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The high and rising cost of medical care is a perennial topic of concern. The problem is usually framed in terms of dollars—dollars spent for bypass surgery, dollars needed for clinical research, dollars spent per capita in the United States compared with other countries, and total dollars spent by the nation. As useful as they are for many purposes, dollars can obscure an underlying truth. The true cost of investing in one kind of medical care is not money, nor even the resources the money represents. It is the health benefits—longer life, better functioning, and freedom from pain—that could have been achieved if the dollars had been spent on something else.

Economists apply the term opportunity cost to this view of costs. The opportunity cost of devoting resources to a particular use is defined as the loss of the benefits the resources could have produced had they been put to their next-best use—the lost opportunity to invest in that alternative. The benefits from the next-best use may be smaller than those of the current use, indicating that the current use is best, or they may be greater, in which case the alternative is preferable.

Opportunity cost analysis suggests such questions as, How much good health would be lost if more money were allocated to this intervention rather than that one? What is the most productive investment, in terms of health, for any new resources? What are the least productive current investments? The notion of opportunity cost provides a way to address these questions without losing sight of the main purpose of medical care—to improve health.

Cost-effectiveness studies show the opportunity costs of medical choices, although this is not emphasized in the way they are conventionally presented. Study results are usually presented in the form of a cost-effectiveness ratio—most commonly, dollars per year of life saved.

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But the cost-effectiveness ratio can be used to focus directly on the alternative health benefits of different medical interventions, and thus on opportunity costs, simply by calculating the number of life-years that could be achieved with a fixed amount of money.

One example of this is the cost-effectiveness ratios of two drugs, Propranolol and Lovastatin, using the medical component of the Consumer Price Index (CPI) updated to 1990 dollars.\textsuperscript{1} Prescribed for people ages thirty-five to sixty-four, Propranolol is the most cost-effective of the drugs used to treat mild to moderate hypertension. At $13,640 per life-year in 1990, $1 million spent on Propranolol would buy 73.3 life-years. Lovastatin prescribed to reduce cholesterol in low-risk men ages thirty-five to forty-four costs $727,260 per life-year saved, and $1 million would buy 1.4 life-years. Both drugs are used here for “primary” prevention, that is, to prevent future disease in people who do not have heart disease at the outset of treatment. Both can also be used to prevent subsequent coronary events in people who have already suffered one or more events (“secondary” prevention). Restatement of cost-effectiveness ratios in terms of life-years per $1 million brings out the opportunity costs involved by focusing on the amount of health that could be “purchased” when the same amount of money is used for different interventions. If these were the only two interventions under consideration, the opportunity cost of investing in Propranolol—the next-best use of the resources—would be the 1.4 years that could have been achieved if the money had been spent on Lovastatin instead. The opportunity cost of investing in Lovastatin would be the 73.3 life-years that would be lost because the resources were not used for Propranolol. Propranolol is clearly the better health investment of the two.

There are not enough cost-effectiveness studies, nor are existing studies precise enough, to apply the notion of opportunity cost exactly by identifying the next-best use of resources in every case. Still, looking at evaluations of some important interventions gives a sense of the range of opportunity costs in modern medicine and outlines some of the potentially important dimensions along which opportunity costs can be considered. In what follows, interventions are compared in terms of the number of life-years produced for an expenditure of $1 million (1990 dollars). Since $1 million is not enough to provide the intervention to the entire population analyzed in each study, the expenditure should be considered to apply to a group representative of the study population. In addition, there is no requirement that the money be spent in a single year. For most of the interventions considered, the time span over which the intervention is applied is longer than a year.
Comparing Interventions

Exhibit 1 provides an overview of opportunity costs in modern medicine. All of the interventions are well accepted and widely used, but the differences in the amount of health that can be bought with $1 million are large. Monitoring low-risk chest pain patients in coronary care units would produce three life-years. The Pap smear, used to screen women for cervical cancer every three years starting at age twenty and ending at age seventy-five, would produce fifty-two life-years.

Bypass surgery for middle-aged men with clinically evident symptoms of left-main coronary artery disease is the most productive investment in the exhibit, at 134 years of life. The number is somewhat overstated, since the analysis omitted the costs of diagnosis, but it also reflects the fact that bypass surgery is quite effective as a therapy for this condition. The example of bypass surgery shows that expensive programs or procedures are not necessarily inferior to inexpensive ones. The important test is how much health is produced for the fixed expenditure; expensive procedures, if also very effective, can be quite productive. Life-years are, of course, an imperfect measure of health, since they do not include improvements in functional status and in the quality of life, but they are a useful first approximation.

The results also point to the importance not only of the particular intervention but of the group to which it is applied (Exhibit 2). Influenza vaccine produces the most life-years for an expenditure of $1 million among the elderly. This figure is calculated from one of the higher cost-effectiveness ratios produced by the study; alternative as-

<table>
<thead>
<tr>
<th>Exhibit 1</th>
<th>Years Of Life Bought For $1 Million (1990 Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring low-risk patients in coronary care units</td>
<td>3 life-years</td>
</tr>
<tr>
<td>Lovastatin as primary prevention for low-risk men ages 35-44 with pretreatment cholesterol 300+</td>
<td>3 life-years</td>
</tr>
<tr>
<td>Pap smear every 3 years</td>
<td>52 life-years</td>
</tr>
<tr>
<td>Propranolol for mild to moderate hypertension</td>
<td>73 life-years</td>
</tr>
<tr>
<td>Bypass surgery for left-main coronary artery disease in middle-aged men</td>
<td>134 life-years</td>
</tr>
</tbody>
</table>


a Low-risk patients are those at 5 percent risk of a myocardial infarction based on evaluation at admission.
b Low-risk is defined as nonsmoker, less than 10 percent overweight, and diastolic blood pressure below 95. The prescribed regimen of Lovastatin is 20 milligrams per day.
### Exhibit 2

**Years Of Life Bought For $1 Million (1990 Dollars) For Elderly Persons**

<table>
<thead>
<tr>
<th>Vaccine Type</th>
<th>Life-Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumococcal pneumonia vaccine</td>
<td>100</td>
</tr>
<tr>
<td>Influenza vaccine</td>
<td>11,100</td>
</tr>
</tbody>
</table>

Lovastatin as primary prevention for people ages 65-74, pretreatment cholesterol 300+:

- **Low-risk women**
- **Low-risk men**
- **High-risk women**
- **High-risk men**

All categories: Maybe zero life-years

Lovastatin as secondary prevention for people ages 65-74, pretreatment cholesterol 250+:

- **Women**: 95 life-years
- **Men**: 79 life-years

**Sources:**
- Primary prevention refers to drug treatment of people free of coronary heart disease at the beginning of treatment; secondary prevention, to drug treatment of those who have already suffered angina pectoris, myocardial infarction, or cardiac arrest. The prescribed regimen of Lovastatin is 20 milligrams per day.
- Low-risk is defined as nonsmoker, less than 10 percent overweight, and diastolic blood pressure below 95.
- High-risk is defined as smoker, 30 percent or more overweight, and diastolic blood pressure 105 or higher.

Assumptions showed that the vaccine would be cost-saving for this age group.\(^2\) The pneumococcal vaccine, again for all persons age sixty-five or older, produces 100 life-years for an expenditure of $1 million; this analysis assumed that 10 percent of all pneumonias were of the pneumococcal type and the immunity conferred by the vaccine lasted three years. Lovastatin as primary prevention for people ages sixty-five to seventy-four produces fourteen to sixteen life-years for low-risk men and women and twenty-four to forty-one life-years for high-risk people. Used for people who have already suffered a coronary event, Lovastatin yields seventy-nine to ninety-five years of life for each $1 million.\(^3\)

The evidence for, and models of, medical effectiveness for each intervention are critical to cost-effectiveness results and thus to the opportunity costs presented here. The same evidence and controversies that are important for clinical decisions are important for defining opportunity costs. As one example, results for Lovastatin used as primary prevention rest on the assumption that reducing cholesterol will lengthen life expectancy in the elderly, which has not yet been documented. A report by the congressional Office of Technology Assessment (OTA) states that “the few studies that investigated this issue found either that the cholesterol level does not predict total mortality at all or that it is a statistically significant predictor of lower mortality.”\(^4\) Lovastatin as primary prevention may result in no health gain for the elderly.
The first question about any intervention is whether to use it at all. For effective interventions, there are then questions about how much to use, how often, for whom, and under what circumstances. The opportunity costs associated with these seemingly minor issues can be large. Exhibit 3 presents opportunity costs for three interventions applied to a high-risk group and a low-risk group. For example, $1 million spent on monitoring chest-pain patients in coronary care units produces fourteen life-years if spent on a high-risk group (20 percent risk of heart attack) and only three life-years if spent on patients with a 5 percent risk.

The differences between risk groups in the effectiveness of therapy depend again on the validity of the model used. In the case of Lovastatin, the model is the multiple logistic estimated by researchers involved with the Framingham study. The multiple logistic incorporates an untested assumption about risk—that a reduction in any one risk factor, such as cholesterol, causes a much larger reduction in the risk of heart disease for someone with several risk factors than the same reduction would produce for someone whose only risk factor was cholesterol. If instead the reduction in risk is the same regardless of other risk factors present or follows still some other pattern, the opportunity costs for high-risk and low-risk men would be different from those shown, and the gap between them might not be so large.

Exhibit 4 shows the opportunity costs of increasing the frequency or dosage of two interventions. For each, the first frequency or dosage is compared with doing nothing. For the Pap smear, spending $1 million to provide screening every three years would produce fifty-two life-years.

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**Exhibit 3**

**Years Of Life Bought For $1 Million (1990 Dollars), For High-Risk And Low-Risk Groups**

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Life-Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring chest pain patients in coronary care units</td>
<td></td>
</tr>
<tr>
<td>20% risk of myocardial infarction</td>
<td>14</td>
</tr>
<tr>
<td>5% risk of myocardial infarction</td>
<td>3</td>
</tr>
<tr>
<td>Bypass surgery, middle-aged men</td>
<td></td>
</tr>
<tr>
<td>Left-main disease</td>
<td>134</td>
</tr>
<tr>
<td>One-vessel disease</td>
<td>17</td>
</tr>
<tr>
<td>Lovastatin as primary prevention for men, pretreatment cholesterol 300+</td>
<td></td>
</tr>
<tr>
<td>Ages 55-64, high-risk</td>
<td>63</td>
</tr>
<tr>
<td>Ages 35-44, low-risk</td>
<td>3</td>
</tr>
</tbody>
</table>


* Risk of myocardial infarction evaluated at admission.

* High-risk is defined as smoker, 30 percent or more overweight, and diastolic blood pressure 105 or higher. Low-risk is defined as nonsmoker, less than 10 percent overweight, and diastolic blood pressure below 95. The prescribed regimen of Lovastatin is 20 milligrams per day.
Years Of Life Bought For Increments Of $1 Million (1990 Dollars), By Increasing Frequency Or Dose Of Intervention

| Pap smear for women ages 20-75 | Every 3 years | 52 life-years |
|                                | Every 2 years | 2 additional life-years |
|                                | Every year    | Less than 1 additional life-year |

| Lovastatin as secondary prevention for men ages 55-64, pretreatment cholesterol 250+ | 20 mg per day | 593 life-years |
|                                                                                   | 40 mg per day | 55 additional life-years |
|                                                                                   | 80 mg per day | 13 additional life-years |

Sources: Data on Pap smears every three and two years from D.M. Eddy, “Screening for Cervical Cancer;” unpublished data for annual screening supplied by D.M. Eddy; and for Lovastatin, L. Goldman et al., “Cost-Effectiveness of HMG-CoA Reductase Inhibition.”

compared with no screening. For Lovastatin used as secondary prevention, $1 million spent on a regimen of twenty milligrams per day would produce 593 life-years, compared with doing nothing.

The numbers for more frequent tests or higher doses show the additional life-years that could be produced if an additional $1 million were spent; in cost-effectiveness terminology, these are incremental analyses, and the results shown in Exhibit 4 are thus incremental opportunity costs. For the Pap smear, for example, an additional $1 million spent to increase the frequency of testing from three to two years would produce an additional two years of life. Another $1 million, to provide annual testing, would add less than one additional life-year.

The range of opportunity costs relevant to health extends beyond medical care, to highway safety, pollution, crime, drug addiction, and other aspects of life. Good cost-effectiveness studies in these areas, as in medical care, can illuminate the opportunity costs of alternative investments in health and put spending decisions in a larger perspective.

Discussion

The interventions I have discussed here are ones for which cost-effectiveness analyses have been done and for which life-years are a reasonable measure of health outcome. While they are important interventions, there may be many others that have not been subjected to cost-effectiveness analysis and whose opportunity costs are much greater or much less. In addition, for many interventions, life-years are not the best or most important measure of health outcome. Much of modern medicine improves the quality of life with little or no impact on its length. Comparisons across the full range of medical interventions re-
quire the use of an outcome measure, such as the quality-adjusted life-year, that can accommodate these different outcomes. Since opportunity costs are derived from cost-effectiveness analyses, the same issues arise about using such a measure for making real decisions about real medical services. One is the problem of the inevitable gaps in scientific information about an intervention. It is important to recognize that these gaps are no more or less a problem for opportunity-cost calculations, and the cost-effectiveness analyses on which they are based, than for clinical decisions. All three depend on the same information about medical effectiveness, and all three suffer when that information is seriously incomplete.

Cost-effectiveness results, and thus opportunity costs, sometimes raise concerns about equity and distributive justice. These concerns seem to be due to fear that cost-effectiveness favors the young, healthy, and well-to-do over the old, sick, and poor. However, this is not the case. Cost-effectiveness favors those for whom medicine can make a difference—often precisely the old, sick, and poor, because prevalence and incidence rates of disease are higher in these groups and, for the poor, because they have received fewer services in the past. For example, OTA studies show that both the pneumococcal and influenza vaccines are more cost-effective for the elderly than for younger, healthier groups. Also, Jeanne Mandelblatt and Marianne Fahs have shown that Pap smears for low-income elderly women who have been infrequently screened in the past are cost-saving, in sharp contrast to the high cost, indicated by the low health output for $1 million in Exhibit 4, of annual Pap smears for average-risk women who have been screened regularly.

Different kinds of opportunity costs will be useful at different levels of decision making and need to be accompanied by estimates of the budget required to make each intervention available to the specified population at the specified frequency and dose. Information about the whole range of opportunity costs in medicine (Exhibits 1 and 2, for example) can be useful to policymakers responsible for public programs and to private insurers, who must make decisions about payment and coverage. Some OTA analyses have been used by Congress to make coverage decisions for Medicare. The narrower range of information in Exhibits 3 and 4 about risk groups, dosages, and frequency would be useful to guidelines developers preparing recommendations for clinicians. A wider range of opportunity costs—pollution, highway safety, and the like, in addition to medical care—would be relevant to national and state legislators and executives; at that level, opportunity costs could influence decisions about reducing or increasing expenditures.

None of these decisionmakers need choose among opportunity costs
as though life-years were equally valuable in all situations. In a recent article about Oregon’s Medicaid reform initiative, David Hadorn argues that by the “Rule of Rescue,” people often prefer to save lives even when cost-effectiveness indicates that the resources could do more to improve health if used in other ways. In response, William Stason notes that this is likely to lead to choosing interventions that focus on a few individuals over those whose health benefits are spread over many people. Awareness of opportunity costs will serve to sharpen such value judgments as the health spending debate continues.

This paper is based on a talk given at the workshop on cost considerations, National Conference on Cholesterol and High Blood Pressure Control, 10 April 1991. I am grateful to Gerald Grob, David Mechanic, and two anonymous reviewers for comments on earlier drafts.

NOTES


2. The figure is based on the assumption that vaccination would be provided through private doctors’ offices at what was considered at the time to be a rather high cost for the vaccine—$9.39 in 1978, or about $25 in 1990.

3. The article also included results for people ages seventy-five to eighty-four, but the essential point is the same.


