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An Investor's Look at Life-Saving Opportunities

John D. Graham, Ph.D.

In public health and medicine, there are numerous lifesaving measures that could be implemented, whether by ordinary citizens, physicians, businesses, or government agencies. A "lifesaving" measure is any behavioral and/or technological intervention that reduces the risk of premature death in a specific target population.

All lifesaving measures sound good to an unsophisticated audience, but they were not created equal. In fact, lifesaving measures vary enormously in their effectiveness, in their cost, and in their ratio of effectiveness to cost ("bang for the buck").   People who advocate or fund one lifesaving measure often have no idea how cost-effective that measure is compared to other feasible lifesaving investments.

"...When lives are at stake, we believe it is particularly important to expend resources wisely."

In this issue of **RISK IN PERSPECTIVE**, we offer a glimpse at how an investor might rate different lifesaving opportunities in the USA. When lives are at stake, we believe it is particularly important to expend resources wisely. To do otherwise is to engage in what we call "statistical murder" -- a phrase meant (with provocative intent) to protect the interests of anonymous people whose lives are lost when cost-effectiveness considerations are ignored. We also discuss some of the critical features and limitations of a particular effectiveness measure, quality-adjusted life years (QALYs) saved, that was recently recommended by an Expert Panel commissioned by the U.S. Department of Health and Human Services.

In a recent report published in the *Annual Review of Public Health*, a team of faculty and students at HCRA compared the cost-effectiveness of 40 lifesaving measures designed to prevent or treat cancer, heart disease, trauma, and infectious disease. The "league table" published in this issue of Risk in Perspective provides readers a sense of perspective about the relative efficiency of lifesaving opportunities. For technical details and data sources, readers should consult the article and associated references. Here we highlight some of the key principles and controversies associated with choosing an effectiveness measure for use in cost-effectiveness comparisons.

HOW IS EFFECTIVENESS MEASURED?

Several decades ago, when the field of risk analysis was founded, a lifesaving measure's effectiveness was defined by the number of lives saved. We later realized that this measure is meaningless, because lives are never really saved. Everyone will die sooner or later -- as far as we can tell!

Dying at the age of 20 strikes people as much more "premature" than dying at the age of 80, even though death at age 80 can still be very disconcerting. Some have suggested that lifesaving measures should be judged by how many "EARLY

DEATHS" are prevented, where an early death might be defined as one that occurs prior to a specified age, such as 65 or 70. The U.S. Centers for Disease Control has published some information that uses such a cut-off. Yet it seems rather arbitrary and callous to imply that life after age 65 is worthless, even if economic productivity were the only concern (which it clearly is not).

A fairly objective statistic that is widely employed to compare different countries and populations is life expectancy, expressed as the average number of years of life. In the USA, a baby born today is expected to live an average of about 80 years (assuming current death rates at each age continue indefinitely). An average 65-year old in the USA can be expected, on average, to live about 20 additional years. In many cost-effectiveness studies, including those published by the Center, lifesaving measures are judged according to how many **years of life** they save.

Although the number of life years saved (or lost) can often be calculated, a problem arises when the additional years of life are not of ideal quality. Living a year of life in good health (e.g., no pain and complete functional status) is a different matter from living a year of life with various kinds of morbidities such as severe chest pain, deafness, arthritis, dementia, or periodic bouts of asthma. Moreover, some measures that save life years also reduce illnesses or impairments that are not fatal but are debilitating. Life expectancy measures do not account for these quality-of-life concerns. Thus, the field of risk analysis has developed new measures of effectiveness that account for changes in quality of life as well as changes in life expectancy.

One such measure is called the **quality-adjusted life year**(QALY), where each year of life is rated (by patients or citizens in the community) on a scale from 0 to 1, where 1 represents perfect health and 0 represents the worst possible health state (often death). If a year in poor health (e.g., severe chest pain) is rated 0.6, it means that the respondent believes that living 10 years with severe chest pain is of equal value to him or her as living 6 years in perfect health. Although such quality-of-life tradeoffs are inherently subjective, there is a strong consensus in the field that quality of life can no longer be ignored. A rapidly growing literature has developed methods for eliciting quality-of-life weights from lay citizens in a rigorous and thoughtful manner. If a person is too young or mentally impaired to participate in a QALY study, the quality-of-life judgment may be supplied by a loved one or a nurse on behalf of the patient.

The QALY measure is useful because it allows information on life expectancy and quality of life to be combined into a single number. For example, consider the case for coronary artery bypass surgery where, absent surgery, a hypothetical patient is assumed to live 10 more years at an average quality weight of 0.6. If surgery can increase life expectancy to 15 years at an average quality level of 0.8, the total effectiveness of surgery is 6 extra QALYs: 4 from the longevity effect (5 x 0.8) and 2 from the improved quality of life (10 x (0.8 - 0.6)).

The original sources of objective data on a measure's effectiveness may come from numerous sources ranging from a randomized clinical trial with human or animal subjects to a natural experiment where epidemiologists compare the health status of citizens with and without a particular intervention or risk factor. In order to make estimates of QALYs gained or lost, objective data on effectiveness must be combined with subjective quality-of-life data in a mathematical model.

WHY NOT EXPRESS EFFECTIVENESS IN MONETARY UNITS?

Some advocates of cost-benefit analysis believe QALYs should be replaced by monetary measures of effectiveness. If this could be done credibly, then the monetary costs of implementing a measure could be compared to the effective-

Cost-Effectiveness Ratios for Selected Lifesaving Measures (1995 $)

Intervention	Comparator	Taget Population	Cost per QALY Saved*
Lap/Shoulder Belts (50% use)	No Restraints	Drivers of Passenger Cars	<0
Daytime Running Lights	Nighttime Lights Only	All Motor Vehicles	<0
Promote Condom Use to Prevent HIV Transmission	No Program	Self-Identified Gay Men	<0
Restriction of Cigarette Sales to Minors	No Restrictions	Children Less Than Age 18	<0
Adjuvant Tamoxifen Chemotherapy	No Such Therapy	Women, Age 45, with Early Stage Breast Cancer	$950
Coronary Angioplasty	No Revascularization	Patients with Severe Angina And One-Vessel Disease	$10,000
Pap Smear Every 4 Years	No Screening	Women Ages 20 - 75	$16,000
Annual Colorectal Screening	No Screening	People Ages 50-75	$18,000
Frontal Airbag System with Manual Belts	Manual Belts (50% Use)	Drivers of Passenger Cars	$24,000
Radon Mitigation in Homes	No Testing or Mitigation	Home Residents with Radon Levels Above 20 pCi/liter	$57,000
Dual Passenger Airbags	Driver-Only Airbags	Front-Right Passengers	$61,000
Autologous Bone Marrow Transplantation	Standard Chemotherapy	Women, Age 45, with metastatic Breast Cancer	$110,000
Coronary Angioplasty	No Revascularization	Patients with Mild Angina and One-Vessel Disease	$110,000
Annual Mammography	Annual Clinical Breast Exam	Women Ages 55-65	$150,000
Methylene Chloride Exposure Limit of 25 ppm	Limit of 500 ppm	Workers Exposed to Methylene Chloride	$190,000
Annual Mammography	Annual Clinical Breast Exam	Women Ages 40-50	$240,000
Solvent-Detergent to Eliminate AIDS Virus and Other Infectious Diseases	No Solvent-Detergent	Patients Undergoing Plasma-Transfusion	$310,000
Screening to Prevent HIV Transmission to Patients	Universal Precautions	Health Care Workers in Acute Care Setting	$490,000
Annual Pap Smear	Pap Smear Every Two Years	Women Ages 20-75	$1,600,000
Lap/Shoulder Belts (9% use)	No Restraints	Rear-Center Seats of Passenger Cars	$2,400,000
Screening and Treatment to Prevent HIV Transmissions	No Screening	Surgeons Every 10 Years	$4,100,000
Prophylactic Intravenous Immunoglobulin	No Prophylaxis	Patients with Chronic Lymphocytic Leukemia	$7,400,000

*Rounded to 2 significant figures.

Harvard Center for Risk Analysis
Harvard School of Public Health
718 Huntington Avenue
Boston, Massachusetts
02115-5924

617 432-4497
www.hsph.harvard.edu/organizations/hcra/hcra.html

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FURTHER READING

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PEER REVIEWERS:

John Evans, Sc.D.

Milton Weinstein, Ph.D

ness of the measure, expressed in monetary units.

There are two principal barriers to widespread acceptance of cost-benefit analysis in this setting. Monetary measures of benefit typically give an advantage to the wealthy compared to the poor, whereas quality-of-life measures have not been shown to be influenced by the respondent's wealth or income. Moreover, some survey researchers believe that answers to questions about quality of life may be more reliable and valid than answers to monetary questions about how much money a person might be willing to pay for improved health. Until these ethical and technical concerns are overcome, it is doubtful whether monetary measures of benefit, even if calculated and published, will be generally accepted.

If QALYs are used instead of a monetary measure of effectiveness, then a variety of assumptions and limitations must be acknowledged. Here are some of the more important ones. First, citizens are assumed to value the following two programs equally: Program A that saves 10 QALYs for sure and Program B that has a 10% chance of saving 100 QALYs and a 90% chance of saving 0 QALYs. The assumption is that citizens should seek to maximize the expected number of QALYs over many uncertain decisions. Second, each QALY is treated the same, regardless of the demographics of the population (rich, poor, old, young, male, female, Polish, Norwegian). Third, a measure that saves 10 QALYs is assumed to be twice as valuable as a measure that gains 5 QALYs. Fourth, a measure that offers 10 people 5 additional QALYs each is assumed to be of equal value to a measure that offers one person 50 additional QALYs. Finally, no one has figured out a credible way to incorporate the welfare of non-human species into the QALY measure. If a lifesaving measure saves, for example, birds as well as humans, the benefits to birds need to be reported separately from the human QALYs that are saved.

Some of these assumptions (and others) are controversial and thus efforts are underway to develop even more sophisticated measures of effectiveness. The World Health Organization and the World Bank are using a slightly different measure of effectiveness called **disability-adjusted life years** (DALYs). One of the major differences between DALYs and QALYs is that the DALY approach assumes that years of life in middle age are more valuable to society -- even after adjusting for their health-related quality -- than years of life at the beginning and end of the lifespan. In contrast, the QALY approach assumes that all years of perfect health are of equal value, regardless of where in the lifespan they occur.

CONCLUSION

It is feasible to compare the cost-effectiveness of alternative public health and medical interventions that save lives and/or reduce illnesses or injuries. Although risk analysts have been criticized for using simplistic measures of effectiveness (e.g., lives saved), progress has been made in recent years. Metrics such as quality-adjusted life years (QALYs) saved can account for an intervention's impact on quality of life as well as length of life. Ordinary citizens have an important role to play in providing thoughtful quality-of-life weights that can be used in cost-effectiveness analyses.

Policy makers can take a modest step toward better resource allocation by requiring that any proposed lifesaving investment be subjected to a cost-effectiveness analysis. Elected officials are certainly entitled to allocate resources inefficiently if that is what their constituents desire; yet it may be that their constituents are not aware of how our lives could be lengthier and healthier with wiser investments. Risk analysts have a professional obligation to offer this kind of information for consideration.