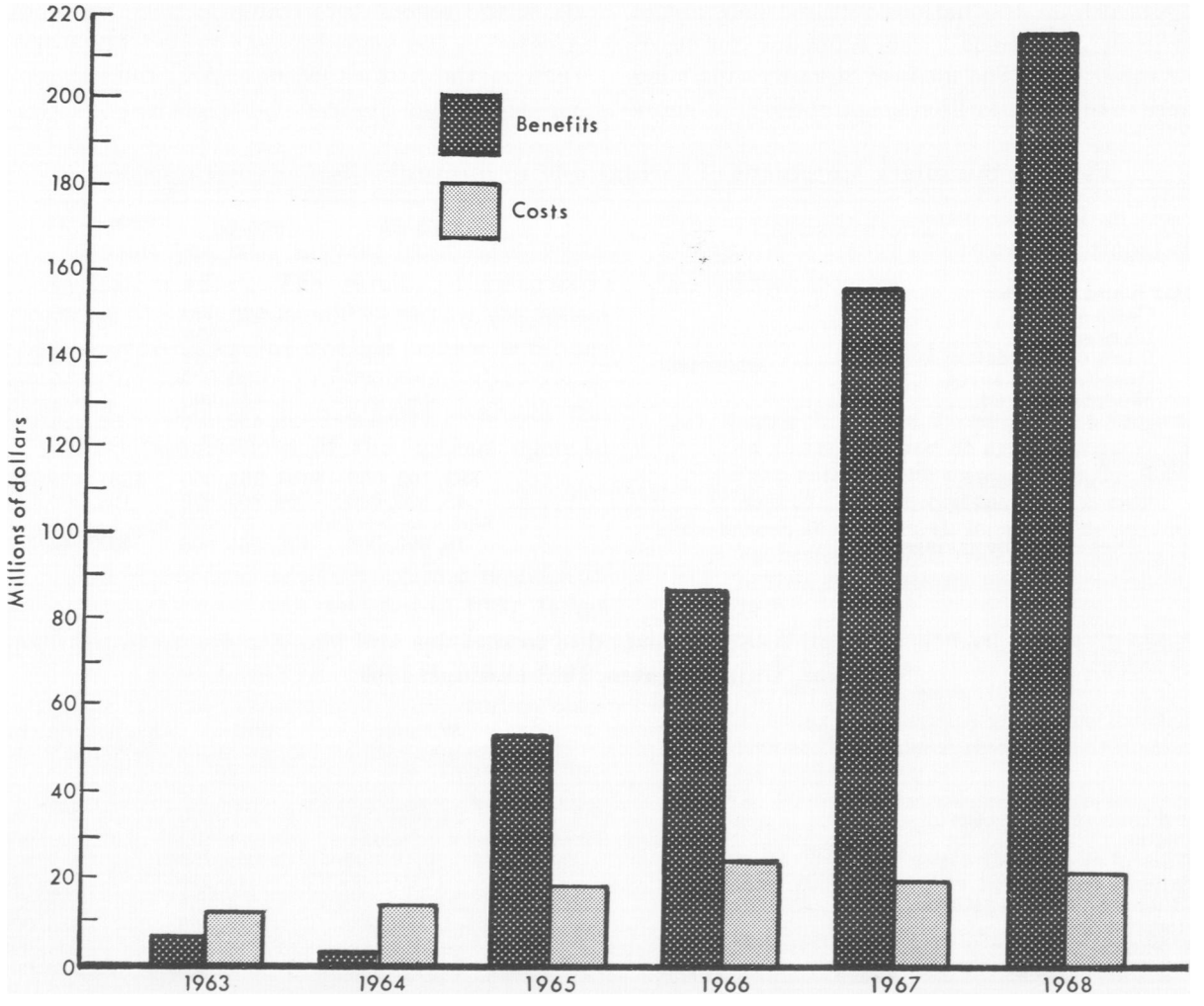


Table 3. Estimated economic costs due to measles and benefits due to immunization, United States, 1963 through 1968 (in thousands of dollars)

Costs	Without immunization	With immunization	Benefits due to immunization
Direct, medical			
Total	$673,990	$395,592	$278,398
Physician services in office:			
Encephalitis cases	402	229	173
Other acute cases	86,701	49,442	37,259
Physician services in hospital:			
Encephalitis cases	4,523	2,552	1,971
Other acute cases	6,892	4,137	2,755
Hospital services:			
Encephalitis cases	26,334	13,975	12,359
Other acute cases	43,927	26,437	17,490
Gamma globulin for contacts	5,558		5,558
Lifetime care for mentally retarded	499,653	298,820	200,833
Indirect, loss of productivity			
Total	604,667	351,522	253,145
Premature death	105,944	56,040	49,904
Mental retardation	407,753	241,320	166,433
Work losses	90,970	54,162	36,808
Grand total	1,278,657	747,114	531,543

sider that since the disease struck so many persons it did great damage and therefore would make an especially good candidate for eradication.

Measles has been a good candidate for an eradication effort. The results of systematic studies like this one should be used in the future not only to determine whether success or failure characterizes certain programs but also to help an administrator identify and evaluate the various ramifications of the options open to him.

Summary

The immunization effort against measles in the United States was initiated in 1963. It has resulted in a sharp decrease in incidence of the disease—from 4 million cases in 1963 to one-quarter of a million cases in 1968—and in associated costs.

A study by researchers of the National Communicable Disease Center shows that during the years 1963 through 1968 the immunization effort is estimated to have averted 9.7 million acute cases of measles and 3,244 cases of mental retardation. It also is estimated to have saved 973 lives, 555,000 hospital days, 291,000 years of normal life, more than 1.6 million workdays, 32 million schooldays, and $423 million.

About nine-tenths of the savings in each of these categories has been realized in the last 3 years—the period of intensive national effort to eradicate measles.

REFERENCES

(1) Enders, J. F., and Peebles, T. C.: Propagation in tissue cultures of cyptopathogenic agents from patients with measles. Proc Soc Exp Biol Med 86: 277–286 (1954).

(2) Sencer, D. J., Dull, H. B., and Langmuir, A. D.: Epidemiologic basis for eradication of measles in 1967. Public Health Rep 82: 253–256, March 1967.

(3) Dull, H. B., and Witte, J. J.: Progress of measles eradication in the United States. Public Health Rep 83: 245–248, March 1968.

(4) U.S. National Communicable Disease Center: Immunization against measles, 1966–1967. Atlanta, Ga., October 1967.

(5) U.S. National Communicable Disease Center: Measles eradication, 1967. Morbidity and Mortality Weekly Report, vol. 16, No. 15 (supp), April 15, 1967.

(6) U.S. National Center for Health Statistics: Acute conditions, incidence and associated disability, United States, July 1963–June 1964. PHS Pub-

lication No. 1000, ser. 10, No. 15. U.S. Government Printing Office, Washington, D.C., April 1965.

(7) U.S. National Center for Health Statistics: Acute conditions, incidence and associated disability, United States, July 1964–June 1965. PHS Publication No. 1000, ser. 10, No. 26. U.S. Government Printing Office, Washington, D.C., December 1965.

(8) U.S. National Center for Health Statistics: Acute conditions, incidence and associated disability, United States, July 1961–June 1962. PHS Publication No. 1000, ser. 10, No. 38. U.S. Government Printing Office, Washington, D.C., June 1967.

(9) U.S. National Center for Health Statistics: Acute conditions, incidence and associated disability, United States, July 1966–June 1967. PHS Publication No. 1000, ser. 10, No. 44. U.S. Government Printing Office, Washington, D.C., March 1968.

(10) Rice, D. P.: Estimating the cost of illness. PHS Publication No. 947–6 (Health Econ. ser. No. 6). U.S. Government Printing Office, Washington, D.C., May 1966.

(11) U.S. Department of Labor: Consumer price indexes for selected items and groups. Bureau of Labor Statistics, Washington, D.C., December 1967 to June 1968.

(12) Rice, D. P.: Economic costs of cardiovascular diseases and cancer. PHS Publication No. 947–5 (Health Econ. ser. No. 5). U.S. Government Printing Office, Washington, D.C., 1962, p. 573.

(13) Scitovsky, A. A.: Changes in the costs of treatment of selected illnesses, 1951–1965. Amer Econ Rev 57: 1182–1195, December 1967.

(14) California Medical Association, Committee on Fees: Relative value studies. San Francisco, 1964.

(15) Schwab, P. M.: Economic cost of the 1966 St. Louis encephalitis epidemic in Dallas, Texas. Public Health Rep 83: 860–866, October 1968.

(16) American Hospital Association: Guide issues. Hospitals, August 1964; August 1965; August 1966; August 1967; August 1968.

(17) U.S. Department of Health, Education, and Welfare: Program analysis: Delivery of health services for the poor. Pub. No. 1967–12. U.S. Government Printing Office, Washington, D.C., December 1967, p. 15.

(18) Langmuir, A. D.: Medical importance of measles. Amer J Dis Child 103: 224–226, March 1962.

The Emergency Medical Identification Symbol

As PART of a campaign to familiarize emergency medical care personnel with the universal Emergency Medical Identification (EMI) symbol, the American Hospital Association, in cooperation with the Public Health Service's Division of Emergency Health Services, is distributing EMI posters, individual EMI cards, and other related material to all general hospitals in the United States.

The American Medical Association estimates that more than 200 health conditions may require special handling in emergencies, and that these conditions affect more than 40 million Americans.

The EMI symbol, developed by the AMA, can be worn as a bracelet, necklace, or anklet by persons with preexisting health problems, such as diabetes, epilepsy, and drug or antibiotic sensitivities. If they recognize the symbol, persons giving emergency care will check the patient's pockets or purse for the EMI card which explains the patient's special health problems. Thus the symbol is a silent spokesman. Without it, emergency personnel might destroy a person's life in attempting to save it.

To be prominently displayed in hospital emergency departments, the posters feature the hexagonal EMI symbol which bears a snake-entwined staff of Aesculapius—the Greco-Roman God of medicine—on a red six-pointed star. The poster has been tested in hospitals in New Mexico and Texas and proved an effective attention-getting device.