ASSESSING THE ECONOMIC IMPACT OF MEDICAL INTERVENTIONS: WHAT IS THE PRICE OF SUCCESS?

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ABSTRACT

Certain medical interventions may result in reduced costs to society. Others, however, by keeping people alive longer, may cause higher costs to be incurred for continuing health care and disability and retirement payments. A generic disease process model for projecting the cost implications of various medical interventions is presented. The model is applied to myocardial infarction in the U.S. male population and results of simulating several interventions specific to that disease process are discussed. Conclusions are drawn and it is argued that this model is useful for identifying interventions that result in higher costs to society in order that adequate resources be set aside to cover those costs.
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INTRODUCTION

The absolute magnitude of health care spending and the rate at which it continues to rise each year have made health care costs one of the most serious social and economic problems we face. There has been a conviction that the key to controlling these rising costs is tigher control of health care expenditures through better reimbursement schemes and programs that limit the availability of health resources such as certificates-of-need. People have also felt, at least in the past, that new health care technologies would help to alleviate various diseases and thereby reduce health care costs by making people "well".

There is a growing awareness, though, that a substantial

part of the rise in health care costs is due to growth in the number of older people, resulting increases in the prevalence of chronic diseases, and the availability of Medicare funding to finance the care needed by older people. Medicine cannot cure these chronic diseases and can only keep them under control at best. Therapeutic interventions have proven to be quite costly. Preventive approaches offer some promise, but their impacts on health care costs are unclear.

The policymaker has a hard time discerning a direction in which to move when faced with these new realizations as well as the "old truths". He must consider a number of questions in considering cost control measures and proposed investments in new medical technologies. How much impact can particular health policy and fiscal measures have when the shift in the population toward older age groups play an important role in cost escalation? What is the cost impact of medical technologies that treat disease once it develops and thereby help to prolong life? How much can preventive strategies do to control costs? If medical technologies can prolong life, what will the implications be for the size of the elderly population and for the Social Security System that is already encountering difficulty in supporting the existing elderly population? These are essential questions to be answered befor major new health programs are enacted, lest the public be "overpromised" about what fiscal measures can do to control health care costs and then be disillusioned in the long run if costs are not controlled.

This paper describes a tool that can help policymakers examine particular disease processes and assess the economic impacts of medical interventions in those processes. The tool is a computer simulation model that consists of a number of numerical relationships. These relationships are used to project a population's experience with a particular disease process over a multi-year time period. The simulations use the DYNAMO computer simulation language to step through time, iteratively computing changes that will occur in various populations due to rates of change (e.g., incidence rates, mortality, and aging), updating the population to reflect those rates, and calculating new rates based on the updated populations.

After presenting the model, the paper goes on to describe the model's application to a particular disease process, myocardial infarction. The paper reports on how the model was quantified to represent myocardial infarction as it affects the U.S. male population and the results that were obtained when several interventions were implemented. The results are not meant to be predictions of the impacts these interventions will have, but allow the reader to contrast the cost impacts of therapeutic, rehabilitative, and preventive interventions. The results are not used to argue for or against particular interventions, but to argue for a new perspective for looking at technological interventions in disease processes.

Lest the reader draw the wrong conclusions, it is important to point out that the authors are <u>not</u> advocating the avoidance of

medical interventions that successfully prolong life simply because in doing so, they create higher costs for society. The value of an extra year of human life goes beyond what can be calculated from a cost-benefit analysis. The central point is, instead, that if certain medical interventions result in higher costs to society, additional resources must be set aside to cover those costs. The Social Security system, reported to face bankruptcy within a few years, must be reformed and strengthened if medical interventions are going to help people live longer and increase the number drawaing benefits from the system. The health care system must be strengthened and made more efficient if there are to be sufficient resources to care for the larger numbers of older people without crippling emerging efforts to make primary care more available to lower income and other underserved populations. Gerontology must make significant advances to assure a higher quality of life during the later years of extended lifespans. If these and similar measures are not taken, it will be difficult to derive the benefits that should accrue from medical interventions and the longer lifespans they make possible.

The next section describes the model that has been developed.

<u>STRUCTURE OF THE GENERIC DISEASE PROCESS MODEL</u>

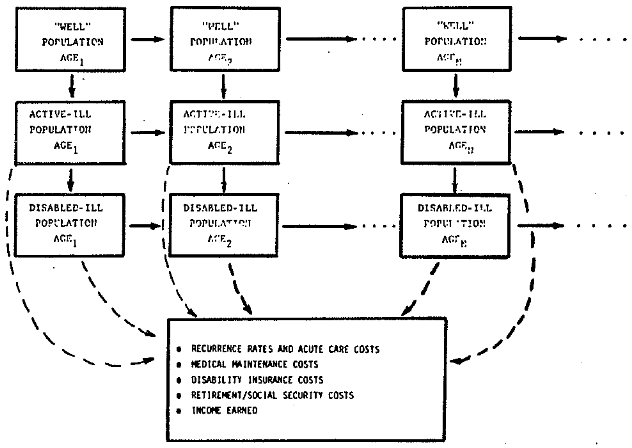
Development of the disease process model began with the disaggregation of the population into several categories. Separating the "well" population and the "sick" population (people who have had at least one experiene with the disease process being considered) was an obvious first step. Further separation of the sick population into active (those who have had some experience with the disease, but have been able to continue their principal activity) and disabled categories was necessary to calculate the sick population's contribution to the general economy (measured by its earnings) and a component of the cost of the disease to the economy, disability income payments. The distribution of peole in the sick population between these two categories for a given disease is an important determinant of the net impact ofthe disease on the economy.

Because many disease processes exhibit marked differences in incidence and survival rates among age groups, age was the other major dimension along which the population was disaggregated. A shift in the population toward a larger fraction in older age groups will, for a disease process such as myocardial infarction that has its principal effect on middle-aged and older people, result in higher incidence, mortality and disability rates. Differences in incidence and mortality patterns between men and women are dealt with by using the model separately with incidence rates, survival rates, and other parameters characteristic of each sex. The two sets of results are then combined to assess impacts of medical intervention for the entire population.

Results reported later in this paper are for MI's in men only. Figure 1 shows the structure of the population categories used in the model.

DISEASE PROCESS MODEL: FIGURE 1

OVERALL STRUCTURE



The model calculates the total population of people with a particular disease by summing across these subpopulations and computes recurrence rates and acute care costs, medical maintenance costs, disability insurance payments, retirement/Social Security payments, and income earned for the total population. The view of the net economic impact of a disease process contained in the model is based on the net flow of funds between the "sick" population and the general economy. Income earnned by members of the population with the disease who are able to work is their contribution to the general economy. Subtracted from this contribution by the model are the costs of health care, disability payments, and retirement payments which are all types of funds flowing from the general economy to the population with the disease. The net flow that results (income minus costs and transfer payments) is used as a measure to contrast the effects of particular interventions in disease processes.

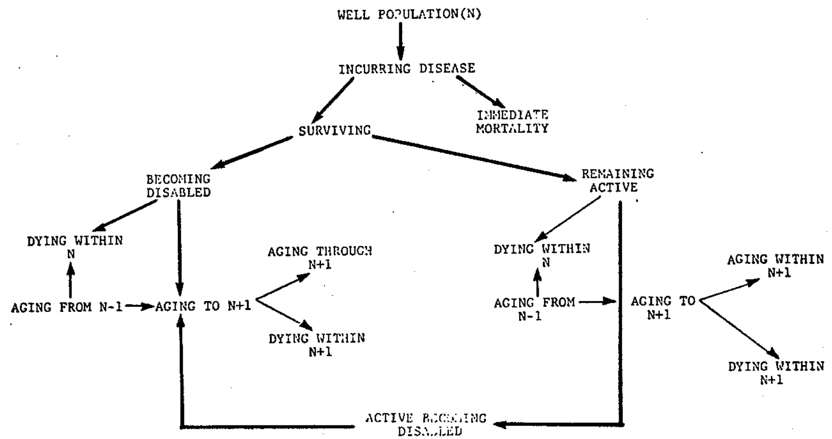
To capture the effects of interventions over time and enable comparisons of interventions, the net flow of funds between the "sick" population and general economy is accumulated over time during each simulation. This is done rather than discounting income and cost streams because the model is not being used to decide whether particular programs should be undertaken (for which discounting would be essential). The model instead is being used to compare how a number of different interventions will affect the net economic impact of a disease process over time. Using this approach also allowed the issue of which discount rate to use to be avoided and kept the results of the analysis from being influenced by the choice of a particular discount rate.

Once these categories were established, it was necessary to specify how the size of the sick population and its distribution between active and disabled categories change over time. Flows in and out of these categories within each age group that determine changes over time were diagrammed and incorporated into the model. Figure 2 shows the set of flows that affect the population's distribution among well, active, and disabled categories

in each age group.

FIGURE 2

DISEASE PROGRESS MODEL:
MODULE FOR AGE GROUP N



People move from the well to the sick population within a given age group as the result of an initial incidence of a particular disease. Of the fraction that survive the initial incidence, some enter the active category while others immediately become disabled. Some fraction of those who remain in the active category after their initial experience become disabled as a result of a later recurrence. People entering the active and disabled categories within a given age group are further divided into those who can be expected to survive past the end of that age interval and those who will die during the interval. Some fraction of the people aging on to the next age group in the active and disabled categories die in the next age group while the remainder survive to continue aging, subject only to the risk of death (due to other causes than the disease process being considered) typical of the general population in the next age group. The well population in each age group is, of course, also subject to the mortality rate for that group due to all causes other than the disease process being considered.

QUANTIFYING THE MODEL TO REPRESENT MYOCARDIAL INFARCTION

As mentioned earlier, this paper will discuss the generic model's application to myocardial infarction in the male population of the United States. Myocardial infarction was selected for the initial application because it is a leading cause of death and because it principally affects people in the older age groups. Simulating myocardial infarction would let us examine whether medical interventions in that disease process yield positive economic impacts, given the older population that is affected. Will additional earnings in the relatively few years before retirement exceed the costs of medical interventions and the higher retirement and disability payments for people who live longer? The model would help to answer this key question.

Data necessary for setting up the model to project the male population's experience with myocardial infarction came from a variety of sources. The use of data from many different sources, studies done many years apart, and some data that were possibly

out-of-date were a cause for some concern. Careful analysis with the model, however, revealed that the conclusions one might draw from the model were not very sensitive to the particular values parameters were given. In some cases, in fact, changes in particular parameters to reflect current trends (e.g., higher costs to represent more intensive use of resources by current technologies, potentially lower mortality rates to reflect improved medical care for MIs) made the results derived from the model even more dramatic rather than causing them to change.

Initial numbers of people in the "well population", birth rate trends, and immigration rates came from U.S. Census data.[1] The Framingham study was the only suitable source of data on the incidence of myocardial infarction by age and revealed annual incidence rates ranging from a low of 1.7 per 1000 per men in the 25-34 age group to a fairly constant 11.5 per 1000 for men over age 55.[2] Immediate mortality rates (the fraction dying within two months) came from a longitudinal study reported on by Cole, Singian and Katz.[3] The fraction of men surviving more than two months but dying within five years is, as reported by Cole, Singian, and Katz and represented in the model, one that ranges from 5% for men aged 25-34 to 45% for men over 65 and averages 32% across all age groups.[4]

The fraction of men becoming (permanently) disabled as a result of their first MI came from a longitudinal study of the members of a prepaid health plan reported by Shapiro, Weinblatt, and Frank. They found that those rates ranged from 2% in men 25-34 to 28% in men over 65.[5] In addition to those men immediately becoming disabled after an initial infarction, another study found that 8-10% of those men who initially return to work after an MI later (within ten years) become disabled by a recurrent MI or other cardiac disease.[6]

Societal costs (defined here as net flows from the general economy to the sick population) due to a particular disease process that are computed by the model have a number of components. A principal one is health care cost which itself has two components, acute care and maintenance. Acute care cost is the cost of a typical hospital stay for someone who had had an MI, reported by Peterson to be one of 28.5 days and costing $2,479 in 1970.[7] This cost was applied to all initial MIs in which the person survived beyond the first month. A lower cost, $922 for a 10.6 day stay[8] was attributed to each of the people who die within two months and are in the 40%[9] that die in the hospital. Health maintenance costs were assumed to be $200 per year ($250 for people over 65), a sum that appeared reasonable to cover several visits to a physician, lab tests, and necessary medications.

Disability income payments for people who cannot work as a result of a myocardial infarction are another important component of the societal costs of the disease. Disability income payment amounts used in the model come from Social Security data[10] and are, therefore, probably somewhat low since they exclude payments by private insurers.

In keeping with the basic premises of our research, retirement payments to people who have had at least one MI, but are alive past their sixty-fifth birthday are also computed and added to total societal costs. These are real costs of successful medical interventions because they would not have been incurred if people died at an earlier age as they would have without those particular interventions. They must be considered along with additional income produced by people under 65 who are able to live longer as a result of successful interventions. Income earned by people in the active sub-population is, of course, also calculated by the model and credited against the total costs arising from myocardial infarction. Retirement payment amounts and income levels came from Social Security data.[11]

REPRESENTING MEDICAL INTERVENTIONS THAT AFFECT THE OUTCOME OF MYOCARDIAL INFARCTION

Once the general disease process model was quantified to represent myocardial infarction, it was used to assess the impact of various medical interventions on that particular disease process' cost to society. To perform the simulations that project the cost impacts of various interventions, it was necessary to specify the direct impacts of these interventions on aspects of the disease process (e.g., incidence, mortality, disability) and their costs. It is important to point out that the costs and impacts assumed for these various interventions are merely illustrative and do not represent assertions by the authors that these costs and impacts are accurate. The impact of coronary care units on mortality, for example, is quite controversial and a number of studies indicate CCUs have no impact on mortality at all. Administration of anticoagulants, another form of treatment simulated, is similarly quite controversial and assuming any one impact is no more likely to be correct than assuming any other or no impact at all. As will be discussed later, the conclusions derived from the model are not sensitive to the values of costs and impacts selected just as they are not sensitive to the values of the model's other parameters that were used. Assuming greater or less impact will influence the extent of a particular program's effect on MI's cost to society, but will not change the basic nature of its effect (i.e., programs that cause costs to go up will cause some degree of cost increase to occur no matter what impact is assumed).

The reader should, again, understand that the simulations done with the model are not intended to be predictions of what will happen if particular interventions are implemented. Given

the quality of some of th data that were used and the controversy surrounding impacts of programs that were simulated, using the model as a predictive tool would be totally inappropriate. The value ofthe simulations is in the way they illustrate the relative impacts of particular interventions on the size of the population surviving MIs and the cost of MIs to society.

The following are medical interventions examined with the model and assumptions made about them.

1. Coronary Care Units

Coronary care units provide intensive monitoring and care to cardiac patients in hospitals and enable very rapid response to arrythmias and other emergencies that develop. The exact impact that CCU's have in reducing mortality is, as mentioned above, somewhat controversial. Impacts reported by various studies range from 25% to 50% reductions with some clustering around 33%.[12]

A 33% reduction in in-hospital mortality was assumed possible with CCU's for the purposes of our analysis.

Because only 40% of all deaths due to MI occur in hospitals,[13] the impact of CCUs on immediate mortality would, therefore, be a reduction of .33 x .40 = 13.2%. The reduction assumed in five-and ten-year mortality took into consideration the fact that only about 55% of those deaths are due to a recurrent MI[15] and could, therefore, be affected by admissions to CCUs. Furthermore, there is reason to believe that CCUs could have less impact on deaths due to recurrences than on first MIs.[15] The reduction in five- and ten-year mortality attributable to CCUs was, therefore, assumed to be .55 x .40 x .25 = 5.5%. The additional cost per patient use was assumed to be $564 above the cost of routine hospital care, the amount found by Peterson to be the cost of the average 4.7 day stay in a CCU.[16] This cost was applied to all people having initial or recurrent MIs and reaching the hospital alive.

2. Pre-hospital Care

Pre-hospital care encompasses a wide range of programs designed to keep the cardiac patient alive until he reaches the hospital. They include the use of specially trained paramedics and telemetry equipment in regular ambulances, "mobile coronary care units" with elaborate equipment and staffed by medical personnel, and fixed life support stations that provide emergency care at large industrial plants and stadiums. Estimates for mortality reduction due to these programs range from as low as 4%[17] to as high as

21%,[18] with clustering around 10%,[19, 20] depending on the particular program considered. A reduction of 10% in immediate mortality was assumed in the model for pre-hospital programs. A reduction in five- and ten-year mortality of .55 x .10 = 5.5% was also assumed as a result of pre-hospital programs. The cost applied to each initial infarction and recurrence was one of $28 estimated by Sidel et al as the cost of responding to all calls with a mobile coronary care unit over and above the costs of a standard ambulance response.[21]

3. Improved Long-Term Follow-Up and Maintenance

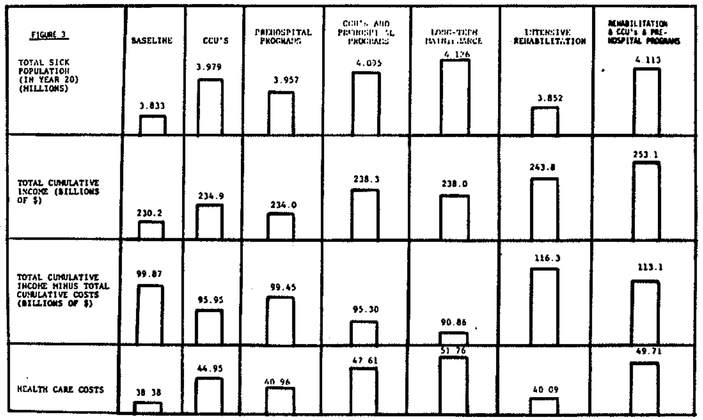
Rather than focusing on patients who are in the acute stages of a myocardial infarction as CCU's and pre-hospital emergency programs do, other programs focus on patients who have recovered from an MI and attempt to prevent recurrences. Significant results in reducing recurrence and mortality are claimed for programs administering large doses of anticoagulent drugs to cardiac patients.[22] A reduction of 50% in mortality due to recurrence and, thus .55 x .50 = 27.5% reduction in five- and ten-year mortality was assumed for simulating this type of program with the model. A 50% reduction in the recurrence rate was also assumed. To cover the cost of the more intensive monitoring and administration of drugs, the annual maintenance cost of $200 ($250 for people over 65) assumed in the model was doubled to $400 (and $500) when these programs were being simulated.

4. More Intensive Rehabilitation

Rehabilitation programs have their impact by reducing the fraction of people who become permanently disabled due to a myocardial infarction and getting people back to work sooner. One program reported on in the literature was able to reduce the fraction of people permanently disabled to 63% less than what it would have been without the sort of intensive rehabilitation this program provided.[23] For simulating the use of intensive rehabilitation as an intervention, a 63% reduction in the fraction of people with initial infarctions becoming disabled was, therefore, assumed. The report on this particular program did not contain cost data and another source had to be used. A report from a leading rehabilitation center indicated that its cardiac program lasted 32 days and, at an average patient-day cost at the center of $211, was assumed to cost $6,752.[24]

SIMULATION RESULTS REGARDING THE ECONOMIC IMPACTS OF MEDICAL INTERVENTIONS

The results of employing these programs and various combinations of them are shown in Figure 3. The "baseline" referred to in the first line of the table is a simulation in which all of the assumptions described earlier (in the section of "Quantifying the Model to Represent Myocardial Infarction") hold true with none of the four types of programs described in the last section assumed to be in effect. The other lines in the table indicate which programs or set of programs were assumed to be in effect in each simulation. Simulations were run for a period of twenty years. This allowed us to observe the potential long-term effects of the various interventions on the size of the "sick" population alive after one or more MIs. The simulations all begin in 1972. All dollar amounts are shown in constant (1972) dollars.



The most striking results that can be seen in Figure 3 are the ones showing that programs that might be expected to have beneficial economic impacts actually produce higher costs and lower net earnings when all costs are taken into consideration. CCUs, for example, by reducing mortality rates, cause the sick population to be about 150,000 higher in the twenthieth year in that particular simulation (the second line in Figure 3) than in the baseline simulation. The larger sick population produced a cumulative income by the twentieth year that is $4.7 billion higher than the income produced by the sick population in the baseline simulation. However, that "gain" is outweighed by higher costs including a cumulative health care cost that is $6.6 billion higher (reflecting the costs of the CCUs as well as slightly higher maintenance costs for the larger population) and cumulative disability payments that are $0.3 billion higher, and cumulative retirement payments that are $1.63 billion higher as a result of the larger population. The result is that the difference between cumulative income and total cumulative costs, the measure of the net contribution to the economy of the MI population, in this simulation is $3.9 billion less than in the baseline rather than being larger as one might expect.

Pre-hospital programs fare better because they are a less expensive way of reducing the mortality rate. Slightly less effective than CCUs, they result in a level of the sick population in year 20 that is 124,000 larger than the level in the baseline simulation, and total cumulative income over the twenty

years that is $3.8 billion larger. Health care costs, however, are only $2.6 billion higher than in the baseline. Even with higher retirement and disability payments as a consequence of the larger population, the difference between total cumulative income and total cumulative costs in this simulation is only slightly lower in this simulation than in the baseline.

Combining CCUs and pre-hospital programs in the fourth simulation produces an impact that falls near the impact obtained with CCUs alone. The sick population in the twentieth year is 261,000 larger than its level in the baseline simulation and total cumulative income is $8.1 billion higher as a result. The higher health care costs (due to both the cost of the combined programs and the higher maintenance costs for the larger population) and retirement and disability payments, however, combine to produce a difference between cumulative income and cumulative costs that is less than what occurred in the baseline.

Long-term maintenance would, at first glance, appear to be highly cost-effective because it involves a relatively small additional investment per person and can have a large impact on mortality rates. There should also be a direct effect in reducing cost due to the lowered frequency of recurrences that results. The impact on mortality rates can clearly be seen in the larger population, 292,000 higher than in the baseline simulation. Total cumulative income is $7.8 billion higher. Costs, however, are much higher. Cumulative health care costs show the greatest increase over the comparable baseline result, $13.4 billion, because of the higher maintenance costs per person that are assumed to be involved and the larger population to which the cost must be applied. Higher retirement payments of $2.9 billion and disability payments that are $0.4 billion higher added to health care costs combine to produce a total cost that is large enough to far outweigh the increase in income. The result is a difference between cumulative income and total cumulative costs that is $9 billion lower than that produced by the baseline simulation.

CCU's, pre-hospital programs, and long-term maintenance all affect mortality rates and result in a larger population that has survived an MI. Though this results in higher income, there are also higher costs due to the interventions themselves and the larger populations that eliminate or almost eliminate the economic benefit arising from the higher income. Rehabilitation programs do not directly affect mortality rates, but instead redistribute the sick population between active and disabled categories. The net gain from doing so is substantial since a person moving from the disabled to active categories reduces the number of people receiving disability payments by one while also increasing the number of wage earners by one. The overall result is a substantial increase in the difference between cumulative income and total cumulative costs, $16.9 billion, over the difference observed in the baseline simulation. Adding CCU's and pre-hospital programs has little additional impact because the

higher cumulative income they produce is again outweighed by higher costs. Though rehabilitation programs are less exciting in that they do not involve elaborate equipment or heroic attempts to save lives, they are able to produce a positive economic impact that the other programs cannot.

PREVENTIVE INTERVENTIONS

What would be the effect of preventing some fraction of the myocardial infarctions altogether? To answer this question, two additional simulations were done with the model. Both assumed reductions in initial incidence of MI of 30.1%, 50.6% and 27.7% for the 35-44, 45-54, and 55-64 age groups respectively. These reductions came from the results of the Framingham study and were derived by comparing MI incidence among smokers and non-smokers.[25] The reductions assumed were therefore ones that could hypothetically be achieved by removing smoking as a risk factor. These simulations are only illustrative rather than predictive of what might happen since it is highly unlikely that everyone could be dissuaded from smoking or that ex-smokers would not suffer some residual ill-effects. The first of the two simulations assumes only this reduction superimposed on the baseline simulation while the second assumes the reduction in incidence combined with CCU, pre-hospital, and rehabilitation programs.

The results are shown in Figure 4 which contrasts the two simulations with the baseline simulation's results. The measure used in reporting the other simulations' results, the total cumulative income minus cumulative costs, was not used because it would have been misleading. The smaller sick populations that resulted from the preventive assumption earned incomes that were naturally smaller than those earned by the sick populations in the other simulations. Thus, comparing differences between cumulative income and costs in the preventive simulations with those in the other simulations would not have made sense. Instead, Figure 4 shows the size of the sick population and health care and disability insurance costs that were produced by the two preventive simulations contrasted against the baseline results.

Figure 4

Comparison of the Economic Consequences of the Prevention of Myocardial Infarction and the Combination of Prevention and Rehabilitation

VALUES BY YEAR 20	Baseline	Prevention	Prevention and Rehabilitation
Total population experiencing MI*	3.833	3.275	3.275
Change from baseline		-.558	-.558
Cumulative health care costs**	38.38	33.42	34.90
Change from baseline		-4.96	-3.48
Cumulative disability payments**	9.65	8.19	4.84
Change from baseline		-1.46	-5.17
Net income**	99.9	109.0	121.5
Change from baseline		+9.1	+21.6

* Millions
** Billions of dollars

Comparing the first simulation with the baseline reveals the reduction in sick population and health care costs that might have been expected. The lower incidence rates assumed as a consequence of prevention in this simulation results in a sick population in year 20 that is 558,000 smaller than in the baseline. Cumulative health care costs are about $5 billion lower. Cumulative disability payments are lower as well. When prevention and other programs are combined though, the result is one that was less easily anticipated. The sick population is lower than in the baseline, but not as low as in the simulation with prevention alone. The other programs employed along with prevention have resulted in a larger sick population in year 20 by reducing mortality rates. Because of the larger population and the costs of the programs themselves, cumulative health care costs in this simulation are higher than in the simulation with prevention alone and higher, even, than in the baseline simulation. Cumulative disability payments in this simulation are lower than in either of the others as a result of the rehabilitation program employed as one of the other programs. The results show that preventive programs can have a definite impact in reducing costs, but that costs may still go up as a result of other programs even if preventive interventions are in effect.

One other type of program that was not simulated, but could potentially help to reduce costs is the treatment of MI patients at home once their conditions have stabilized. Studies done in the U.S. reveal the possibility of substantial savings if such a practice achieved widespread implementation. Further work with the model could examine the effects of this practice on the net economic impact of MI.

CONCLUSIONS

Many cost-benefit analyses tend to "credit" a successful medical intervention (that prevents a death due to a particular disease process) with the earnings that would accrue from the time of the intervention through the remainder of a person's working life. The principal cost considered is that of the intervention itself. The person is considered no more likely to contract the disease again later and incur additional health care costs than the average member of the population. The person is also assumed to be fully able to return to work after the intervention and, thus, earn income at the same rate that he earned before. Using this sort of cost-benefit approach, it is possible to assert that certain medical interventions "save money" for society and make resources available for other purposes.

This approach may be suitable for certain disease processes and interventions that prevent death due to those disease processes. For other disease processes, however, this approach is naive, as demonstrated in the previous sections. Heart disease, cancer, and other very common chronic disease have risks of recurrence that are much higher than the risk of a new occurrance

for a person who has not had any experience with the disease. Preventing a death due to these disease processes creates a potential for future health care costs that must be weighed against any future earnings generated by a person who lives longer as a result of medical interventions. There is also a continuing cost for health care that is given in an attempt to prevent recurrences. Not all people who survive a life-threatening stage in a disease process can return to work and earn income that can be "credited" to the medical intervention that saved their lives. In addition to not earning income, many of these people may require disability income payments which constitute a net cost rather than a contribution to the economy. Furthermore, in disease processes that have their highest incidence in older age groups such as heart disease and cancer, a successful intervention may only allow a person only a few more earning years (or none at all) before they become eligible for retirement payments that also constitute a net cost. Thus, a medical intervention that, upon superficial analysis, may appear to have a beneficial economic impact can actually cause costs to be borne by society that exceed the additional income earned by people whose lives were saved.

The results described in the previous sections indicate the importance of fully understanding the economic consequences of particular medical interventions and allocating sufficient resources for meeting the additional costs that are incurred. They also point out the need to give higher priority to interventions such as preventive and rehabilitative programs that have positive economic impacts as well as improving the quality of life.

Further work with the model will involve its application to other disease processes. An application to end-stage renal disease is currently underway. It will be important to ascertain that the model is applicable to other diseases and yields plausible results with disease processes in which incidence is evenly distributed across age groups or in which it is predominant in younger age groups. If the model does prove suitable for application to a number of different disease processes, it will be a useful tool for assessing medical interventions, developing a better understanding of their impact on society, and estimating the additional resources needed if their impact entails higher costs.

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