Assessing Prevention Effectiveness Using Data to Drive Program Decisions

STEPHEN B. THACKER, MD, MSc
JEFFREY P. KOPLAN, MD, MPH
WILLIAM R. TAYLOR, MD, MPH
ALAN R. HINMAN, MD, MPH
MARTHA F. KATZ, MPA
WILLIAM L. ROPER, MD, MPH

The authors are with the Public Health Service's Centers for Disease Control and Prevention (CDC). Dr. Thacker is Acting Director of the National Center for Environmental Health. Dr. Koplan is Director of the National Center for Chronic Disease Prevention and Health Promotion. Dr. Taylor is Medical Officer, Prevention Effectiveness Activity, Epidemiology Program Office. Dr. Hinman is Director of the National Center for Prevention Services. Ms. Katz is Director of the Office of Program Planning and Evaluation. Dr. Roper is President of the Prudential Center for Health Care Research and the former Director of CDC.

Tearsheet requests to Stephen B. Thacker, MD, MSc; CDC, NCEH, Mail Stop F29, 4770 Buford Hwy. NE, Atlanta, GA 30341—3724; tel. (404) 488-7000; fax (404) 488-7015.

Synopsis

The measure of the effectiveness of health promotion and disease prevention activities is the impact of prevention policies, programs, and practices on public health and clinical medicine. Assessing prevention effectiveness involves continuing quantitative analysis of health outcomes resulting from prevention practices. Additionally, assessment involves evaluation of disease- and injury-prevention activities, including their medical, legal, ethical, and economic impacts. Although assessing the effectiveness of prevention activities involves measuring efficacy, safety, and cost, the primary criterion is to improve health at a reasonable cost, not merely to contain costs.

Policy makers can use the results of assessments to set priorities in public health. The authors use case studies to illustrate various approaches to evaluating prevention programs, including school health-education programs, and programs for preventing measles, breast cancer, and diabetic retinopathy. Rigorous evaluation of the effectiveness of prevention activities is essential to the wide acceptance of preventive interventions and the willingness to pay for them.

HEALTH PROMOTION AND DISEASE PREVENTION goals are defined national health priorities (*1, 2*), with funding included in Federal budgets (*3*). However, public health program decision makers cannot expect those who fund public health to accept on faith the value of prevention activities. To convince policy makers to fund prevention programs, we need a comprehensive system for assessing the value of those programs.

In 1976, the Congress' Office of Technology Assessment listed the general principles for technology assessment (*4*). In 1990, the Agency for Health Care Policy and Research, of the Public Health Service, began a program to assess the effectiveness of medical treatments (*5*). No approach to evaluating prevention activities has been accepted widely, however, and evaluations have not resulted in significant coverage of preventive services by health care insurers.

Advocates may consider the value of prevention activities to be obvious. However, only 3 percent of health expenditures are dedicated to prevention, and efforts to encourage preventive practices often fall short. We illustrate the importance of evaluating prevention activity by providing successful and cost-effective examples of primary, secondary, and tertiary prevention (see table) (*6*). The examples show how results of evaluations can be used to establish, modify, or justify a particular prevention program and to identify information still needed by decision makers. We discuss evaluations of school health-education programs, as well as remaining challenges

Selected examples of prevention-effectiveness assessment

Prevention type[1]	Undesired outcome	Annual national incidence without intervention	Prevention method	Percent effectiveness of method	Economic analysis	Percent of persons at risk covered by prevention method
Primary	Measles	4,000,000	Vaccination	95–98	$16.85 per case prevented	By age 2 years,50—80 By age 6 years, 98
Secondary ..	Breast cancer deaths	50,000	Mammography: screening women age > 40 years	20–70	$45,000—$165,000 per year of life saved	15–38
Tertiary	Blindness from diabetes	24,000	Retinal screening, treatment	50	$100 per year of vision saved	60–80

[1]Primary prevention is defined as the protection of health by personal or community-wide efforts. Secondary prevention refers to methods for early detection and effective intervention to correct departures from good health. Tertiary prevention includes methods to reduce or eliminate long-term impairments and disabilities (reference *5*).

in prevention and public health and recommend ways to overcome barriers to the appropriate use of assessment data.

Assessing Effectiveness

Prevention effectiveness is assessed by measuring the impact that prevention policies, programs, or practices have on public health or clinical preventive practices. Assessment needs to be an ongoing process. Health care technologies, including drugs, devices, and procedures that may be curative, diagnostic, or preventive, as well as the programs to implement the technologies, need to be evaluated at all levels of the health system (*7*). Assessing prevention effectiveness involves quantitatively analyzing the impact of prevention on health outcomes and examining the societal consequences of disease- and injury-prevention activities, including any medical, legal, ethical, or economic factors (*8*). The underlying principle is that a procedure, drug, or practice needs to be evaluated for its benefits compared with its risks and costs, and its safety compared with its efficacy, and so forth. The diffusion of prevention technologies and the prevalence and distribution of their use in the population can be evaluated as well. Assessment results can be used by clinicians to manage patients and by policy makers to set priorities in public health.

The steps in the assessment process are to (*a*) identify the technologies to be assessed, (*b*) select an assessment method, (*c*) conduct the assessment and analyze data, (*d*) use the conclusions to implement programs, (*e*) monitor the use and impact of the technologies, and (*f*) periodically reassess. Next, select the appropriate method for assessing the effectiveness, safety, and cost of alternative prevention strategies or technologies. The validity and usefulness of the result of the analysis can be improved by integrating other factors into the analyses, such as social acceptability, political reality, ethical implications, and quality of life issues.

Case Study Examples

Primary prevention: measles vaccination. Before measles vaccine was licensed in 1963, childhood measles infection was universal. In the United States, thousands of deaths from measles were recorded annually, reaching a peak of more than 10,000 deaths in 1923. In the preantibiotic era, much of the mortality resulted from superimposed bacterial pneumonia (*9*). Even with antibiotics, however, about 500 measles deaths were documented each year. In 1966, a campaign was begun to eradicate measles (*10*), and during the next quarter-century there was a dramatic decline in incidence. The annual average number of reported measles cases decreased from more than 500,000 to 1,497 in 1983. Cases of complications from measles (including pneumonia and otitis media) and substantial health care and other costs attributable to measles decreased as well (*11*).

Analyses of the benefits and costs of measles immunization programs have shown ratios ranging upward from 5:1, depending on the techniques and assumptions used (*12–14*). Such results contributed strongly to the formulation in 1979 of a national policy for measles elimination. A 1985 analysis of the use of a combination measles-mumps-rubella vaccine showed a benefit-to-cost ratio of 14:1, highlighting the advantages of combined vaccines in an immunization program (*15*). On the basis of that analysis, we estimated that the cost per case prevented was $16.85.

Recently, however, a series of developments has undermined the assumptions and estimates used in previous analyses of programs to vaccinate children against measles. Continued sporadic outbreaks among

schoolchildren in 1989 led to a reassessment of the national vaccine strategy and to recommendations for a second dose of measles vaccine for all school-age children (*16*). For reasons that remain unclear, 2 to 5 percent of children were not fully protected by the first dose of measles vaccine; the second dose was intended to provide protection for the small proportion of unprotected children. Thus far, no one has evaluated the cost effectiveness of a second dose of measles vaccine.

Despite the proven success of measles vaccine and the demonstrated cost effectiveness of that primary prevention technique, measles remains a public health problem. Public health surveillance systems show that measles cases have risen from a low of 1,497 cases in 1983 to 18,193 in 1989, and to 27,786 in 1990, falling to 9,643 in 1991 and 2,237 in 1992 (*17*). Although 97 percent of children are vaccinated against measles by the time they enter school, the proportion of vaccinated poor, inner-city preschoolers may be substantially lower, which suggests a failure of vaccine-delivery systems (*18*).

Finally, social and ethical issues may prevent vaccine delivery from being totally effective. Such issues include concerns about adverse reactions to vaccine, limited access to health care, religious exemptions from vaccination requirements, socioeconomic circumstances, and personal perceptions and values. One person's exercise of their right to decline vaccination can place many others at increased risk for illness, thus creating an ethical dilemma for local public health officials.

Measles vaccination is an example of effective technology with a dramatic impact on disease, but it has fallen short of its anticipated effect. The challenge remaining is to extend that preventive technique to all children at the recommended age of 12–15 months (*15*). Although the benefit-to-cost ratio for the one-dose program using 1985 data and assumptions was high, we cannot assume it remains high for a two-dose program in 1993. Because of the additional cost, a formal evaluation of the cost effectiveness of the two-dose program is warranted. If the benefit-to-cost ratio for the two-dose program is lower than that for the one-dose program, policy makers must consider factors other than cost effectiveness (for example, parental concern) when making decisions about vaccination programs.

Secondary prevention: screening for breast cancer. In 1991, about 175,000 women developed breast cancer and 44,800 died from the disease (*19*). A woman's risk of developing breast cancer in her lifetime is 9.3 percent (*20*). The evidence is strong that mammographic screening for women older than 50 years can reduce mortality from breast cancer (*21–23*). Some trials of biennial screening have shown mortality reduced as much as 20 to 70 percent (*20*). The American College of Physicians, the American Cancer Society, the National Cancer Institute, and other organizations recommend annual screening for women 50 years and older; the American Cancer Society recommends screening every 1 to 2 years for women ages 40–49 years (*24*). Evidence that women younger than 50 years benefit from screening is controversial (*25, 26*).

In 1987, 38 percent of women 40 years or older reported having had at least one mammogram; 15 percent had a mammogram in the year preceding the interview (*27*). The proportion of women who ever had a mammogram increased with age among women 40 to 54 years, peaking at 45 percent for the 50–54-year age group, but falling to less than 30 percent for women 70 years or older. Surveys of women 50–74 years of age in seven communities showed that the least educated and the poorest were least likely to be screened (*28*).

The price of a mammogram averages $100 to $125 and ranges from $25 to $250 (*29*). The costs are a barrier to establishing policy recommendations about breast cancer screening, to convincing physicians and insurers that mammography is cost effective for the patients, and to providing access to mammography services for persons without health insurance. By 1990, about 10,000 mammography units had been installed. However, only 2,600 units would be needed if the health care delivery system were even moderately efficient in distributing facilities and services (*30*).

The cost effectiveness of breast cancer screening can vary according to the delivery strategies chosen and the risk levels of the groups screened. Analysts have estimated that if all women 50 years or older were screened annually by breast physical examination alone, 4,280 lives would be saved and the cost of saving an additional year of life would be from $10,000 to $15,000 (*20*). If mammography were combined with breast physical examination, more lives would be saved, but the cost of an additional year of life would be $30,000 to $105,000. If annual screening by breast physical examination and mammography were extended to all women 40 years or older, the cost of an additional year of life would be $45,000 to $165,000.

To achieve the greatest health effects for a given cost, we must assess a range of delivery strategies. One health maintenance organization evaluated women's risks before screening, invited women for

screening regimens that varied according to prescreening results, and created a special clinic for breast cancer screening (*31*). Dutch investigators modeled benefits and costs of four breast cancer screening programs in The Netherlands and found that biennial screening for women 50 to 70 years of age was the most cost-effective policy (*32*). They estimated that the program would cost $4,850 per year of life saved and $50,000 per death averted.

In summary, although the efficacy of mammographic screening is evident, the effectiveness of screening programs must be increased and the costs decreased. To accomplish those goals, screening guidelines must be systematically implemented, delivery must be made effective and efficient, technology distribution must improve, and data systems used for screening and implementing followup must be more centralized. Future assessment of the effectiveness of breast cancer screening should include economic analyses of mammography programs, diagnostic testing, followup treatment, and management. Those performing assessments need to consider changes in the average stage at which breast cancer is diagnosed and changes in mortality, as well as variations in breast cancer rates within racial, ethnic, and socioeconomic subgroups.

Tertiary prevention: screening for retinal complications of diabetes. Each year, 12,000 to 24,000 people have significant or severe visual loss as a result of diabetes (*33*). Among the 14 million persons with known or undiagnosed diabetes mellitus, the estimated prevalence of retinal disease is 17 percent among those with disease for fewer than 5 years and 97.5 percent among those with the disease for 15 or more years, if the diabetes was diagnosed before age 30 years (*34–36*).

Through retinal screening, health care givers can detect complications from diabetes early in the disease and improve the likelihood of preventing or minimizing vision impairment. The basic components of the current program include identifying a person with diabetes mellitus, screening for retinal disease, and using photocoagulation to slow the rate of progression for those with significant retinal disease. Future programs may include more efforts at rigorous control of blood glucose levels.

Researchers have found evidence that among persons with onset of diabetes at a young age, screening for retinal complications 5 or 10 years after diagnosis is more effective than screening earlier (*37*). However, persons who develop diabetes late in life should be screened shortly after diagnosis (*35, 38*).

Various methods of retinal photography and ophthalmoscopy are effective screening techniques. Some study results suggest that a variety of medical personnel, including opticians, optometrists, and ophthalmologists, can screen satisfactorily. If true, those results suggest that screening could be made widely available at relatively low cost (*39, 40*). Other study results suggest, however, that the ability to detect retinal disease varies by the type of medical specialty; if so, patient access to screening would be reduced and screening costs increased, particularly in rural areas (*38, 41*).

The overall effectiveness of screening for retinal problems depends on the efficacy of treatment. In a carefully designed and managed trial, researchers found that panretinal coagulation reduced the risk of severe vision loss during a 5-year period by 50 percent or more (*42, 43*). In studies of followup rates after screening, a research group found that, in a general population, more than 80 percent of those screened and needing treatment were treated (*44*); another group found that, in an 87-percent minority population in Texas, more than 85 percent of those needing treatment were treated or scheduled for treatment (*45*).

Results of a cost-effectiveness analysis showed that the costs of screening programs were recovered by avoiding the costs of blindness in the population subgroups that took insulin; this was not true for the subgroup of persons who developed diabetes late in life and did not take insulin (*46*).

Scottish investigators estimated a benefit-to-cost ratio for screening for retinal problems of 3.3:1 (*47*). Other investigators predicted that a program of screening would cost $966 per person-year of vision saved from proliferative retinopathy and $1,118 per person-year of central acuity saved from macular edema. This is only one-sixth to one-seventh of the $6,900 average cost of 1 year of Social Security disability payments for those disabled by vision loss (*48*). Thus, screening for retinal problems in association with diabetes appears to be a cost-effective approach to maintaining vision and preventing blindness. Nevertheless, the cost-effectiveness analysis of a screening program must consider the number of people to be screened and the prevalence of the disease in the population.

National goals for prevention of blindness have been established on the basis of assessment of effectiveness (*2*), and professional organizations have disseminated data-driven recommendations for clinicians. What remains is to translate the results of those studies and demonstration projects into a coordinated public health program, to monitor the use and impact

of program interventions, and to evaluate rigorously the costs and benefits of such programs.

Applying assessment techniques: a school health-education program. Health education programs in schools are designed to influence children's decision making and behavioral patterns later in life. They teach children healthful practices during the ages that they are most amenable to acquiring knowledge and forming attitudes. Although the programs vary in purpose, they seek to dissuade students from engaging in behaviors that increase health risk. Among those behaviors are alcohol or other substance abuse, smoking, not using automobile seat belts, unhealthy dietary choices, sedentary lifestyles, and unsafe sexual practices.

Comprehensive school health education programs generally have characteristics in common. They include a documented, planned, and sequential curriculum for all students in grades kindergarten through 12; specially trained teachers; and materials that are integrated into many parts of the school curriculum. Such programs emphasize developing the children's decision-making skills and address a wide range of health problems, such as those listed.

The Youth Risk Behavior Surveillance System (YRBSS) was developed by the Centers for Disease Control and Prevention to track behaviors covered in school health education programs (*49*). YRBSS monitors six health risks: (*a*) tobacco use, (*b*) alcohol and drug use, (*c*) unhealthy sexual behaviors, (*d*) dietary patterns that result in disease, (*e*) lack of physical activity, and (*f*) behaviors that result in intentional or unintentional injuries. The YRBSS single-survey instrument is an anonymous questionnaire, administered in the classroom at 2-year intervals, that asks young people to report their behaviors in the six risk areas. The survey permits us to monitor trends in risk behaviors, relate trends to health education programs, assess the extent to which those behaviors are interrelated, and to compare health education programs among the States.

Analysts have published many evaluations of school health-education programs, including programs with specific curriculums, such as Growing Healthy, Teenage Health Teaching Modules, and more extensive programs, such as Know Your Body, which includes physiologic tests (*50*). The following examples of the effectiveness of school health-education programs show the diversity of approaches, results, and methodologic issues.

A 3-year study of 4 health instruction programs involving 30,000 students in 1,000 fourth through seventh grade classrooms in 20 States showed that substantial improvements can be achieved in students' knowledge, attitudes, and self-reported practices. For example, among seventh grade students who received a particular curriculum of health education, 40 percent fewer reported that they smoked cigarettes than students who received no health education. Programs with trained teachers, with materials integrated into regular classroom activities, that continued through several grades, and that focused on basic health education have been found to be more effective than programs on categorical health problems begun in later grades (*51*).

'It is critical to understand that although assessing the effectiveness of prevention activities takes into account efficiency, safety, and cost, the primary goal is to improve health status at a reasonable cost, not simply to contain cost.'

To evaluate the effectiveness of the Know Your Body Program, analysts used physiologic measurements, such as blood pressure, triceps skin fold thickness, pulse recovery rate, serum cholesterol, and serum thiocyanate. They found "significant net favorable changes," among participants, including a 14-percent increase in health knowledge, a 5-percent reduction in total serum cholesterol levels, and a 73-percent reduction in the rate of initiation of cigarette use (*52–54*).

There are few data on the cost effectiveness of health education in schools. However, a crude cost-effectiveness analysis of health education in Tasmanian schools showed that the best possible outcome (minimum cost, maximum benefits) of a 3-year program would be a cost-effectiveness ratio of A$6,301 (Australian dollars) (about US$7,875) per year of life saved. The worst possible outcome (maximum cost, minimum benefits) would cost A$75,032 (about US$93,750) per year of life saved (*50*).

Assessing the effectiveness of health education in schools presents unique challenges, such as separating the outside influences of family and community, identifying effective components crucial to the program, determining the best ways of measuring outcomes, controlling for secular trends, determining economic value, and determining the effectiveness of programs for various subpopulations (*55*). Further complicating the task of implementing health educa-

tion in schools and assessing its effectiveness is the ethical and societal debate about what subjects are appropriate to teach in schools. Nonetheless, we must continually reassess the effectiveness of health education in schools in the effort to help prevent many of today's major public health problems.

Discussion

Assessing the effectiveness and cost of prevention is not a new idea (*56*). As evidenced in the case studies, researchers have spent considerable effort assessing some preventive health practices, and the results have had an impact on clinical practice and public policy. That success was achieved despite limited resources and some disagreement about methods of evaluation.

Still, our knowledge about the effectiveness of prevention efforts has many gaps. We want to fill those gaps quickly to help prevent unnecessary morbidity, mortality, and disability. We cannot work quickly, however, if we follow the traditional method of testing an intervention, sometimes for years, in a small, high-risk population. While we are testing, many people in the large low-risk population are denied access to the intervention. To resolve that problem, we must establish public policy on the basis of the best available scientific evidence, responding to the societal demand for that intervention (*57*).

We need continual monitoring, not only of adverse outcomes to be prevented, but of the effectiveness of delivering preventive technologies to persons at risk for disease or injury. Moreover, each case study shows the need for continuously reassessing technologies and programs as populations, disease patterns, and social mores evolve (*58*). To assess the effectiveness of preventive efforts in a timely manner, we need inexpensive and practical data-gathering systems to track the technical methods used in prevention. The information gathered should be made available quickly to prevention practitioners (*59, 60*).

Assessing prevention effectiveness involves weighing risks and costs against benefits. The case studies illustrate several issues related to risk. Measles vaccination is complicated by self-limited febrile illness in 5 to 15 percent of nonimmune vaccinees, but severe reactions are rare. Mammography causes some discomfort and involves a slight risk from radiation exposure. The major concern, however, is false positivity, which leads to followup when no disease is present (*28*). Unnecessary followup efforts result in direct costs for mammography, sonography, and biopsy, and indirect costs for complications resulting from those procedures and from emotional distress associated with unnecessary fears of cancer among patients.

For health education in schools to succeed, we must resolve concerns about cost, acceptance by teachers and parents, and the undocumented assertion that children will be harmed by learning about sexual practices, substance abuse, and violence.

Assessing the effectiveness of health technology used in prevention poses unique methodologic challenges. For example, population-based studies of programs to prevent such chronic conditions as breast cancer or diabetic retinopathy require a large number of subjects who must be followed for many years to observe changes in disease incidence or outcomes. Such studies are expensive and complicated methodologically by confounding variables and secular trends that may obscure the impact of the intervention being assessed (*61*).

Prevention assessment requires standard measurements of an intervention's effectiveness and cost, yet there is no consensus on their appropriate uses in prevention. For example, should the assessment of program effectiveness take into account both the efficacy of a single technology and the proportion of the population that uses that technology appropriately? That proportion is termed the prevented fraction. Should a single standard measurement of outcome be used as a proxy for a range of outcomes that are difficult to measure? Specifically, should a measurement, such as quality-adjusted life years, be used to assess a person's degree of autonomy in terms of physical and social function, mental health, perception of overall health, and pain intensity (*62–64*). We need broader definitions of health and of active life expectancy beyond mere reductions in morbidity and mortality.

In prevention, we need to develop assessment techniques that account for the many interventions aimed at achieving lifelong adherence to a behavioral pattern, rather than interventions that require behavior to change only once or infrequently. For example, altering nutritional practices requires sustained behavioral changes, whereas getting vaccinations or mammographic examination requires infrequent behaviors. Similarly, seatbelt use requires decision making every time a person enters a motor vehicle.

Consideration of societal values is essential in decisions involving public policy. People's perception of the risk and benefit of a particular preventive activity and their willingness to avoid risks influence the likelihood that an intervention will be successful. For example, the benefit from secondary prevention of breast cancer has been established. As a result, some women have shown their willingness to pay for

screening mammograms. However, we have not established how much risk reduction women are willing to pay for, or how breast cancer screening programs can be made more systematic, efficient, or effective, all at reasonable cost.

It is critical to understand that although assessing the effectiveness of prevention activities takes into account efficiency, safety, and cost, the primary goal is to improve health status at a reasonable cost, not simply to contain cost. Although disease and injury prevention is cost effective in many cases, we must not assume that prevention will necessarily save money.

Currently, demand is increasing for assessments of medical and surgical procedures that usually have been introduced on the basis of clinical perceptions of utility. In response to that demand, the Agency for Health Care Policy and Research (*5*) and the Health Care Financing Administration (*65*), have established programs that emphasize evaluating outcomes for individual patients. But, prevention activities (especially population-based programs) have long been scrutinized vigorously for evidence of cost effectiveness (*66*). Today, the public health community must continue to lead the way in initiating and refining effective and efficient interventions. The processes we describe can help us achieve a more systematic approach toward assessing the effectiveness of our prevention programs.

References

1. Public Health Service: Healthy people: the Surgeon General's report on health promotion and disease prevention. DHEW Publication No. (PHS) 79-55071. U.S. Government Printing Office, Washington, DC, 1979.
2. Public Health Service: Healthy people 2000: national health promotion and disease prevention objectives. DHHS Publication No. (PHS) 91-50212. Office of the Assistant Secretary for Health, Office of Disease Prevention and Health Promotion. U.S. Government Printing Office, Washington, DC, 1990.
3. Office of Management and Budget: Budget of the United States, fiscal year 1992. IV.B. Focusing on prevention and the next generation. U.S. Government Printing Office, Washington, DC, 1991, pp. 21–34.
4. U.S. Congress, Office of Technology Assessment: Development of medical technology. Publication OTA-H-34. U.S. Government Printing Office, Washington, DC, 1976.
5. 101st Congress: Omnibus Budget Reconciliation Act of 1989 (Public Law 101-239). U.S. Government Printing Office, Washington, DC, 1989.
6. Last, J. M.: A dictionary of epidemiology. Oxford University Press, New York, NY, 1988.
7. Banta, H. D., Behney, C. V., and Willems, J. S.: Toward rational technology in medicine. Springer, New York, NY, 1981.
8. U.S. Congress, Office of Technology Assessment: Assessing the efficacy and safety of medical technologies. Publication OTA-H-75. U.S. Government Printing Office, Washington, DC, 1978.
9. Krugman, S.: The conquest of measles and rubella. Natural History 92: 16–20 (1983).
10. 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.
11. Block, A. B., et al.: Health impact of measles vaccination in the United States. Pediatrics 76: 524–532 (1985).
12. Witte, J. J., and Axnick, N. W.: The benefits from 10 years of measles immunization in the United States. Public Health Rep 90: 205–207, May-June 1975.
13. Albritton, R. B.: Cost-benefits of measles eradication: effects of Federal intervention. Policy Analysis 4: 1–22 (1978).
14. Koplan, J. P., and White, C. C.: An update on the benefits and costs of measles and rubella immunization. *In* Immunizing against mental disorders: progress in the conquest of measles and rubella, edited by E.M. Gruenberg, C. Lewis, and S. Goldston. Oxford University Press, Oxford, England, 1985.
15. White, C. C., Koplan, J. P., and Orenstein, W. A.: Benefits, risks and costs of immunization for measles, mumps and rubella. Am J Public Health 75: 739–44 (1985).
16. Measles prevention: recommendations of the Immunization Practices Advisory Committee (ACIP). MMWR Morb Mortal Wkly Rep 38 (S-9): 1–18, Dec. 29, 1989.
17. Summary of notifiable diseases, United States, 1992. MMWR Morb Mortal Wkly Rep 41: 55, Sept. 24, 1993.
18. Hinman, A. R.: What will it take to fully protect all American children with vaccines? Am J Dis Child 145: 559–562 (1991).
19. Cancer facts and figures, 1991. American Cancer Society, Atlanta, GA, 1991.
20. Eddy, D. M.: Screening for breast cancer. Ann Intern Med 111: 389–399 (1989).
21. Eddy, D. M., et al.: The value of mammography screening in women under 50 years. JAMA 259: 1512–1519, Mar. 11, 1988.
22. Council on Scientific Affairs: Mammography screening in asymptomatic women aged 40 years and older. JAMA 261: 2535–2542, May 12, 1989.
23. Guide to clinical preventive services: an assessment of the effectiveness of 169 interventions. Report of the U.S. Preventive Services Task Force. Support provided by the Office of Disease Prevention and Health Promotion, U.S. Department of Health and Human Services. William and Wilkins, Baltimore, MD, 1989.
24. Hayward, R. S. A., et al.: Preventive care guidelines: 1991. Ann Intern Med 114: 758-783 (1991).
25. Miller, A. B., Baines, C. J., To, T., and Wall, C.: Canadian National Breast Screening Study, 1. Breast cancer detection and death rates among women aged 40 to 49 years. Can Med Assoc J 147: 1459–1476 (1992).
26. Miller, A. B., Baines, C. J., To, T., and Wall, C.: Canadian National Breast Screening Study, 2. Breast cancer detection and death rates among women aged 50–59 years. Can Med Assoc J 147 1477–1488 (1992).
27. Dawson, D. A., and Thompson, G. B.: Breast cancer risk factors and screening: United States, 1987. Vital Health Stat [10] 172 (1989).
28. NCI Breast Cancer Screening Consortium: Screening mammography: a missed clinical opportunity? JAMA 264: 54–58, Jan. 5, 1990.

29. Dodd, G. D.: The major issues in screening mammography: the history and present status of radiographic screening for breast cancer. Cancer 60: 1669–1702 (1987).
30. Brown, M. L., Kessler, L. G., and Rueter, F. G.: Is the supply of mammography machines outstripping need and demand? An economic analysis. Ann Intern Med 113: 547–552 (1990).
31. Carter, A. P, et al.: A clinically effective breast cancer screening program can be cost-effective, too. Prev Med 16: 19–34 (1987).
32. van der Maas, P. J., et al.: The cost-effectiveness of breast cancer screening. Int J Cancer 43: 1055–1060 (1989).
33. Will, J., Geiss, L., and Wetterhall, S.: Diabetic retinopathy. N Engl J Med 323: 613–614 (1990).
34. Klein R., et al.: The Wisconsin epidemiologic study of diabetic retinopathy. II. Prevalence and risk of diabetic retinopathy when age at diagnosis is less than 30 years. Arch Ophthalmol 102: 520–526 (1984).
35. Klein, R., et al.: The Wisconsin epidemiologic study of diabetic retinopathy. III. Prevalence and risk of diabetic retinopathy when age at diagnosis is 30 or more years. Arch Ophthalmol 102: 527–532 (1984).
36. Public Health Service, Centers for Disease Control: Diabetes surveillance. National Center for Chronic Disease Prevention and Health Promotion, Division of Diabetes Translation. Atlanta, GA, 1990.
37. Karma A., et al.: Predicting diabetic retinopathy. Acta Ophthalmol 65: 136–139 (1987).
38. Klein, R., Moss, S. E., and Klein, B. E. K.: New management concepts for timely diagnosis of diabetic retinopathy treatable by photocoagulation. Diabetes Care 10: 633–638 (1987).
39. Burns-Cox, C. J., and Dean Hart, J. C.: Screening of diabetics for retinopathy by ophthalmic opticians. Br Med J 290: 1052–1054 (1985).
40. Dean Hart, J. C., et al.: The role of optometrists in screening diabetic retinopathy. Semin Ophthalmol 2: 68 (1987).
41. Sussman, E. J., Tsiaras, W. G., and Soper, K. A.: Diagnosis of diabetic eye disease. JAMA 247: 3231–3234, June 18, 1982.
42. Diabetic Retinopathy Study Group: Photocoagulation treatment of proliferative diabetic retinopathy: clinical application of diabetic retinopathy study (DRS) findings. DRS No. 8. Ophthalmol 88: 583–600 (1981).
43. Early Treatment Diabetic Retinopathy Study Research Group (ETDRS): Photocoagulation for diabetic macular edema: early treatment. DRS No. 1. Arch Ophthalmol 103: 1796–1806 (1985).
44. Will, J., et al.: Compliance in eye disease screening programs. Diabetes 10: 351A (1991).
45. Preventing blindness from diabetic eye disease—Texas. MMWR Morb Mortal Wkly Rep 39: 812–813, 819, Nov. 16, 1990.
46. Dasbach, E. J., et al.: Cost effectiveness of strategies for detecting diabetic retinopathy. Med Care 29: 20–39 (1991).
47. Foulds, W. S., et al.: Diabetic retinopathy in the west of Scotland: its detection and prevalence, and the cost-effectiveness of a proposed screening programme. Health Bull 41: 318 (1983).
48. Javitt, J. D., Canner, M. K., and Sommer, A.: Cost effectiveness of current approaches to the control of retinopathy in type 1 diabetics. Ophthalmology 96: 255–264 (1989).
49. Kolbe, L. J.: The epidemiological surveillance system to monitor the prevalence of youth behaviors that most affect health. Health Ed 21: 44–48 (1990).
50. Dwyer, T., Viney, R., and Jones, M.: Assessing school health education programs. Int J Technol Assess Health Care 7: 286–295 (1991).
51. Connell, D. B., Turner, R. R., and Mason, E. F.: Summary of the findings of the school health education evaluation: health promotion effectiveness, implementation, and costs. J Sch Health 55: 316–321 (1985).
52. Bush, P. J., et al.: Cardiovascular risk factor prevention in black schoolchildren: two-year results of the "Know your Body" program. Am J Epidemiol 129: 466–482 (1989).
53. Walter, H.: Primary prevention of chronic disease among children: the school-based "Know Your Body" intervention trials. Health Ed Q 16: 210–214 (1989).
54. Walter, H., and Wynder, E.: The development, implementation, evaluation, and future directions of chronic disease prevention programs for children: the "Know Your Body" studies. Prev Med 18: 59–71 (1989).
55. Davis, R. L., et al.: Comprehensive school health education: a practical definition. J Sch Health 55: 335–339 (1985).
56. Banta, H. D., and Luce, B. R.: Assessing the cost-effectiveness of prevention. J Community Health 9: 145–165 (1983).
57. Brown E. Y., Viscoli C. M., and Horwitz R. I.: Preventive health strategies and the policymakers' paradox. Ann Intern Med 116: 593–597 (1992).
58. Banta, H. D., and Thacker, S. B.: Reassessment of medical technologies: once is not enough. JAMA 264: 235–240, July 11, 1990.
59. Koplan, J. P., and Gutzwiller, F. F.: Some observations on the assessment of preventive technologies. Int J Technol Assess Health Care 7: 361–364 (1991).
60. Thacker, S. B., and Berkelman, R. L.: Surveillance of medical technologies. J Public Health Policy 7: 363–377 (1986).
61. Thacker, S. B., and Berkelman, R. L.: Public health surveillance in the United States. Epidemiol Rev 10: 164–190 (1988).
62. Katz, S., and Akpom, C. A.: A measure of primary sociobiological functions. Int J Health Serv 6: 493–508 (1976).
63. Katz, S., et al.: Active life expectancy. N Engl J Med 309: 1218–1224, Nov. 17, 1983.
64. Stewart, A. L., et al.: Functional status and well-being of patients with chronic conditions. JAMA 262: 907–913, Aug. 18, 1989.
65. Roper, W. L., et al.: Effectiveness in health care: an initiative to evaluate and improve medical practice. N Engl J Med 319: 1197–1202, Nov. 3, 1988.
66. Foege, W. H.: Budgetary medical ethics. J Public Health Policy 4: 249–251 (1983).