

Is Technological Change In Medicine Worth It?

When costs and benefits are weighed together, technological advances have proved to be worth far more than their costs.

by David M. Cutler and Mark McClellan

ABSTRACT: Medical technology is valuable if the benefits of medical advances exceed the costs. We analyze technological change in five conditions to determine if this is so. In four of the conditions—heart attacks, low-birthweight infants, depression, and cataracts—the estimated benefit of technological change is much greater than the cost. In the fifth condition, breast cancer, costs and benefits are about of equal magnitude. We conclude that medical spending as a whole is worth the increased cost of care. This has many implications for public policy.

IT IS WIDELY ACCEPTED THAT technological change has accounted for the bulk of medical care cost increases over time. But it does not necessarily follow that technological change is therefore bad. Presumably, technological change brings benefits in addition to costs—increased longevity, improved quality of life, less time absent from work, and so on. These benefits need to be compared with the costs of technology before welfare statements can be made. Technological change is bad only if the cost increases are greater than the benefits.

In aggregate, health has improved as medical spending has increased. Given then prevailing medical spending by age, the average newborn in 1950 could expect to spend \$8,000 in present value on medical care over his or her lifetime. The comparable amount in 1990 is \$45,000. An infant born in 1990 had a life expectancy that was seven years greater than that of the one born in 1950, and lower lifetime disability as well.¹ But how much of the health improvement is a result of medical care? Is the medical component worth it? These questions capture perhaps the most critical issue in the economic

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evaluation of medical technology, an issue that is the subject of this paper.

We report on a series of studies that examine the costs and benefits of medical technology changes. A key feature of these studies is that they measure costs and benefits at the disease level, not the level of medical spending as a whole. Health improvements in aggregate are very difficult to parcel out to different factors; improvements at the disease level, while still difficult, are more manageable. We consider five conditions: heart attacks; low-birthweight babies; depression; cataracts; and breast cancer.

Our results show the good and the bad of technological change. For the first four of these conditions, technological change is on net quite valuable. The cost of technology for them all is high, but the health benefits are even greater. However, although technological change in breast cancer screening and treatment brought some benefits during our period of analysis, they are roughly equal to the costs. In this case, technological change was neither clearly worth it nor clearly wasteful.

One key to understanding these results is to recognize the different ways in which technology affects the medical system. New technologies often substitute for older technologies in the therapy of established patients, which we term the “treatment substitution effect.” The unit cost of new technologies may be higher or lower than the cost of the older technologies they replace. But new technologies often bring health improvements, and this is valued highly.

In other cases, new technologies lead more people to be treated for disease, which we term the “treatment expansion effect.” Diagnosis rates for depression, for example, doubled after Prozac-like drugs became available, and cataract surgery was performed much more frequently as the procedure improved. When treatment is effective, getting it to more people is beneficial. But expanding therapy to more people may not be worth it when treatment is not so effective. The treatment expansion effect is a major factor in the benefits and failures of technological innovation. Still, it has not been much studied.

Although we analyze only some conditions, our results have implications for the health care system more broadly. The benefits from lower infant mortality and better treatment of heart attacks have been sufficiently great that they alone are about equal to the entire cost increase for medical care over time. Thus, recognizing that there are other benefits to medical care, we conclude that medical spending as a whole is clearly worth the cost.

This finding has immediate policy relevance. In recent years, public and private policy has been focused on how to reduce waste from

the system. Reducing waste is valuable, but waste reduction must be balanced against the potential for less rapid technical innovation. We return to this issue after summarizing the evidence on the value of technological change.

This evidence has other implications for policy as well. Our findings imply that the quality-adjusted price of medical care is actually falling over time, in contrast to standard figures that show rising prices for medical services. Further, our results provide a valuable methodology for gauging the impact of health system change, such as the rise of managed care on consumer welfare. Finally, our results suggest that extending National Health Accounts data to include the benefits of medical care as well as the costs could lead to much more useful statistics for understanding the productivity of the health care sector.

The Costs And Benefits Of Medical Innovation

Measuring the value of medical innovation requires a conceptual understanding of the costs and benefits involved. Our methodology follows much of what is in the literature. The costs of technological change are the current and future costs of the conditions under study. We use the present value of future costs (and benefits), discounted back to the present at a 3 percent real discount rate. The qualitative results are not very sensitive to this discount rate.

There are two benefits of medical innovations. The most important is the value of better health—longer life as well as improved quality of life. We follow the consensus of the literature and measure health using the quality-adjusted life year (QALY) approach.² Many (but not all) of the conditions we consider have high fatality rates, so changes in longevity tend to dominate the results. Again following the literature, we assume that the value a year of life in the absence of disease is \$100,000.³ The qualitative results we present are not very sensitive to a wide range of values of a year of life.

A second benefit of medical innovation is its effect on the financial situation of others. One part of this benefit is any increase in production that results from technology allowing people to work and earn more. Offsetting this productivity benefit are the medical and nonmedical costs of additional years of life, if any, from the technology. The entire cost of sustaining life is appropriate to include in this latter component, as the right comparison is the value of medical innovation less the total cost of providing the care.⁴

The net value of medical technology change is the difference between the benefits and costs. A positive net value implies that the technological change is worth it in total.

■ **The disease approach.** The central empirical issue in imple-

menting this framework is determining the importance of medical technology changes for better health. A variety of factors may influence health over time, of which medical technology is only one. We need to isolate the medical contribution before it can be valued.

Decomposing health changes in aggregate is not possible. Instead, we focus on the disease level. Using observational data or clinical trial evidence, we can often tell for a particular condition how much medical technology has contributed to better health.⁵ Even when the disease-level analysis is not exact, the range of uncertainty is generally better understood.

The trade-off is that one needs to study many diseases to make statements about the medical system as a whole. While we summarize results for a number of conditions, we do not have a sufficiently large set of conditions to enable us to draw firm conclusions. Still, we can say some things about medical spending as a whole, which we summarize in the concluding section.

The disease analysis groups together all of the technologies used in treating the condition under study. Policy is also interested in the costs and benefits of each individual technology. In most circumstances, though, it is extremely difficult to pinpoint the specific benefits of any particular technology.⁶ Thus, disease analysis is the only viable alternative.

■ **Treatment substitution and expansion.** Technological change affects treatments provided in two ways, “treatment substitution” and “treatment expansion.” Analysts have traditionally viewed technical change in the context of treatment substitution, a new technology substituting for an older one. Unit costs may increase or decrease; outcomes are likely to improve, though, as that is typically the goal of the new technology. Overall, the net effect of treatment substitution on welfare is not known.

The effect of treatment expansion is often overlooked. Doctors diagnose disease more frequently when treatments are safer and easier to take, and patients pay more attention to their condition when therapy is more effective. This treatment expansion adds to costs but also improves outcomes. Treatment expansion is worth it if these marginal patients benefit more than they cost. We consider both treatment substitution and treatment expansion in the conditions we analyze.

A First Example: Technology For Heart Attacks

To demonstrate the nature of the analysis, we consider one example in detail: technological change in the treatment of heart attacks. A heart attack is an acute event characterized by the occlusion of the arteries that supply blood to the heart. Without adequate oxygen,

part of the heart muscle dies within hours. The task of medical treatment is to limit immediate damage to the heart and, in the longer term, to prevent further episodes.

Because heart attacks are severe, all known heart attacks that are not quickly fatal are treated. Thus, we do not worry about selection into the sample. Much work has been done on the costs and benefits of technological change in heart attack care, including some by us and coauthors Joseph Newhouse and Dahlia Remler.⁷ We extend those results here.

■ **Treatment options.** One option for heart attack treatment is medical management. Thrombolytic drugs are often used to dissolve the blockage that caused the attack before all of the affected heart muscle has died. An alternative to thrombolysis and supportive care is surgical intervention. Bypass surgery, developed in the late 1960s, involves grafting an artery or vein around the occluded coronary artery. It is a major open-heart surgical procedure. Angioplasty, developed in the late 1970s, involves use of a balloon catheter to break up the blockage. Since the mid-1990s angioplasty has increasingly been used with the insertion of stents in the area of blockage—small mesh tubes that hold open the coronary artery. Both bypass surgery and angioplasty are preceded by cardiac catheterization, a diagnostic procedure to measure the location and extent of arterial blockage. Long-term drug therapies are also used to help prevent the development or progression of new blockages and to limit the workload of the heart.

■ **Data.** To measure the costs and benefits of these treatment changes, we use data from Medicare claims records. Our sample consists of every Medicare beneficiary in the fee-for-service Medicare program who had a heart attack between 1984 and 1998. We do not have data from managed care enrollees. For most of this time period, such enrollment was relatively small, although gathering data on managed care enrollees will be increasingly important if managed care enrollment among the elderly population grows. We analyze trends in total reimbursement for hospital care (including copayments and coverage limits) in the year after the heart attack.⁸ The data are expressed in real (1993 dollar) terms, relative to prices in the economy as a whole.

The Medicare data have been linked with comprehensive Social Security death records through 1999, so we can measure survival for heart attack patients. Mortality is a common result of heart attacks in the elderly; almost a quarter of patients die within thirty days.

■ **Treatment costs.** In 1984, \$3 billion was spent on heart attack patients; by 1998 the total was near \$5 billion, 3.4 percent annual growth in real terms (Exhibit 1). This increase is not a result of more

EXHIBIT 1
Accounting For The Increased Cost Of Heart Attack Treatments, 1984 And 1998

	1984	1998	Annual change
Total spending (billions)	\$3.0	\$4.8	3.4%
Number of cases	245,687	221,133	-0.8
Average spending per case	\$12,083	\$21,714	4.2

SOURCE: Authors' analysis of Medicare claims records for all elderly patients with a heart attack in 1984 and 1998.

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people having heart attacks; the number of heart attacks declined by almost 1 percent a year despite a large increase in the fee-for-service Medicare population. Rather, this reduction is likely a result of better risk-factor management such as reduced smoking and better control of blood pressure and cholesterol levels. Total spending increased because the average amount spent per heart attack case increased—nearly \$10,000 per case in real terms, or 4.2 percent per year.

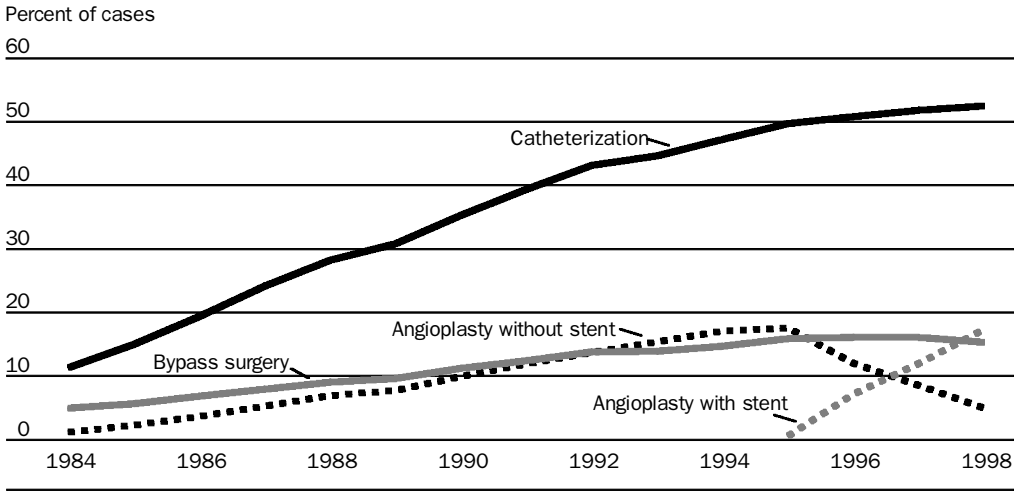
To understand why per case spending increased, we decompose spending growth into price and quantity components. We group the patients into five treatment options that are related to Medicare reimbursement rules: medical (nonsurgical) management of the heart attack; cardiac catheterization with no revascularization procedure; angioplasty without use of stents; angioplasty with use of stents; and bypass surgery. For each option, we calculate average Medicare reimbursement, which we use as the price of the option, and the share of patients receiving each treatment.

Changes in treatment rates are more important than are price changes in explaining spending increases. Nearly half of cost increases (45 percent) result from people getting more intensive technologies over time. Increased prices per treatment, in contrast, are a smaller part (33 percent). Indeed, even this estimate of the price component is likely to be too high, since some reimbursement increases are attributable to technological change within the treatment categories and should properly be called quantity changes. In total, therefore, technological change accounts for half or more of cost growth for heart attacks, a finding consistent with previous literature about the sources of cost growth for the medical sector as a whole.⁹

Exhibit 2 shows the nature of this technological change. In 1984 only 10 percent of heart attack patients received some surgical intervention; nearly 90 percent of patients were managed medically. By 1998 more than half of heart attack patients received catheterization and (usually) additional intensive procedures.

Exhibit 2 shows clearly that most of the technological change in heart attack care is not the development of entirely new therapies. Only one truly new therapy—angioplasty with stent—was devel-

EXHIBIT 2
Changes In The Surgical Treatment Of Heart Attacks, 1984-1998



SOURCE: Authors' analysis of Medicare claims records for all elderly patients with a heart attack.
NOTES: Procedure use is within ninety days of the initial admission for the heart attack. See references in text for more detail.

oped in this time period. Rather, technological change is predominantly the extension of existing technologies to more patients, as a result of increased knowledge about which patients will benefit from treatment and process innovations that reduce complications and lead to better outcomes.

■ **Comparing costs and benefits.** The increasing cost of heart attack treatment must be weighed against the benefits of this innovation. Both length and quality of life may be affected by treatment changes. Because length-of-life changes are so large and good data on quality of life are not readily available, we analyze changes in length of life only. Our earlier work suggests that accounting for changes in quality of life would strengthen the conclusions here.

We measure survival after a heart attack in several steps.¹⁰ In those years for which sufficient long-term data are available, we measure survival directly for up to five years after a heart attack. When five years of follow-up data are not available, we extrapolate from previous years, using an approach that understates mortality improvements. After five years, we assume that survival is the same for all patient cohorts. This too is conservative, as mortality rates are declining within the first five years after the heart attack and there is no reason to expect that trend to stop after five years. Thus, our estimates understate the value of technological change at all stages.

Based on Social Security records, life expectancy for the average person with a heart attack was just under five years in 1984 but had risen to six years by 1998. We value the health benefit of this addi-

“Around 70 percent of the survival improvement in heart attack mortality is a result of changes in technology.”

tional year of life at \$100,000. Since most heart attack survivors do not work, there are no productivity benefits from increased longevity. Annual consumption for the elderly averages about \$25,000, which we take to be the basic medical and nonmedical cost of living. Thus, the benefit to society of an additional year of life for heart attack patients is \$75,000. Using this methodology, the present value of the benefits from technological change is about \$70,000; treatment costs about \$10,000 more in 1998 than in 1984.

Clearly, technological change in heart attack care is worth the cost. The net benefit (value minus cost) is about \$60,000. Put another way, for every \$1 spent, the gain has been \$7. Technology increases spending, but the health benefits more than justify the added costs.

Indeed, the net benefit of technology changes is so large that it dwarfs all of the uncertainties in the analysis. For example, not all of the improvement in survival results from changes in intensive treatments. Detailed analysis of the association between specific treatment changes and heart attack mortality trends suggests that around 70 percent of the survival improvement is a result of changes in technology, with the remainder coming from changes in risk factors such as smoking and in diagnostic technologies allowing the detection of milder heart attacks.¹¹ Still, even if one took away 30 percent of the benefits, technological change would still be overwhelmingly worth it. Similarly, the value of a year of life need only be one-third of what we assume to make the technological change worth it. And we have omitted any changes in quality of life, which likely adds to the benefit of technological change.

The Range Of Other Conditions

Several recent studies have examined the costs and benefits of technological change for a range of other conditions. We discuss these conditions in turn; Exhibit 3 presents a summary.

■ **Low-birthweight infants.** David Cutler and Ellen Meara have examined the costs and benefits of technological change in the treatment of low-birthweight infants.¹² Data on neonatal mortality by birthweight are available from 1950 through the 1990s.

In 1950 very little could be done for low-birthweight infants. Mortality for infants born under 2,500 grams was 18 percent, and mortality for even lighter infants, those born under 1,500 grams, was

EXHIBIT 3
Summary Of Research On The Value Of Medical Technology Changes

Condition	Years	Change in treatment costs	Outcome		
			Change	Value	Net benefit
Heart attack ^a	1984–98	\$10,000	One-year increase in life expectancy	\$70,000	\$60,000
Low-birthweight infants ^b	1950–90	\$40,000	Twelve-year increase in life expectancy	\$240,000	\$200,000
Depression ^c	1991–96	\$0	Higher remission probability at some cost for those already treated		
		<\$0	More people treated, with benefits exceeding costs		
Cataracts ^d	1969–98	\$0	Substantial improvements in quality at no cost increase for those already treated		
		<\$0	More people treated, with benefits exceeding costs		
Breast cancer ^e	1985–96	\$20,000	Four-month increase in life expectancy	\$20,000	\$0

SOURCES: Authors' own work and summary of other studies; see below.

^a See Note 7 in text.

^b D. Cutler and E. Meara, "The Technology of Birth: Is It Worth It?" in *Frontiers in Health Policy Research*, vol. 3, ed. A. Garber (Cambridge, Mass.: MIT Press, 2000), 33–67.

^c See Note 16 in text.

^d I. Shapiro, M.D. Shapiro, and D.W. Wilcox, "Measuring the Value of Cataract Surgery," in *Medical Care Output and Productivity*, ed. D. Cutler and E. Berndt (Chicago: University of Chicago Press, 2001).

^e D.M. Cutler and M. McClellan, "The Productivity of Cancer Care" (Unpublished paper, 2001).

70 percent. With little to be done, costs of caring for these infants were low. By 1990 there was a substantial armamentarium of medical technologies available to treat low-birthweight infants, ranging from special ventilators to artificial surfactant to speed the development of infant lungs. Such technology is expensive. In 1990 the lifetime costs of caring for a low-birthweight infant, including costs during the birth period, costs of treating medical complications resulting from premature birth (such as cerebral palsy), and related nonmedical costs such as special education and disability payments, were about \$40,000 in present value.¹³

Survival improved as well. In 1990 mortality for low-birthweight infants was only one-third its 1950 level. The overall increase in life expectancy is about twelve years per low-birthweight baby. Cutler and Meara present evidence that this change is due to medical technology improvements and not other factors such as changes in maternal behavior.¹⁴

Further, quality of life has perhaps improved. At the margin of viability, there are high rates of medical and developmental problems, including cerebral palsy, blindness, and mental retardation. The share of marginal infants with these problems is believed to be the same now as in 1950. But as survival has improved at lower birthweights, infants above those birthweights are increasingly healthy. A 2,500-gram baby used to face substantial risk of long-term complications; the risk is now much lower. Thus, the share of

low-birthweight babies with severe complications is falling. For convenience, we focus on the longevity gains alone, thus understating health improvements over time.

Babies who survive birth will both work (absent the disability issue noted above) and consume. Over a person's lifetime, these two factors roughly cancel each other out—the average person neither inherits much nor leaves a substantial bequest. Thus, the benefits to increased survival are just the health benefits from increased longevity, or \$100,000 per year of additional life.

With this valuation, the present value of the additional longevity is about \$240,000 per low-birthweight infant.¹⁵ Compared to the \$40,000 of increased cost, the return is about 6 to 1, or \$200,000 in total. As for heart attacks, this net benefit is so large that it dwarfs all of the uncertainties inherent in the data. For low-birthweight babies, as with adults having heart attacks, technological change increases spending, but the benefits are even greater.

■ **Depression.** Ernst Berndt and his colleagues have analyzed changes in the treatment of depression in the 1990s, using claims data on several thousand episodes of depression over the 1991–1996 time period.¹⁶ This time period is shorter than that used in the analyses of heart attacks and neonatal mortality, but it spans a particularly important period in the treatment of depression, when new medications such as selective serotonin reuptake inhibitors (SSRIs, including Prozac and related medications) were introduced and their use exploded. In the mid-1980s treatment with either psychotherapy or tricyclic antidepressants was the norm. By 1991, 30 percent of depressed patients were treated with an SSRI. In 1996, the share was nearly half.

Berndt and colleagues use an indirect method of analyzing the costs and benefits of technological change. They combine medical claims data on changes in treatment patterns and costs with clinical trial evidence on the efficacy of alternative treatments in reducing depressive symptoms.

This evidence suggests that full courses of psychotherapy, tricyclic antidepressants, and SSRIs have roughly equivalent efficacy, with the two medications being somewhat better in some cases and generally similar to each other in efficacy. But pharmaceuticals are less expensive than psychotherapy for a full course of therapy, and about the same cost when dropouts from both therapies are included. Once physician visits are added in, SSRIs cost about the same as older tricyclic antidepressants. Thus, the shift from psychotherapy and tricyclic medications to SSRIs was accomplished at virtually no net cost. But dropout rates are higher for psychotherapy and tricyclic antidepressants than for SSRIs. SSRIs have fewer side

effects than other drugs have, and they cost patients less than psychotherapy does. Thus, patients take them for longer periods of time and get more effective doses. For roughly the same cost, treatment efficacy has improved. Berndt and colleagues estimate that this treatment substitution reduced spending per incremental remission probability by about 20 percent.

SSRIs also have led to significant treatment expansion. Numerous studies prior to the 1990s estimated that about half of persons who met a clinical definition of depression were not appropriately diagnosed by their physician, and many of those diagnosed did not receive clinically efficacious treatment.¹⁷ Manufacturers of SSRIs encouraged doctors to watch for depression, and the reduced stigma afforded by the new medications induced patients to seek help. As a result, diagnosis and treatment for depression doubled over the 1990s.¹⁸

Treatment expansions have both costs and benefits. Treating an episode of depression costs up to \$1,000, depending on the type of therapy followed. The health benefit of treatment is the reduced time spent depressed. Data suggest that effective treatment can reduce time spent depressed by about eight weeks.¹⁹ The quality-of-life improvement from reducing depressive symptoms has been estimated by several studies, with estimates ranging from 0.1 to as much as 0.6, on a scale where 1 is moving from death to perfect health.²⁰ Using an intermediate value of 0.4, and again assuming that a year of life is worth \$100,000, the reduction in time spent depressed is a benefit of about \$6,000 ($8/52 \times 0.4 \times \$100,000$). This is six times greater than the cost of treatment.²¹ In addition, there are gains from persons' being able to work and produce more, which are not in this calculation. Thus, increasing rates of treatment among depressed patients is almost certainly well worth the cost.

■ **Cataracts.** Irving Shapiro and colleagues consider technological change in the treatment of cataracts from the late 1960s through the late 1990s.²² In the late 1960s a cataract operation was an intensive procedure. It involved three nights in a hospital (down from a week a few decades earlier) and substantial operating room and physician time. Complications were frequent, including glaucoma and infection. By the late 1990s cataract operations were routinely performed on outpatients in under half an hour, with many fewer complications. Postoperative visual quality has also improved.

The reduction in inputs needed for the operation has offset the increase in cost of each input. Even though hospital and surgeon fees have increased, so many fewer hospital days and surgical hours are needed to perform the operation that total operative costs for a cataract operation are essentially unchanged in real terms. With no

“Some of the increase in breast cancer treatment most likely reflects cases that would not have been detected in earlier years.”

increase in spending over three decades and a large increase in visual quality and reduction in complication rates, the substitution of newer for older therapies is a clear case of technological change with positive net benefits.

There has also been treatment expansion for cataracts. People are operated on at much less severe measures of visual acuity now than in the past. A rough calculation suggests that treatment expansion is worth it socially. Medicare reimbursement for a cataract operation is about \$2,000 to \$3,000. The benefits of the operation are several years of improved vision. Estimates in the literature suggest a quality-of-life decrement from vision impairment associated with cataracts of about -0.2, on the same 0-1 scale described above. For a person with five years of remaining life expectancy, this amounts to one year of improved quality-adjusted life. Valuing this at \$100,000 (assuming no productivity gains and no increase in longevity) gives a present value of about \$95,000. This is much greater than the cost. One would need data on the age and life expectancy of cataract operation recipients to do this calculation precisely, but the treatment expansion effect almost certainly is beneficial.

■ **Breast cancer.** We have recently analyzed the costs and benefits of treatment changes for breast cancer over the period 1985-1996.²³ This analysis is more preliminary than for the other conditions, so we stress our qualitative findings more than our quantitative ones.

Over time, several innovations in therapeutic treatment of breast cancer have been made. First, although much of the treatment for breast cancer itself has moved out of the hospital, chemotherapy regimens have become somewhat longer and more complex. Second, there have been many changes in supportive care—ranging from more frequent surgery for complications to more outpatient visits for drug treatments for such conditions as anemia and nausea.

Detection technology and public awareness of the benefits of screening also have advanced. As a result of these changes, overall cancer diagnosis and treatment rates have risen. Incidence rates rose 10 percent in the late 1980s and then fell somewhat in the 1990s, as increased early detection led to reduced rates of metastatic disease. Still, many more cancers were being treated at the end of the time period than the beginning. Some of this increase in treatment may reflect a true increase in cases, but it most likely reflects detection of

existing cases that would not have been detected in earlier years.

This increased detection may or may not be valuable. While breast cancer is often fatal if untreated, most breast cancers progress slowly, and many occur in older women who may die of other causes before their cancer becomes symptomatic. As a result, there is considerable professional uncertainty about the appropriateness of breast cancer screening in women above age sixty-five or seventy.²⁴

To measure the benefits of these diagnostic and therapeutic changes, we calculate survival for women as a whole as a result of reduced breast cancer mortality. This effectively combines the treatment substitution and treatment expansion effects. In the breast cancer case, we do not feel sufficiently sure of our ability to separate the two. We express these population-based survival improvements on a per case basis to compare with per case treatment costs.

The data we used are from Medicare claims records matched to the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) program. The SEER data contain mortality information along with stage of cancer at diagnosis, which allows us to control to a considerable degree for the severity of the detected disease.

We estimated that survival after breast cancer increased by four months over this time period.²⁵ The benefits of this additional survival are \$75,000 per year: the \$100,000 health benefits less the \$25,000 of basic medical and nonmedical costs (the women we analyzed were elderly, and few were working). In present value, the increase in survival is worth about \$20,000. Since the average case of breast cancer costs about \$20,000 more to treat in 1996 than in 1985, technological change was neither beneficial nor harmful on net.

There are uncertainties in this calculation that could make technological change valuable or not. For example, we did not account for quality of life, which many believe has improved over this time period. On the other hand, we did not factor in screening costs. These uncertainties could tip the balance one way or the other, but the magnitudes are unlikely to reach the level of the other conditions we have analyzed.

■ **Summary.** In most of the cases we analyzed, technological innovations in medicine are on net positive. Technology often leads to more spending, but outcomes improve by even more. In one case, breast cancer, there is no clear result. Outcomes are slightly better, but costs have increased substantially, and the two are roughly equal orders of magnitude.

These results can be understood by recognizing the two ways that medical innovation affects patients. Treatment substitution is clear in all of our examples. Among those already treated, innovation

changes how people are treated. Per case costs may rise or fall with this substitution; our examples show both scenarios. But outcomes are usually better. Thus, treatment substitution appears generally worthwhile.

Treatment expansion is a notable feature of three of our cases: depression, cataracts, and breast cancer. Treatment expansion is generally cost increasing, since no therapy other than routine physician visits was provided prior to the diagnosis. Treatment expansion may or may not be worth it, depending on how valuable the treatment is in the marginal patients. Some of the greatest successes of the medical care system, and some of its greatest failures, are in this treatment expansion effect. To date, treatment expansion has received relatively little study by researchers.

Policy Implications

■ **Is technological change as a whole worth it?** While we have considered a range of diseases, we have not considered enough to draw firm conclusions. Most importantly, we have not yet analyzed any chronic diseases such as diabetes, asthma, and congestive heart failure. Further, the conditions we have chosen may not be random among acute disease. Thus, generalizing from our results is not easy.

But we can say more.²⁶ Consider the facts given in the introduction to this paper: Between 1950 and 1990, the present value of per person medical spending increased by \$35,000, and life expectancy increased by seven years. Valuing these years at \$100,000 per year, the present value of the increase in longevity is about \$130,000. Thus, the increase medical spending as a whole is worth it if medical spending explains more than a quarter ($\$35,000/\$130,000 = 27$ percent) of increases in longevity.

We have highlighted two conditions where medical technology greatly reduced mortality: care for low-birthweight infants and treatment of acute heart attacks. Our heart attack analysis was for only the recent time period, but other data suggest medical benefits for a longer period of time.²⁷ If one takes just the medical component of reduced mortality for low-birthweight infants and ischemic heart disease, medical care explains about one-quarter of overall mortality reduction.

Thus, medical care is certainly worth it if any of the additional increase in longevity results from improved medical care, or if medical care improves quality of life. We have shown examples where it clearly does. Thus, we conclude that medical care as a whole is clearly worth the cost increase, although we cannot present a specific rate-of-return evaluation.

■ **Policies toward medical spending increases.** Medical care

“Policies that eliminate waste and increase the incremental value of treatment may also retard technological progress.”

costs are high, and much evidence documents waste in the provision of medical services. Responding to such concerns, the public and private sectors have periodically focused on the need to reduce spending. In the public sector, cost constraints were central to the Clinton administration’s Health Security Act and to various proposals for Medicare reform in recent years. In the private sector, the focus on cost containment drove much of the move to managed care in the 1990s.

Eliminating waste—or, in economic terms, reducing costly treatment use where the marginal value is low—is an important goal. Our results suggest, however, that this needs to be balanced by concern about impacts on technical change. Policies that eliminate waste and increase the incremental value of treatment may also directly or indirectly retard technological progress. This fear is a particular concern in light of recent evidence that managed care has slowed the rate of diffusion of new medical technologies.²⁸ If managed care has reduced the adoption of treatments of low value or has limited the treatment expansion effect only to patients with expected benefits greater than costs, then it may have increased productivity growth even as it slowed technology diffusion. But if the reduced technological change is not of marginal value, then managed care growth may have reduced long-term productivity growth in health care. There is considerable evidence that managed care and other policy changes can reduce costs without harming outcomes at a point in time. But there is less evidence on the dynamic effects of managed care and other policy influences.²⁹ Our results suggest that this issue and the impacts of any change in technical innovation should be carefully monitored.

■ **Price indices for medical care.** Official data indicate that medical prices are increasing more rapidly than prices in the rest of the economy. For example, between 1960 and 1999 the medical care Consumer Price Index (CPI) increased by 1.8 percentage points annually above the growth rate of the all-items CPI.

There are two problems with such indices. First, they include as price changes many factors that are more accurately counted as quantity increases resulting from medical innovation. For example, a day in a hospital was traditionally included in the CPI. It showed a very rapid price increase, but this was almost certainly a result of the increased technological sophistication that has occurred in hospital

stays over time.

More fundamentally, official price indices have only a poor adjustment for quality change. If price increases over time are matched by quality improvements, the quality-adjusted price of medical care will not increase. Our results imply that quality change has been greater than, or at least comparable to, price increases for a range of conditions. Thus, the quality-adjusted price index for these conditions should not be rising. An equivalent statement is that productivity in treating these conditions has been greater than that of the typical industry. Government statistical agencies are beginning to incorporate quality adjustment into official indices.³⁰ As demonstrated here, this is a difficult task. We expect that continued changes in this direction will greatly reduce the perceived inflationary component of medical care cost increases.

The fact that price indices for medical care are falling should not be taken as a recommendation that Social Security cost-of-living increases or increases in other government programs should be moderated. That is in large part a distributional question of how much of the higher costs associated with rising health care productivity should be borne by the elderly versus workers. Conventional price indices may not be what we want to use in updating benefit payments for public programs.

■ **Managed care and other policy reforms.** Our analysis has focused on technological changes in medical practice over time, but it is equally applicable to technological changes in the delivery system, such as the growth of managed care. Managed care has clearly reduced medical spending increases, at least over the short term (several years). This cost savings must be compared to any effect of managed care on the quality of medical services provided—either improvements, as advocates claim, or reductions, as detractors fear. The net benefit of managed care is the cost savings less the value of reduced health (or plus the value of health improvements).

Estimating the health impacts of managed care can be done with the same sort of data that we have analyzed in this paper, expanded to include people in different insurance plans. One needs to separate out the impacts of managed care on treatment from selection differences in patients over time, but this is possible. The impact of other health system reforms such as malpractice law changes or steps to affect provider competition can be evaluated in the same way.³¹

■ **More complete National Health Accounts.** Current National Health Accounts track the costs of medical care. This is an important and difficult task. Our results suggest adding another task as well: measuring the benefits of medical care. Including the benefits side in National Health Accounts is vital for making sound

policy. At least some of the focus on reducing medical spending is because spending, and not health outcomes, is what is currently measured. A fuller set of National Health Accounts could allow policymakers to make more sound decisions.

Two steps are needed to include health in national accounts. First, it is necessary to measure the population's health. We focused our analysis primarily on longevity, but an ideal system would measure quality of life, too. Second, it is necessary to decompose the sources of changes in health. Our analysis suggests that it is possible to do this at the disease level, if enough conditions are chosen.³² We hope that the expanding research on productivity changes in the treatment of common illnesses helps us to move toward this goal.

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NOTES

1. K.G. Manton and X. Gu, "Changes in the Prevalence of Chronic Disability in the United States Black and Nonblack Population above Age 65 from 1982 to 1999," *Proceedings of the National Academy of Sciences* (22 May 2001): 6354-6359.
2. U.S. Department of Health and Human Services, Office of Public Health and Science, Office of Disease Prevention and Health Promotion, Panel on Cost-Effectiveness in Health and Medicine, *Cost-Effectiveness in Health and Medicine* (Washington: U.S. Government Printing Office, 1996).
3. W.K. Viscusi, "The Value of Risks to Life and Health," *Journal of Economic Literature* (December 1993): 1912-1946; G. Tolley, D. Kenkel, and R. Fabian, eds., *Valuing Health for Policy: An Economic Approach* (Chicago: University of Chicago Press, 1994); and K. Murphy and R. Topel, "The Economic Value of Medical Research" (Unpublished paper, University of Chicago, 1999).
4. There is substantial debate about whether such costs ought to be included in the analysis or not. See Panel on Cost-Effectiveness in Health and Medicine, *Cost-Effectiveness in Health and Medicine*; and D. Meltzer, "Accounting for Future Costs in Medical Cost-Effectiveness Analysis," *Journal of Health Economics* (Jan/Feb 1997): 33-64. These two sources present opposing views. Conceptually, such costs ought to be included, but so too should the gains from extending longevity. To see why, consider the simplistic case of a medical technology that at negligible monetary cost would add one year to the life of a person just about to die. The technology will be worthwhile if the value to society of the person living a year is greater than the cost to society of having the person alive. Omitting either the costs or benefits from this equation biases the answer. The argument against including these costs and benefits has largely been based on the practical difficulty of doing so.
5. This is the approach followed by J.P. Bunker, H.S. Frazier, and F. Mosteller, "Improving Health: Measuring Effects of Medical Care," *Milbank Quarterly* 72, no. 2 (1994): 225-258.
6. As we discuss later, one exception is heart attack care, where clinical trial evidence on treatment effects as well as epidemiologic evidence on specific treatment trends is extensive.
7. D.M. Cutler et al., "Are Medical Prices Falling?" *Quarterly Journal of Economics*

- (November 1998): 991-1024; and D.M. Cutler et al., "Pricing Heart Attack Treatments," in *Medical Care Productivity and Output*, ed. D. Cutler and E. Berndt (Chicago: University of Chicago Press, 2001).
8. Hospital spending is the bulk of costs for heart attack patients. Incorporating more limited data on physician services does not change our conclusions qualitatively.
9. J.P. Newhouse, "Medical Care Costs: How Much Welfare Loss?" *Journal of Economic Perspectives* (Summer 1992): 3-21; D.M. Cutler, "Technology, Health Costs, and the NIH" (Paper presented at the National Institutes of Health Economic Roundtable on Biomedical Research, Bethesda, Maryland, November 1995); and E.A. Peden and M.S. Freeland, "A Historical Analysis of Medical Spending Growth, 1960-1993," *Health Affairs* (Summer 1995): 235-247.
10. Cutler et al., "Pricing Heart Attack Treatments," has a detailed discussion of the methods used.
11. P.A. Heidenreich and M. McClellan, "Trends in Treatment and Outcomes for Acute Myocardial Infarction: 1975-1995," *American Journal of Medicine* (15 February 2001): 165-174, examines trends in characteristics of heart attack patients from samples such as the Worcester Heart Attack Study and the Minnesota Heart Study.
12. D.M. Cutler and E. Meara, "The Technology of Birth: Is It Worth It?" in *Frontiers in Health Policy Research*, vol. 3, ed. A. Garber (Cambridge, Mass.: MIT Press, 2000): 33-67.
13. Average birth-related costs are about \$20,000 per low-birthweight baby. The remainder are Medicaid and disability spending for disabled children and special education costs for severely disabled children during school years. The probability that a child has any disability in 1990 is about two-thirds for the very lightest infants (under 1,000 grams) and about one-quarter for the remaining low-birthweight infants. About half of children with disability are severely disabled.
14. Maternal behavior has a powerful influence on the birthweight of the baby but, conditional on birthweight, does not have a large impact on infant survival.
15. The undiscounted value is \$1.2 million. The present value is lower because a baby who survives will live about seventy years on average, and many of these years are far in the future.
16. E.R. Berndt et al., "The Medical Treatment of Depression, 1991-1996: Productive Inefficiency, Expected Outcome Variations, and Price Indexes," NBER Working Paper no. 7816 (Cambridge, Mass.: National Bureau of Economic Research, July 2000); R.G. Frank et al., "The Value of Mental Health Care at the System Level: The Case of Treating Depression," *Health Affairs* (Sep/Oct 1999): 71-88; and E.R. Berndt, S.H. Busch, and R.G. Frank, "Price Indexes for Acute Phase Treatment of Depression," in *Medical Care Output and Productivity*, ed. Cutler and Berndt.
17. See, for example, R.M. Hirschfeld et al., "The National Depressive and Manic-Depressive Association Consensus Statement on the Undertreatment of Depression," *Journal of the American Medical Association* (22/29 January 1997): 333-340.
18. The National Ambulatory Medical Care Survey shows such an increase.
19. A typical episode of depression lasts about half a year, and medication results in a roughly 30 percent reduction in depressive symptoms. Thus, the impact on time spent depressed is about eight weeks. See Agency for Health Care Policy and Research, *Depression in Primary Care*, Clinical Practice Guideline No. 5 (Washington: AHCPR, 1993).
20. D.L. Sackett and G.W. Torrence, "The Utility of Different Health States as

- Perceived by the General Public," *Journal of Chronic Diseases* (November 1978): 697-704; D.G. Frybeck et al., "The Beaver Dam Health Outcomes Study: Initial Catalog of Health-State Quality Factors," *Medical Decision Making* (April-June 1993): 89-102; S.F. Anton and D.A. Revicki, "The Use of Decision Analysis in the Pharmacoeconomic Evaluation of an Antidepressant: A Cost-Effectiveness Study of Nefazodone," *Psychopharmacology Bulletin* (Summer 1995): 249-258; and C.J.L. Murray and A.D. Lopez, eds., *The Global Burden of Disease: A Comprehensive Assessment of Mortality and Disability from Diseases, Injuries, and Risk Factors in 1990 and Projected to 2020* (Cambridge, Mass.: Harvard University Press, 1996).
21. In another metric, Frank and colleagues estimate that incremental spending per QALY is about \$15,000, which is well below the value of a year of quality-adjusted life. Frank et al., "The Value of Mental Health Care."
 22. I. Shapiro, M.D. Shapiro, and D.W. Wilcox, "Measuring the Value of Cataract Surgery," in *Medical Care Output and Productivity*, ed. Cutler and Berndt.
 23. D.M. Cutler and M. McClellan, "The Productivity of Cancer Care" (Unpublished paper, Harvard University, 2001).
 24. For a discussion, see A.B. Nottlinger, "Older Women, Mammography, and Mortality from Breast Cancer," *American Journal of Medicine* (February 2000): 174-175, and the references therein.
 25. To isolate the role of breast cancer treatments, we consider deaths only from breast cancer.
 26. For discussion, see D.M. Cutler and E. Richardson, "Your Money and Your Life: The Value of Health and What Affects It," in *Frontiers in Health Policy Research*, vol. 2, ed. A. Garber (Cambridge, Mass.: MIT Press, 1999), 99-132.
 27. P.A. Sytkowski, W.B. Kannel, and R.B. D'Agostino, "Changes in Risk Factors and the Decline in Mortality from Cardiovascular Disease," *New England Journal of Medicine* (7 June 1990): 1635-1641.
 28. L. Baker and M. Brown, "The Effect of Managed Care on Health Care Providers," *RAND Journal of Economics* (Summer 1999): 351-374; M.E. Chernew et al., "Managed Care, Medical Technology, and Health Care Cost Growth: A Review of the Evidence," *Medical Care Research and Review* (September 1998): 259-288; and D. Cutler and L. Sheiner, "Managed Care and the Growth of Medical Expenditures," in *Frontiers in Health Policy Research*, vol. 1, ed. A. Garber (Cambridge, Mass.: MIT Press, 1998), chap. 3, 77-115.
 29. Two studies that consider dynamic effects, at least over short time periods, are D.P. Kessler and M. McClellan, "Do Doctors Practice Defensive Medicine?" *Quarterly Journal of Economics* (May 1996): 353-390; and D.P. Kessler and M. McClellan, "Is Hospital Competition Socially Wasteful?" *Quarterly Journal of Economics* (May 2000): 577-615. These studies find one-time beneficial productivity effects of malpractice liability limits and increased competition, respectively. However, they find little evidence of dynamic effects on productivity.
 30. E. Berndt et al., "Medical Care Prices and Output," in *Handbook of Health Economics*, vol. 1A, ed. A.J. Culyer and J.P. Newhouse (Amsterdam: Elsevier, 2000), 119-180.
 31. In other work with Joseph Newhouse, we have begun to develop evidence on this question. D.M. Cutler, M. McClellan, and J.P. Newhouse, "What Does Managed Care Do?" *RAND Journal of Economics* (August 2000): 526-548.
 32. This approach is conceptually similar to the understanding of investment at the aggregate level, which involves the analysis of about 800 separate types of investment. See J. Triplett, "What's Different about Health? Human Repair and Car Repair in National Accounts and National Health Accounts," in *Medical Care Output and Productivity*, ed. Cutler and Berndt.